Smart Money?

The Role of
Venture Capitalists' Knowledge
in the Financing of
New Biotechnology-Based Ventures

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To

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SHORT ABSTRACT

Venture capitalists (VCs) are often said to play a vital role for the development of new technology-based ventures – as experts in identifying and developing successful opportunities, and by providing 'smart money' to them.

However, most existing literature treats VCs as a homogeneous group, either neglecting likely differences in VCs' knowledge completely or measuring it inadequately.

At the same time, anecdotal evidence and recent events, such as the development and burst of the 'high-tech Bubble', cast some doubt about whether all VCs are truly experts.

In this project we therefore examine the impact of VCs' knowledge on their investment approach and the performance of their investments in a more systematic way than is to be found in the existing literature.

For this purpose, we develop a several proxies for VCs' knowledge that are based on the number and type of the VCs' previous investments.

We would generally expect that the impact of VCs' knowledge on their investment approach and the performance of their investments is the stronger the better matched the VCs' knowledge is to a focal venture.

Based on a unique sample of more than 14.000 investments made by 2,000 VCs in 1,700 biotech ventures between 1970 and 2002, we test this proposition by examining three specific research hypotheses on the relation between VCs' knowledge and 1) the syndication of investments, 2) the staging (round-length) of deals, and 3) the likelihood of VC-backed ventures to go public.

Our findings overall provide support for our hypotheses: controlling for various other factors, VCs' knowledge is negatively related to VCs' propensity to syndicate and to the round-length of VC deals, and it is positively related to the likelihood of VC-backed ventures to go public. These relations are the more pronounced the better matched the VCs' knowledge is to the focal venture.

Two additional case studies on German biotech ventures, however, also suggest that the actual impact of VCs' knowledge is strongly influenced by the contextual situation: even knowledgeable VCs can behave myopically – in good and in bad times.

CHAPTER A: ABSTRACT

Introduction

Entrepreneurial ventures, particularly in high-tech sectors, face a number of challenges to realize their potential and to develop into sustainable companies. Chief amongst those challenges is the lack of vital monetary and non-monetary resources. However, high levels of project risk and a liability of 'newness and/or smallness' make it difficult for these ventures to obtain missing resources externally.

In this situation, venture capitalists (VCs) are often assumed to play a key role for the ventures' successful development, by providing not only cash but also 'smart' money. VCs are said to be experts in identifying the most promising investment opportunities prior to the investment and in providing value-added oversight and support to them in the post-investment phase. This assertion seems plausible looking at many of today's well-known high-tech organizations that had received venture capital during their early days.

However, the recent high-tech Bubble at the stock markets casts some doubt about the actual 'smartness' of VCs. In the aftermath of this Bubble, also thousands of VC-backed ventures went bankrupt, incurring substantial losses for all stakeholders. This intensified resource constraints on existing ventures and threatens the development of promising new sectors.

It is therefore pertinent to ask how 'smart' venture capital really is and to investigate how VCs' knowledge is related both to their investment approach and the performance of their investments.

The academic literature on venture capital offers several theories of venture capital investment – the financial intermediation or financial signalling theory, the principal-agent theory, and the resource-based or resource-dependence theory - each of which (implicitly or explicitly) suggests a positive role for VCs' knowledge.

The empirical literature in this context, however, produces ambiguous findings. VCs' investment activities apparently differ widely, as does the outcome of these activities: VC-backing has been found in turn to enhance, to have no effect on or even to detract from the performance of entrepreneurial ventures.

One plausible explanation for this ambiguity in the literature may be that most previous studies have not differentiated between VCs on the basis of their

observable characteristics at all. Instead, they have treated VCs as a homogenous group, implicitly assuming that they all have the same characteristics and levels of competence. Put it simply, research has looked at what VCs *do*, and how this differs from more traditional investors when confronted with different investment opportunities. By contrast, virtually no study has looked at how VCs differ in what they *know* and how this may impact their style and performance. Furthermore, literature ignores the issue of how VCs develop knowledge in the first place, and what kinds of knowledge may be most relevant for their activities and their outcomes.

As a consequence of this the few studies that have differentiated between VCs have done so by using certain VC characteristics – such as the VC age or size - that may be appropriate for analysing the role of VCs' reputation, but seem inadequate to capture VCs' actual knowledge. Even where studies have used potentially adequate proxies for this purpose, they often have employed them in questionable ways. For instance, many studies did not take into account that ventures usually receive *several* rounds of funding, which often involve *different* (syndicates of) VCs. In addition, most research is based on quite heterogeneous samples of ventures, apparently assuming that ventures from different industries involve the same challenges and have the same requirements, in particular with respect to investor knowledge.

Together, these deficiencies in the literature have the potential to obscure the 'true' impact of VCs' knowledge.

Propositions and hypotheses

Most of the academic literature takes a static view of VCs' knowledge - emphasizing, for instance, possible information asymmetries between VCs and entrepreneurs at any given point of time but neglecting the dynamic role of learning and knowledge present in the evolution of a new industry.

By contrast, in this thesis, our interest focuses primarily on the evolution of VCs' knowledge and its impact on their investment approach and performance.

For this purpose it is necessary to develop more adequate proxies for VCs' knowledge and more systematic ways to employ those proxies than described in the literature.

From the literature on organizational learning, we know that organizations 'learn by doing'. In the VC context, this could translate into 'learning by investing': by repeatedly investing in entrepreneurial ventures, VCs develop relevant knowledge that enables them to conduct their activities more efficiently and effectively. However, this knowledge has several facets, ranging from *general experience* in financing and managing entrepreneurial ventures to very *specific expertise* with respect to ventures in particular industry sectors and at particular development stages.

We therefore propose a set of proxies for VCs' knowledge that is based on both the *number* and the *type* of VCs' previous investments. They allow us to measure several dimensions of VCs' knowledge, reaching from their general experience (number of investments overall) to their specialist expertise (number of investments in a particular industry sector and development stage). Furthermore, we can use these proxies to measure the knowledge of individual VCs and syndicates of VCs, in single rounds or across several rounds of the same venture. Together, this enables us to examine the impact of VCs' knowledge in a more adequate and systematic way than has been done in previous studies.

We would generally expect the VCs' knowledge, as approximated by our measures, to be more influential the better it is matched to the particular venture under consideration, and – in syndicated rounds - to be more influential with view to the most knowledgeable 'lead' VCs than with view to the syndicates overall. This forms the basis of the three main research hypotheses tested in this thesis. They focus on the relation between VCs' knowledge and 1) the syndication of investments, 2) the staging of deals, and 3) the performance of ventures.

Methods and data

Our study focuses on one particular reference industry, biotechnology. This sector is particularly interesting and suitable to our purpose not only because biotechnology is widely expected to be one of the key technologies for the 21st century but also because it involves unique challenges, in particular with respect to VCs' knowledge.

We examine our hypotheses by means of a large-sample approach based on information from Venture Economics. From this source we collect information on some 14,700 individual investments by some 2,000 VCs in about 1,700 biotech ventures over the period from 1970 to 2002. This is one of the largest single-industry samples from the Venture Economics database extracted to date. The care with which this dataset has been put together means that it is more accurate than many of the existing datasets in the area and the results derived from it should therefore be significantly more reliable than the average.

In addition, we conduct in-depth case studies on two German biotech ventures. This allows us to obtain a 'richer picture' of the VC-entrepreneur relationship, of the factors influencing VCs' activities and their outcomes than is possible simply from the large sample analysis alone.

Findings

Overall, our findings confirmed the postulated hypotheses:

1. VCs' knowledge is negatively related to the VCs' propensity to syndicate investments, and this relation is the more pronounced the better matched the VCs' knowledge is to the particular venture under consideration.

2. VCs' knowledge is positively related to the staging of investments (equivalently, is negatively related to round-length), and this relation is the more pronounced the better matched the VCs' knowledge is to the particular venture under consideration. It is also more pronounced for the syndicate 'lead' VCs' knowledge than for the syndicate VC's average knowledge.

3. VCs' knowledge is positively related to their investee ventures' likelihood of experiencing an IPO and negatively related to their time-to-IPO, and these relations are again more pronounced the better matched the VCs' knowledge is to the particular venture under consideration.

Our findings also indicate that some of the proxies for VCs' knowledge used in previous research, such as VC's age, are inappropriate to capture the impact of VCs' knowledge on either their investment approach or the performance of their investments.

However, our study also suggests that the VCs' knowledge, as approximated by our measures, is only one of many factors with an impact on the examined aspects. Context-related factors, for instance, often seem to play an equal or even more important role.

Interestingly, we find - at the aggregate level - that the average experience of the VCs active during the Bubble period from 1995 to 2000 declined by no less than one third compared to the pre-Bubble period.

Implications

Our findings have both academic and practical implications.

From an academic perspective, our study suggests that it is important to differentiate more carefully between VCs, and their knowledge, than has been done previously. Furthermore, our study calls for more research in this area, both theoretical and empirical.

From a practical perspective, our study suggests that, for VCs, specialist knowledge and expertise is a likely ingredient for successful investment.

Furthermore, for entrepreneurs, it might be interesting to know that VCs' knowledge can indeed make a difference and that it really could be 'more important from whom you get the money than how much money you get'.

Finally, our study also suggests that even knowledgeable VCs, are, at times, not safe from myopic behaviour.

or public authorities wishing to develop certain high-tech sectors this may raise the question of whether there are more reliable sources of funding for entrepreneurial ventures in these sectors that are less subject to the cyclical behaviour of financial markets.

CHAPTER B: INTRODUCTION

B.I. Promises and problems of entrepreneurial high-tech ventures

Promises

Today, the notion of entrepreneurship everywhere is at the top of the social, political, and academic agenda (GEM, 2001; OECD, 1998), and new technology based firms widely are considered important vehicles for development and growth (Cooper & Folta, 2000). This is because entrepreneurial ventures, and particularly those in high tech sectors, are generally regarded as being more capable of innovation than large, established firms, which are often said to be subject to inertia and 'competence traps' (Leonard-Barton, 1992, 1995; Levitt & March, 1988; March, 1991).

Whilst it has long been recognised that entrepreneurial ventures may be key drivers of economic development and growth in a process of creative destruction with new industries replacing older ones (Schumpeter, 1934), their true potential has become particularly evident in recent times. For instance, with a view to recent developments in the United States (U.S.), widely seen as the country with the most advanced entrepreneurial culture, Timmons (1999) mentions that between 1980 and 1999 the U.S. economy created over 34 million new jobs, whilst less-entrepreneurial Europe has basically experienced stagnant job creation during this period. Of these new jobs in the U.S. a staggering 94% were created by just 15% of the young and fastest growing ventures, whilst at the same time, the Fortune 500 companies lost over 5 million jobs![1]

Amongst the entrepreneurial ventures that were responsible for this development are many of today's household names such as Apple, Compaq, Dell, Genenetch, Intel, Microsoft, Netscape, and Yahoo. Needless to say that these ventures not only created an enormous number of new jobs, but also whole new industries, and immense wealth for their founders and owners.

[1] With view to those figures, it should be mentioned that large and small firms are highly interdependent and that these figures probably overstate the contribution of small firms in certain respects. Furthermore, job creation is of course a bi-product rather than an objective of the firm.

In sum, there is little doubt that entrepreneurial ventures overall offer considerable upside potential as regards the creation, enhancement, realization, and renewal of value for all their stakeholders (Timmons, 1999).

However, there is equally little doubt that those ventures also face significant challenges to realise their potential; but, although the study of factors that contribute to venture development has been in the focus of scholars from various areas such as strategy, economics, finance, and entrepreneurship, remarkably little is in fact known about what influences a start-up's success, or failure (Baum et al., 2001; Reynolds et al., 2000, 2001).

Problems

One undisputed problem of most entrepreneurial ventures is that they lack many resources vital for their development into sustainable companies (Aldrich & Martinez, 2001; Baum, 1996; Fichman & Levinthal, 1991). New ventures have few if any resources other than the innovative knowledge of their founders (Chrisman & McMullan, 2000, Manigart et al., 2002a). Certain resources are essential to business development, and innovations may fail to create value when they cannot attract the resources required (Gompers & Lerner, 2001b). Therefore, skills in obtaining 'other people's resources', particularly in the early growth stages of a venture, often are key for entrepreneurial success (Timmons, 1999).

Missing and/or complementary resources fall into two broad categories: non-financial and financial.

To begin with the *non-financial resources*, researchers have long noted that startups have higher failure rates than mature firms because they suffer from a 'liability of newness and/or smallness' (e.g. Baum, 1996; Freeman et al., 1983; Hannan & Freeman, 1984; Stinchcombe, 1965). For instance, they often have no established internal structures, and lack important management, finance, and industry know-how. In addition, they usually have no established external relationships, and they lack general influence, endorsement, and legitimacy. All of these non-financial resources are likely to be vital for the success and survival of small firms (e.g. Box et al., 1993; Bruno & Tyebjee, 1984, 1985; Chandler & Hanks, 1994; Chrisman & McMullan, 2000; Cooper et al., 1994; Dyke et al., 1992; Gartner et al., 1998; Mullins, 1996; Pennings et al., 1998; Reuber & Fischer, 1999; Siegel et al., 1993; Westhead, 1995).

The lack of *financial resources*, however, arguably presents an even more obvious deficiency of many entrepreneurial ventures (e.g. Bruno & Tyebjee, 1985, 1986; Cooper et al., 1991, Cressy, 1996, Cressy & Olofsson, 1997). Simply speaking, this is because financial resources are required for obtaining or developing many non-financial resources. Davila et al. (2003), for instance, point out that startups that are better funded are more able to hire, retain, and pay talented employees, who are critical to startups' growth.

Sahlman (1990) describes the 'typical' development of the financial needs of a venture during its development as follows:

- *Seed stage*: a small amount of capital is needed to determine whether an idea deserves further consideration and investment; this might involve, for instance, building a prototype
- *Startup stage*: a more substantial amount of funding is needed for product development, prototype testing, bringing together a management team, and refining the business plan
- *First stage* (early development): if the prototype and/or market needs looks promising more funding is needed to begin small-scale production – whilst the company is still unprofitable
- *Second stage* (expansion): the company begins shipping first products; however, being still unprofitable, it needs more capital for equipment, inventory, and/or receivable financing
- *Third stage* (profitable but cash poor): the company's sales grow and profit margins turn positive, but rapid expansion requires more working capital than can be generated internally
- *Fourth stage* (rapid growth toward liquidity point): although profitable the company may still need outside cash to sustain growth
- *Bridge stage* (mezzanine investment): the company may have some idea which form of exit is most likely, and when; but it still needs more capital to sustain rapid growth
- *Liquidity stage* (cash-out or exit): depending on stock markets, interest rates, and availability of commercial credit, liquidity may come in the form of an IPO or an acquisition.

Whilst the above might represent a 'typical' pattern, both the required amount and timing of the financial resources vary widely between ventures. For instance, the funding requirements of high-tech, fast-growth ventures are certainly to be considered more extreme than those of low-tech ventures, and so are their difficulties in actually raising the required funds (Lindstroem & Olofsson, 2001;

Mason & Harrison, 2000; Murray 1999). Many high-tech ventures require substantial funds but do not generate revenues, let alone profits, for a long time; and in some cases, such in the biotechnology sector, ventures often remain unprofitable even past IPO. This is despite their need to grow quickly to snap up a large market share.

With a view to ventures in emerging or rapidly changing industries, Florin (2005) therefore points out that they generally require large injections of capital early on. Most either quickly and successfully go public as a result of their so-called first-mover advantage, or are acquired by competitors who went public first. The success of these ventures therefore is a function of their strategy, and their top-management's ability to secure funding and to manage growth.

It is evident, then, that many entrepreneurial high-tech ventures are vitally dependent on the external provision of missing/complementary resources to develop into sustainable businesses. As a consequence, there is a growing recognition that new firms are shaped by the relationships their founders are able to nurture and maintain with a range of external agencies (Brush et al., 2001; Florin, 2005; Gulati & Higgins, 2003; Hsu, 2003; Larson, 1992; Powell, 1990; Stuart et al., 1999).

However, most entrepreneurial ventures face a vicious circle: they depend on the external provision of vital resources, but obtaining those resources from third parties is difficult. This is particularly obvious with respect to the financial resources; and many technology entrepreneurs report significant financial constraints on their businesses (Evans & Jovanovic, 1989; Steier & Greenwood, 1995; Westhead & Storey, 1996).

At least in theory, entrepreneurial ventures have a broad choice of different financing sources such as the entrepreneurs' own savings, family and friends, angle investors, public subsidies, corporations, and/or banks (Hellmann & Puri, 2000). In practice, however, the availability of funding for fast growth entrepreneurial ventures is very restricted.

For instance, own savings, family and friends, angel investments and public subsidies are usually very limited in size. This makes them, at best, useful in the very early stages of entrepreneurial high-tech projects.

Corporations, in contrast, are less financially restricted. However, not very many corporations are willing to invest in early stage ventures. Furthermore, incentive problems and bureaucracy are frequently believed to limit the usefulness of corporate investors (Block & McMillan, 1993; Gompers & Lerner, 2000). In addition, entrepreneurs may be quite reluctant to receive funding from corporations if there is a potential conflict of interest (Hellmann & Puri, 2000).

Bank loans, finally, are less limited in size, and they should not involve much conflict of interest. However, obtaining funds from this source is also difficult for several reasons. The most obvious constraint is in the availability of collateral for bank loans (Gompers & Lerner 2001a; Maier & Walker, 1987). Another reason is the inability of the typical bank manager to understand the potential of high tech businesses. They are therefore perceived as presenting very risky opportunities, and for the average bank manager's skills in managing them, this is probably correct. For instance, there is uncertainty about the talent of the entrepreneur, the market need for the product, the development of a saleable product, the raising of second-round financing for working capital and expansion, the manufacturing of the product, competitors' responses, and government policies (Bygrave, 1988; Wang & Zhou, 2004). In addition, likely information asymmetries may prevent banks from investing in such ventures. For instance, an entrepreneur of a privately held venture probably knows more about his company's progress and prospects and his own capabilities and intentions than the investors (Admati & Pfleiderer, 1994). Such information asymmetries present a considerable obstacle to investors, and particularly those that do not specialise in certain investment sectors, as is the case with most banks.

Summarizing the above, Wang and Zhou (2004: 131) describe the situation many high-tech entrepreneurial ventures face as follows:

> 'One prominent characteristic of many new startup ventures in high-tech industries is the high risk due to the great uncertainty about returns, the lack of substantial tangible assets and the lack of a track record in operations. Many high-tech startups may face many years of negative earnings before they start to see profits [...]. Given this situation, banks and other intermediaries are reluctant to or even prohibited from lending money to such firms. Furthermore, these financial institutions usually lack the expertise in investing in young and high-risk companies. Consequently, these startups often seek venture capitalists to be involved in their activities by offering revenue sharing in the form of equity joint ventures in order to obtain the necessary funding and to benefit from the venture capitalists' experience in management and finance'.

B.II. Importance of venture capitalists (VCs) for entrepreneurial high-tech ventures

The above suggests that, for the development of many entrepreneurial high-tech ventures, venture capital could play an important role.

However, before we look in more detail at the venture capital's alleged contributions, we first provide an overview over the VC sector as such.[2]

B.II.1. Overview over the venture capital industry

Whilst venture capitalists (VCs) are a generally seen as a somewhat distinct type of investor, 'unlike most other parts of the financial sector, the venture capital industry lacks a precise legal or regulatory definition' (Brander et al., 2002: 428). Mason and Harrison (1999: 14), for instance, provide a comprehensive definition of the scope of 'venture capital':

> 'Venture capital is a distinctive form of industrial finance that is part of a more broadly based private equity finance market (Brophy, 1997). It can be defined generically as the provision of finance by an investor to businesses that are *not quoted* on a stock market and which have the potential to grow rapidly and become significant businesses in international markets. Venture capital is *equity-oriented*. Although venture capitalists may use a number of different financing instruments the majority of their investments are either pure equity or in a form that can be converted into equity under agreed contractual conditions. The objective is to achieve a *high return* on the investment in form of *capital gain* through an *exit*, achieved by the sale of the equity stake rather than through dividend income. Exit is normally achieved through an initial public offering (IPO), involving the flotation of the company on a stock market where its shares can be traded freely, or through a trade sale in which the venture capital fund, normally along with all of the other shareholders in the company, sell out to another company. Venture capital is therefore a *high-risk* investment. The investor shares in the success of the business but as equity finance is subordinated to other forms of finance (e.g. debt finance provided by the banks), shareholders are at the back of the queue in the event of the failure of the business. Furthermore, once an investment is made it will be illiquid for several years and cannot be realized unless and until an exit is achieved. Finally, venture capitalists are normally *minority shareholders*; hence although they will have seats on the board of directors, they are unlikely to have outright voting control. In order

[2] At this stage we only provide an overview over the VC industry. A more detailed description of many important features of this industry will be given in our subsequent literature review.

> to compensate for these risks venture capital investors are highly selective in the types of businesses in which they will invest. In terms of financial return, they are seeking companies that can provide an internal rate of return of at least 30% in the case of established companies, rising to 60% or more for seed and start-up investments. Thus, only firms able to demonstrate the probability of achieving exceptions returns are candidates for venture capital.'

In a similar vein, Gompers and Lerner (2001a: 254) define venture capital more briefly as 'independently managed, dedicated pools of capital that focus on equity or equity-linked investments in privately held, high-growth companies'.

In addition, it is often emphasized that VCs are different from other, more traditional types of investors in that they are actively involved in the development of their investee ventures (Kunze, 1990), and develop close relationships with them (Fried & Hisrich, 1995). This potential value-adding role of VCs has attracted much academic interest in addition to their role as financiers.

Venture capital has its origin in the US, where - already in 1946 – with 'American Research and Development' (ARD) arguably the first modern venture capital organisation was founded by MIT president Karl Compton, Harvard Business School professor Georges Doriot, and several local business leaders to make high-risk investments in emerging companies that based their innovation on technology developed for the war. The ARD as well as the few other venture organizations that were founded over the next decade all were structured as publicly traded closed-end funds.

However, in 1958 - with Draper, Gaither & Anderson - a new organizational form emerged, the *limited partnership*, which today is the dominant structure of most of VC firms. Here, the VCs act as *general partners*, who manage one or several funds (each representing a legally separate limited partnership), and outside investors in those funds act as *limited partners*.[3]

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[3] As Sahlman (1990) describes, the limited partnership organizational form has important tax and legal considerations. Limited-partnership income is not subject to corporate taxation; instead income is taxable to the individual partners. Also, partnerships can distribute securities without triggering immediate recognition of taxable income: the gain or loss on the underlying asset is recognized only when the asset is sold. However, To qualify for this form of tax treatment, partnerships must meet several conditions: 1) the fund's life must have an agreed-upon date of termination, 2) the transfer of limited partnership units is restricted (unlike most registered securities, they cannot be easily bought and sold), 3) withdrawal from the partnership before the termination date is prohibited, and 4) limited partners cannot participate in the active management of a fund if their liability is to be limited to the amount of their commitment.

Typically, the general partners provide only a small proportion (about 1%) of the capital raised by a given fund (often in form of a promissory note rather than cash), but they typically receive compensation from two sources: they are entitled to a management fee (ca. 2.5 % of the committed capital), and they receive some percentage of the profits over the life of each fund ('carried interest'; ca. 15% to 30%). Most VC firms have several general partners and a staff of associates – who function as apprentices to the general partners and often become general partners themselves in later funds - and administrative support personnel.[4]

A typical lifespan of a VC fund is about ten years, with many partnership agreements providing for an extension of up to three years.

Once a venture-capital fund is raised, the VC must identify investment opportunities. Here, Sahlman (1990) notes, VC firms tend to specialize by industry or stage of investment; and many firms also limit their geographic scope. As soon as investee candidates are identified, deals must be structured and executed with entrepreneurial teams. In each new fund, the capital is invested in new ventures during the first three to five years of the fund. Thereafter few if any investments are made in companies not already in the portfolio, and the goal is to begin converting existing investments to cash.

As investments yield cash or marketable securities, distributions are made to the partners rather than reinvested in new ventures (Sahlman, 1990); but successful partnerships often raise new funds either from existing or new limited partners (Hochberg et al., 2004).

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[4] The VCs' size – in terms of capital under management, number of portfolio ventures, and staff – varies. However, two studies provide some idea about the size ranges. Sahlman (1990), for instance, finds that the average (U.S.) VC firm in 1988 had $65 million in committed capital. The largest 89 firms (about one third of all VCs at the time) had average committed capital of almost $200 million and controlled almost 60% of the industry's assets. A fund with $200 million in committed capital is typically managed by a professional staff of between 6 to 12 who invest approximately $15 to $35 million each year in new companies and companies already in the portfolio. The average capital managed per professional (partner or associate) was $12.6 million; but the capital managed by each professional is a function of the total capital under management. For VC firms with total committed capital of more than $200 million, each professional was responsible for managing $34 million (Sahlman, 1990). More recently, Manigart et al. (2004) found, in a survey of 317 European venture capital firms, that a VC firm employs on average 7.7 investment executives and has on average 36.4 portfolio companies. Each investment executive thus manages about 5.7 portfolio companies. The minimum investment preference is on average €2.91 million (median = €0.5 million) while the maximum investment preference is on average €18.81 million (median = €5 million). The average age of a VC in the sample is 10.4 years (median = 7 years).

Although 'venture capital' now has become well-known term, it is important to note that it still is a very specialized form of financing, limited in its overall scope and focus; and, generally speaking, it is only available for a small number of highly innovative firms. This is because it is the VCs' mission is to capitalize on revolutionary changes in an industry (Gompers & Lerner, 2001).[5] Furthermore, VCs are attracted to high-growth ventures with the potential to go public (Florin, 2005). Consequently, venture capital typically is funnelled into sectors such as computer software, communications, Internet, and biotechnology.

However, even with view to those industries the proportion of venture capital funding varies over time, reflecting major technology trends and innovations. This is depicted in Figure B-1 for the period from 1980 to 2000.

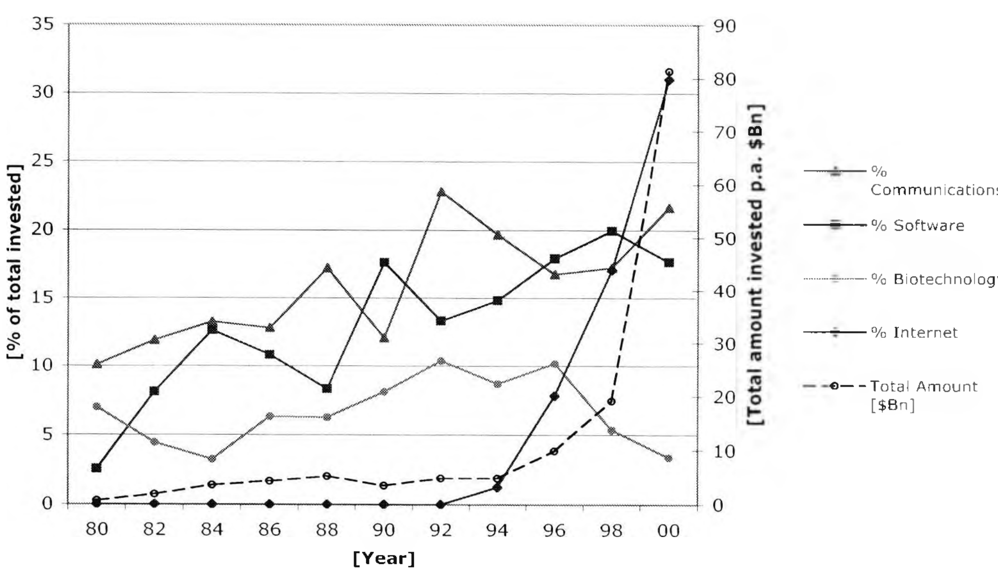

Figure B-1: Venture capital invested overall [$Bn] and in selected sectors [%]
(based on data collected by Gompers & Lerner, 2001a)

Arguably the most striking aspect of Figure B-1 is the fact that the total amount of venture capital invested really took off only after the mid 1990s. For instance, whilst the total amount invested in 1994 was less than $5bn, there was an increase to more than $80bn in 2000 (although not shown here, after its peak in 2000, the total amount invested dropped significantly to a level that today is similar to that in 1998).

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[5] Gompers and Lerner (2001), for instance, point out that investments made by the entire venture capital sector for most of the period from 1970-2000 totalled less than the R&D and capital-expenditure budgets of large, individual companies such as IBM, General Motors, or Merck; and, in 2000, a record year, only about 2,200 firms received venture capital for the first time.

Figure B-1 also shows that the proportion of the total amount that is invested in particular sectors varies significantly over time, responding to new technological developments in the economy and potentially assisting those developments. For instance the proportion invested in Internet-related ventures rose from about 1.3% to more than 31% between 1994 and 2000, reflecting the commercialisation of the Internet after 1995, but during the same period the proportion invested in biotechnology ventures fell from about 8.7% to 3.4%.

B.II.2. VCs' role as 'expert' investors

From the above it is evident that VCs could play a dual role for the development of entrepreneurial (high-tech) ventures: as investors providing vital monetary resources and as experts identifying and managing the most promising ventures.

Whilst there is relatively little dispute regarding the VCs' role as 'investors', there is more ambiguity regarding the VCs' role as 'experts'.

B.II.2.a) VCs' undisputed role as 'investors'

To begin with the VCs' role as investors, as outlined before, most entrepreneurial ventures, particularly in high-tech sectors, lack the financial resources to develop into sustainable businesses. They often have considerable capital requirements but they present too risky and incomprehensible propositions for traditional investors such as banks, but at the same time they are not ready to approach the formal equity capital markets.

Therefore, as Florin (2005) argues, high-potential ventures need to pass through two critical stages of financing before significant growth can occur. The first stage involves the acquisition of venture capital and/or private equity for the startup and development phases of the business. This phase may include several rounds of financing of seed capital to mezzanine financing and often involves attracting venture capitalist firms to help secure resources to support product and technology development. The second critical stage is the IPO of the firm's shares. The IPO is a vehicle that provides access to large amounts of capital that will fuel subsequent growth.

As a consequence, VCs are widely recognized as important intermediaries that bridge a 'funding gap', which otherwise might prevent the realisation of the ventures' potential in terms of innovating activities, economic growth and wealth (Manigart et al., 2002; Rosenstein et al., 1990, 1993; Sweeting, 1991).

Gompers and Lerner (2001a: 62), among others, point out that VCs 'can act as a buffer between the volatile suppliers of capital and the hungry entrepreneurial firms that need it – smoothing out the capital formation process so that innovators can implement their ideas'; and 'firms that receive venture capital financing can grow more quickly and uniformly because the assurance of future financing if they reach their milestones releases them from having to track down new money'.

In a similar vein, Sorenson and Stuart (2001: 1549), summarize the increasing overall importance of VCs' role as investors:

> 'As the [VC] industry amasses ever-larger pools of capital to dispense, venture capitalists expand their influence in determining who receives funding to pursue their entrepreneurial visions. To the extent that these spells of entrepreneurship affect socio-economic trajectories, venture capitalists become agents for social stratification. Similarly, VC firm have been critical catalysts in the development of many high-technology industries. Because young companies in these areas make large investments in technology development significantly in advance of their ability to generate cash flows to finance these investments, they must rely on capital infusions from venture capitalists and other investors. As these industries become important engines for economic growth and wealth creation, access to venture capital funding might significantly affect the macroeconomic health of regions and nations'.

This view is supported additionally by a major study on the 29 leading industrial nations, which found a strong correlation between entrepreneurial activity and the type of financing sources of new technology-based firms (GEM, 2001).

In sum, there is little doubt that VCs often play a key role for the financing at least of a small group of high-tech/-risk entrepreneurial ventures; and many of today's ventures might not have come into existence were it not for the availability of venture capital.

B.II.2.b) VCs' disputed role as 'experts'

Whilst there is little doubt regarding the importance of the VCs' role as vital investors for many (high-tech) entrepreneurial ventures, there is considerable dispute regarding the VCs' role as experts in 'picking' and/or 'building winners' (Baum & Silverman, 2004). In fact, there is plenty anecdotal evidence both in favour of and against this assertion.[6]

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[6] At this stage we mainly refer to the anecdotal evidence in favour or against VCs' roles as 'experts', but we note that this anecdotal evidence is also mirrored in the academic research, which we will review in our next chapter.

To begin with the evidence that seems to support the notion of VCs' 'expertise', despite its modest scope, the VC industry has undoubtedly helped to create many successful enterprises (Sahlman, 1990). Indeed, all of the above-mentioned ventures that, by now, have become household names (Apple, Compaq, Dell, Genenetch, Intel, Microsoft, Netscape, and Yahoo), received venture capital early in their development.[7] Gompers and Lerner (2001a) point out that VCs have spurred the creation of more than 2,000 publicly traded firms that have an aggregate market capitalisation of over $2.7 trillion. They are also responsible for nearly one third of the total market value of all public companies in the United States. Those 'success stories' are often taken as a proof of VCs' expertise, at least in identifying promising ventures, i.e. in 'picking winners'. But, in addition, many commentators claim that VCs have developed particular expertise and sophisticated investment approaches that enable them not only to identify worthy investment opportunities but also to support their subsequent development, i.e. to 'build winners'.

This assertion finds support from a number of industry experts. Timmons and Bygrave (1986: 161), for instance, point out that many entrepreneurs 'actively seek out those VCs with noteworthy reputations for their non-financial, high value-added contributions to fledgling firms'; and the same authors also refer to the common industry adage that 'it is far more important whose money you get [as an entrepreneur] than how much you get or how much you pay for it' (Bygrave & Timmons, 1992: 208). Bhide (1994) further notes that the remarkable ascension of the entrepreneurial firm in the US is at least partially the result of public policies that prevented the development of close relationships between outside investors in large public firms and the firms' management. At the same time it made it more likely for private entrepreneurial ventures to establish personal relationships with investors such as VCs, who try to actively increase a company's value through oversight and counselling. In the same vein, Amit et al. (1998) argue that VCs have developed 'special abilities', and they should emerge 'in environments where their relative efficiency in selecting and monitoring investments and providing value-enhancing services gives them a comparative advantage over other investors'. In other words, 'VCs are financial intermediaries with a comparative advantage in working in environments where

[7] The payoff to venture capitalists indeed has been handsome in some cases. During 1978 and 1979, for instance, slightly more than $3.5 million in venture capital was invested in Apple Computer. When Apple went public in December 1980, the approximated value of the VCs' investments was $271 million, and the total market capitalization of Apple's equity exceeded $1.4 billion (Sahlman, 1990).

informational asymmetries are important; this is their niche'. Similarly, also Gompers and Lerner (2001: 43; highlighting by us) argue:

> 'VCs have developed a specific set of techniques to manage risk and to encourage the success of their investees, [...] these techniques provide a powerful mechanism for the efficient, *smart* financing of young, high-growth companies. Thus, venture capitalists not only bring financial backing to the table; they provide an essential competitive advantage for promising new enterprises [...]. Those very terms and controls, along with a venture capitalist's *expertise* and financial strength, translate into a well-financed and well-managed company - a company that stands a much better chance of succeeding in the marketplace'.

In the same vein, Cuny and Talmor (2003) point out that in contrast to other forms of financing, venture capital is often called '*smart money*, denoting the fact that it might play a dual role: in addition to providing funding, venture capitalists serve their portfolio firms by providing coaching and guidance, as well as networking for strategic alliances and for further funding. All this is assumed to ultimately contribute to venture performance (Busenitz et al., 2004).

On the other hand, there is also evidence that casts doubt about VCs' expertise in general, and the value added of VCs' expertise in particular.

For instance, as Timmons and Bygrave (1986) report, 'VC' is also sometimes used as an abbreviation for 'vulture capitalists'. In the same vein, but slightly less extreme in tone, one venture CEO asks: 'VCs have been involved in many more failures than successes - maybe they contribute to the failure of many companies?' (cited in: Gomez-Mejia et al., 1990). This seems to be not just an exceptional viewpoint of an individual entrepreneur. Gompers and Lerner (1995) find that - whilst VCs claim that the information they generate and the services they provide for portfolio companies are as important as the capital infused - many entrepreneurs believe that venture capitalists provide little more than money. Indeed, as we will analyse in more detail below, the extant literature provides a rather ambiguous picture of the relation between VC-backing and venture performance, which has at turns been found, to be positive, neutral or negative in sign. Furthermore, it is also well known that even the majority of VC-backed ventures either provide no return, or fail completely (for more details: see literature review in the next chapter).

However, by itself, the above does not necessarily deny that VCs are experts. For instance, the finding might be a consequence of a hedging strategy in which VCs manage their investments as portfolios, and where the above-average performance of a few ventures makes up for the majority of failed investments (Manigart et al., 2002). Thus, even expert VCs might not be truly interested in the survival of individual portfolio companies (Bygrave & Timmons, 1992). Instead, they might primarily follow 'home-run' strategies, providing active non-financial support only to those ventures in their portfolios with the highest potential, but neglecting and ultimately even abandoning other, and even viable, though underperforming, portfolio ventures (Steier & Greenwood, 1995). This, in turn, might lead the majority of (neglected) entrepreneurs to be frustrated with their VCs to whom they handed over substantial parts of their equity to get some, very expensive, venture capital in return. It might also explain why many are doubtful as regards the value of VCs' 'expertise', but it is not a proof of VCs' ignorance.

But there is also some less biased evidence that indeed casts doubt whether VCs in general are truly experts. In this context, it should be referred to the 'dot.com Bubble' that built up in the second have of the 1990s to burst in 2000. During that period, many investors - including VCs - apparently became victims of an 'irrational exuberance' (Shiller, 1998), which not only caused substantial losses to almost all parties involved but now even seems to threaten the further development of even very promising ventures and sectors.[8]

Therefore, Gompers and Lerner (2001a) point out, the dramatic swings in venture capital activity and the recent dramatic movements of VC-backed ventures in the public markets have added to the notion the VCs are 'rapacious investors'. The authors proceed to account for this by two main factors (Gompers & Lerner, 2001a: 73):

> 'On the one hand, venture capitalists are opportunistic, always trying to find the latest technological breakthrough that might have an important market [...]. A less kind picture however, has to do with herding by venture capitalists. Venture capitalists often look around at other investors to determine what is 'hot'. If a venture capitalist suddenly notices that a market segment is quite active, he might invest in that segment as well. This can lead [...] to over-funding in certain industries while other industries with attractive growth opportunities remain under-served'.

[8] In this context, it is further worth pointing out that the dot-com boom is not the first event of this kind involving VCs. Sahlman and Stevenson (1985) provide an early example of 'capital market myopia' phenomenon that apparently affected many professional venture capital firms between 1977 and 1984. During that period VCs invested almost $400 million in 43 different manufacturers of Winchester disk drives, a market sector believed by many to provide sufficient capacity for about 4 manufacturers only.

Notwithstanding the possibility that this might be a plausible explanation, it clearly raises the question whether (all) VCs are (always) experts.

B.III. Guiding question

One plausible explanation for the contradictory findings in the literature is that VCs differ both in general, and with respect to their knowledge levels and types. This could translate into different investment approaches and, consequently, into different performance of investments by different - and differently knowledgeable - VCs.

However, as several industry experts point out, whilst anecdotal evidence dominates many discussions, overall the venture capital industry isn't very well researched. Steier and Greenwood (1995: 340), for instance, note, '... venture capital involvement thus represents a unique form of new venture creation, albeit one that is imperfectly understood'. Pointing into a similar direction, Amit et al. (1998: 442) argue: '... despite its growing importance, the venture capital industry has received much less academic scrutiny than other parts of the financial sector. This applies both to the theory and to empirical investigation'.[9] Also Gompers and Lerner (2001a: 1) conclude, 'Venture capital has been an important element behind innovation and wealth creation in the U.S. economy for the past thirty years. It has also played an increasing role in developed and developing countries elsewhere around the world. It influences nearly every aspect of business today - yet the manner in which venture capitalists operate has often been shrouded in mystery and cliché'.

Thus, it seems, there is plenty of scope for research in the venture capital area. This scope is moreover is even more marked with respect to the differences between VCs, and their knowledge.

For instance, Roberts (1991) notes that VCs are as different from each other as individuals. However, based on an overview of the recent venture capital literature, Harrison and Mason (1999: 27) conclude that 'studies that have

[9] Amit et al. (1998) assume that part of the reason for the lack of academic research on venture capital might be that 'the venture capital industry is more difficult to study than other financial industries such as banking, insurance, stock markets, etc. Little of the relevant information is in the public domain, since the firms financed by venture capitalists are privately held and therefore do not have the same public reporting requirements as publicly traded firms. Also, regulatory scrutiny of the industry is modest compared to other financial services, therefore relatively little information arises from regulatory activities. Finally, as there are no organized exchanges for venture capital investments, no information derives from that source.'

sought to identify different types of investors are rare' and 'the question whether and in what ways VCs add value continues to be a lively focus for debate with no consensus on the answers'. The same authors therefore, recommend further research to progress from generic approaches to studies that reflect the diversity of VC firms. In the absence of such studies, they point out, there is a risk that conclusions derived from research on particular types of VC firms will be incorrectly attributed to the entire industry (Harrison & Mason, 1999). But, even more recently, Hsu (2003) still finds that although there is substantial anecdotal evidence that indicates 'VCs have different value-added *potential* [...] the extant academic literature has not emphasized VC heterogeneity, implicitly treating VCs as one uniform class' (Hsu, 2003: 3). He therefore, notes that 'future research exploring variation within the VC industry, especially as it translates to organizational performance, would be interesting' (Hsu, 2003: 5)

Similar conclusions hold for research on VCs' *knowledge*.

Barney et al. (1996), for instance, point out that an interesting direction for future research would be to examine the impact of the type/level of knowledge on the supply (i.e. the VC) side. This is because, as the authors suspect, 'the level of contributions may well vary by type of VC firms'; and they further note: 'perhaps the involvement by the VC depends on its experience in related industries or the diversity of its overall investment portfolio? [...] Do factors such as VC industry experience, technical knowledge [...] impact the amount and type of advice given? These are critical issues that future research needs to investigate' (Barney et al., 1996: 268). But recently, Shepherd and Zacharakis (2002: 1) note that although researchers have described in detail how VCs make their investment decisions, 'the underlying *belief* is that they can tap into their expertise, they can understand how to predict which ventures are most likely to be successful' but 'this approach *presumes* that the VCs is the expert'. Similarly, Cuny and Talmor (2003) point out that VCs are generally '*presumed* to be sophisticated'. Also Busenitz et al. (2004) observe that an *assumption* in much of the research on VCs is that their information improves a venture's performance. However, whether those assertions actually enjoy general empirical validity is far from clear. Very recently, Bottazzi et al. (2004), for instance, point out that although venture capital scholars have been advocating the benefits of focus and specialization, these issues have been largely ignored in the literature.

The above discussion leads us to the guiding questions for our subsequent general literature review:

What role does VCs' knowledge play for financing entrepreneurial high-tech ventures; and how does it affect their investment approach and the performance of their investments?

B.IV. Objectives

Our research aims to further the understanding of the factors affecting a VC's investment approach and the performance of his investments. In particular we shall explore the role that VCs' knowledge plays in these areas.

Contribution to academic knowledge

From an *academic perspective*, the main objective of our project is to study an aspect that – despite its likely relevance - has been widely neglected in the existing theoretically oriented and empirical literature on venture capital: the role of VCs' knowledge for both the VCs' investment approach and the performance of VCs' investments. For this purpose, furthermore, we develop – based on the theoretical concept of organizational learning, which has not yet been employed in the venture capital context - a set of proxies for various types of VCs' knowledge, which are more fine-grained and systematic than the proxies found in the literature so far. Thus addressing several methodological deficiencies in the previous empirical studies of venture capital, we aim to resolve some of the ambiguity in the findings of extant empirical research on VCs' investment behaviour and the performance of VCs' investments. The insights gained from our research, finally, are not confined to the literature on finance but should be of relevance also to the literature on entrepreneurship and organizational learning.[10]

Contribution to practitioners

From a *practical perspective*, we expect, a better understanding of the impact of differences between VCs, and particularly between VCs' knowledge, should be of interest to (high-tech) entrepreneurs, investors, and policy makers alike.

[10] Several scholars support the assertion that insights gained in the venture capital context could also be of relevance for other fields. Sahlman (1990: 518), for instance, notes 'the venture capital organizational form may be applicable in other settings, particularly corporate and project governance, but 'much research remains to be done on the venture capital organization. Though the economic resources under management are modest, the model seems to have been effective. Understanding why it works is in the interest of academic and practitioners alike'. This certainly also includes a better understanding about the impact of VCs' knowledge. Kaplan and Stroemberg (2002), furthermore, argue that whilst VCs are interesting in their own right, they also are interesting theoretically in that they approximate investors assumed by theorists.

Entrepreneurs, now find themselves in a situation where, globalisation of the financial markets provides the possibility of cross-border comparisons and choice and may now be in a position to demand more than merely the provision of finance for a stake in their ventures. For this purpose they need to understand how variations in potential investor's expertise impact the outcome of their activities. This in turn should enhance their ability to negotiate terms with the VCs they are in contact with. *Investors* – private or institutional – work in an environment where billions are invested each year in the intangible assets of startups but where even 'experts' admit that investing in such ventures is an 'art rather than a science'. The rapid globalisation of markets for venture capital is also expanding the funding alternatives available to entrepreneurs. For venture capital firms, this trend spells intensified competition and the need for expertise to deal with it. The findings of this thesis should help VCs focus activities, structure their portfolios, choose which competencies to develop, in setting operating policies, in deciding levels of governance effort and in deciding how to add value to their investments. Such knowledge should also prove useful for identifying investment opportunities that value their specific contributions most. For *policy-makers*, finally, if it is true that, as some claim, venture capital can play a role in spurring the growth of new jobs, the employment skill base and entrepreneurial activity - knowledge about VCs' different capabilities in meeting ventures' requirements could help deciding about the most efficient support for the sector, be that support in the form of subsidies, training or a changed regulatory environment.[11]

B.V. Structure of the thesis

The remainder of this thesis is structured as follows:

In *Chapter C* we review the theoretical and empirical literature of relevance for our above-stated guiding question. We conclude this chapter with a discussion of the deficiencies in the existing literature, with a particular focus on the proxies for VCs' knowledge used in this literature.

Based on a review of another strand of literature - organizational learning - that has not yet been used to ground research on venture capital, in *Chapter D* we

[11] In this context, Gompers and Lerner (2001a) point out that public sector effort to promote venture capital have proved to be costly failures; in Germany for instance, more than 600 government programs encouraged venture activity between 1965 and 1995, with few appreciable benefits. This is an aspect we will also deal with in our case studies in Chapter I.

propose a set of more appropriate and fine-grained proxies for VCs' knowledge that will serve as theoretical variables in our large sample analyses of three research hypotheses also introduced in this chapter.

Chapter E comprises two main parts. The first part describes our general research methodology, with a particular focus on our sampling procedures and further aspects of the data. The second part of this chapter then provides an exploratory overview over the data used in the large sample analyses. This part also serves as background information for our case studies.

Based on our large sample data, *Chapters F-H* deal with three specific research questions/hypotheses on the relation between VCs' knowledge and 1) syndication, 2) staging, and 3) performance of VC investments. Each of these chapters will be 'self-contained', containing an introduction, a review of literature with particular relevance to the question at hand, a research hypothesis, an explanation of the analytical approach, a portrayal of descriptive statistics and main results, and a discussion of those results. However, to avoid excessive repetition, each chapter will also refer to the general literature review, the proposition, and methodology that had been in the focus of previous chapters.

Chapter I presents two case studies providing richer detail on the relationship between VCs and entrepreneurs and their ventures that a large sample statistical analysis cannot offer. This material complements the large sample analyses of the previous three chapters.

Chapter J offers a concluding summary and synthesis of our findings from both the large sample analyses and the case studies. This chapter is followed by the *Bibliography*.

Appendix I provides background information on the biotechnology industry that is relevant for all chapters, but particularly so for the case studies in Chapter I.

Appendix II, finally, contains tables from the previous chapters C-H.

CHAPTER C: GENERAL LITERATURE REVIEW

Overall, research on venture capital tends to be empiricist and somewhat atheoretical (Sapienza et al., 1996). Many studies look at what VCs do, and how they are different from more traditional investors.

However - although there is no bespoke theory on venture capital (Morris et al., 2000) - some studies, explicitly or implicitly, also refer to relevant theoretical concepts that have been developed outside the venture capital context. Those concepts provide some insights into answering our guiding question.[12] At the same time though, there are few empirical studies that simultaneously touch upon this question and use these theoretical concepts.

Therefore, we divide our literature review in three main sections. The first two sections deal with the relevant theoretical and empirical studies, respectively. The third section then summarizes and discusses the relevance of the previous two sections to answering our guiding question.

At this stage though, it should also be mentioned that we shall review additional, theoretical and empirical literature in the subsequent Chapters F-H that deal with our individual hypotheses.

C.I. Theoretical literature

Three main theoretical concepts referred to in the literature on venture capital seem of relevance to answering our guiding question.[13] These are:

1) the financial-intermediation/signalling theories,

2) the principal-agent theories, and

3) the resource-based theories.

In the following, we review these theories, first in general, and then with reference to venture capital.

[12] To recall, our guiding question for the general literature review is: What role does VCs' knowledge play for financing entrepreneurial high-tech ventures; and how does it impact VCs' investment approach and the performance of VCs' investments?

[13] In addition to these three theories, a few studies also refer to other concepts, such as 'Procedural Justice Theory' (e.g. Busenitz et al., 1997, 2004; Sapienza & Korsgaard, 1996; Sapienza et al., 2000). However, we will not review those concepts in detail since they have not been widely used/mentioned and/or don't seem to provide much additional insights with view to our guiding question.

C.I.1. Intermediation/signalling theories

Starting with Spence (1974), there has been a sizeable theoretical literature on the phenomenon of actors signaling their quality to the external market. This literature has identified *reputation* as an economically important asset that can generate future rents when information among actors is asymmetric. A related strand of research emphasizes the importance of *certification* through a firm's affiliates (e.g. Diamond, 1991). Here, the ability of third party specialists to certify the value of securities issued by relatively unknown firms in capital markets that are characterized by asymmetric information between corporate insiders and public investors has attracted much academic interest. Booth and Smith (1986), for instance, developed a formal certification hypothesis, which has been developed further and tested by several other authors.[14]

Building upon this literature, also VCs have been considered as financial intermediaries (e.g. Lockett & Wright, 1999; Bottazzi et al., 2004). The rationale behind this is clear when referring back to what has already been outlined in the introduction: entrepreneurial ventures suffer from a 'liability of newness/smallness', making it difficult for third parties – such as investors but also other 'business partners' – to obtain and evaluate relevant information about their quality. As a consequence, those third parties are reluctant to get involved with them; and the ventures face a vicious circle: they need resources to grow and gain legitimacy, but they need legitimacy to get access to these resources.

In this context, Chan (1983), for instance, develops a theoretical model that shows the general value of VCs as intermediaries - in a market with imperfect and costly information – for resource allocation and welfare of investors. According to this model, when all investors are uninformed, entrepreneurs are induced to undertake inferior projects, offering low returns, and investors consequently will not enter the market. However, the presence of some zero-

[14] The phenomenon of reputation-based signalling/certification effects has been examined, for instance, with view to the underpricing of IPOs. Because underpricing, which is related to uncertainty, is costly to the issuing firm's pre-IPO shareholders, firms signal their risk by hiring reputable investment bankers, auditors, and/or under-writers who might help resolve the uncertainty and asymmetric information associated with the issuing firm (e.g. Beatty & Ritter, 1986; Carter & Manaster, 1990; Rock, 1986; Titman & Trueman, 1986).

cost, perfectly informed investors, as VCs are assumed to be, induces entrepreneurs to select projects with higher investor returns.[15]

Other authors further point out the particular value of VCs for ventures going public. Megginson and Weiss (1991), for instance, argue that VCs could play an important role as intermediaries who certify the quality of entrepreneurial ventures at IPO to outside investors in the markets. This, the authors argue, could be for three main reasons: firstly, many VCs bring companies to market on an ongoing basis, and therefore should have a very strong incentive to establish a trustworthy reputation in order to retain access to the IPO market on favourable terms; secondly, the value of VCs' reputational capital is likely to exceed the maximum possible benefit from certifying falsely – because successful VC fund managers who are able to establish profitable 'follow on' funds, are also able to achieve an enhanced deal flow from entrepreneurs, and are more likely to retain/attract high-quality staff; and, thirdly, VCs' services (financial and/or non-financial) are expensive for the issuing firm, for instance, in terms of the equity or control they have to hand over. Based on this, Megginson and Weiss (1991) further note that the importance of VC certification will vary for different ventures. Greater information asymmetry and uncertainty are more likely to be associated with new entrepreneurial ventures than with older, more established ventures. Therefore, the certification function of VCs should be most attractive to relatively young, rapidly growing, R&D intensive ventures.

At the same time, some also note that different VCs should have a different signalling effect for ventures. Barry et al. (1990), for instance, propose that the association with *skilled* VCs may be particularly beneficial to the issuing firm. This is because differences in the perceived abilities of VCs should have an impact on the signal they send out to the capital markets. Therefore, all else being equal, investors may be willing to pay more for companies brought to market by VCs perceived to be better able to oversee and guide new enterprises, resulting in a less underpriced issue. Similarly, Sahlman (1990) points out that successful VCs bring instant credibility associated with their capital; their contacts in the financial community can make it easier to raise capital from other sources including IPO.

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[15] Here, Chan (1983) argues that VCs can be considered zero-cost agents, since the clients pay their costs. Furthermore, as information about firms is reusable for different clients, there are economies of scale in the intermediary's operations, even if the intermediaries' information cost is assumed to be the same for investors and intermediaries.

Moreover, VCs' role as intermediaries might not only be relevant with view to the financial markets. Instead, it could also facilitate ventures' access to non-financial resources. Manigart and Sapienza (1999), for instance, note that the VCs' certification/signalling role also should be relevant with respect to other external resource-holder and other resources such as personnel, suppliers and customers. Also Stuart et al. (1999) argue that differences in the – technological and/or commercial – 'prominence' (network positions) of VCs should translate into different performance of VC-backed ventures because, faced with great uncertainty about the quality of young companies, third parties rely on the prominence of the affiliates of those companies to make judgements about their quality. Similarly, Hsu (2004) argues that VC information intermediation may help startups get matched with cooperative partners. Because VCs are active in a range of activities and functions that span industrial segments, they can act as information intermediaries, providing privileged information access and reducing search costs for startups seeking appropriate cooperation partners.

In sum, the literature that takes an intermediation/signalling theory on the VCs focuses on the VCs' role in alleviating the problems resulting from information asymmetries between the ventures and third party providers of financial and/or non-financial resources. As such, this theory provides explanations not only for why VCs exist at all as an independent type of investor but also for how VC backing might be related to venture performance.

However, in this context a major *assumption* is that VCs are able to overcome information asymmetries and related problems – and, by this, ensure the quality of the ventures they back. But the intermediary/signalling literature hardly looks in detail at how VCs actually deal with those issues. Furthermore, its focus is on the relation between VCs and outside investors rather than on the relation between VCs and ventures. The latter aspect though is in the focus of another stream of literature, the principal-agent theory, which we will come to next.

C.I.2. Principal-agent theories

The principal-agent (short: agency) theory was developed primarily in the context of publicly traded firms with diffuse ownership structures and managers with very limited equity stake (Jensen & Meckling, 1976). Agency theory deals with relationships between agents of the firm (managers) hired to perform tasks by the owners of the firm (principals). Agency theory is particularly interested in the antecedents and consequences of potential conflicts between the two parties, and in the means to avoid or mitigate those conflicts (see, for instance, Amit et al., 1998; Bamberg & Spremann, 1987; Jensen & Meckling, 1976; Ross, 1973; Weißenberger, 1997).

Most agency models are based on a set of common assumptions (Eisenhardt, 1989): principal and agent 1) face situations of uncertainty with respect to the task to be undertaken by the agent, 2) have different risk preferences over the returns they will receive from the contract, 3) pursue different goals, or 4) maximise different utility functions, 5) are boundedly rational, and 6) have different information sets in that the principal cannot (fully) observe the (outcome of the) agent's action and possibly also his 'type' (e.g. quality).

Agency models show that that information asymmetry gives rise to two main problems: adverse selection and moral hazard.

Adverse selection might be due to 'hidden information'. The principal might be able to observe the activities of the agent, but the agent might have private information (e.g. about his own capabilities or certain details of his project) that is not available to the principal. This, in turn, might lead to a misinterpretation by the principal regarding the agent's ability, and, as a result, to a suboptimal contract, at least from the principal's perspective.

Moral hazard, by contrast, might be due to 'hidden action'. Specifically, it refers to unobservable behaviour by the agent, such as low effort or shirking, which impacts negatively on the principal's welfare. Since the principal often cannot (fully) observe the agent's activities, it is difficult for him to differentiate a negative outcome of an activity due to factors under the control of the agent (e.g. inadequate effort) or due to factors outside the agent's control. Thus, the agent can 'explain' unsatisfactory outcomes by exogenous factors and act – without sanctions – against the interests of the principal. Clearly, both types of problems are likely to lead to conflicts that have a negative impact on the performance of an organization.

Building upon the principal-agent theory, there is large academic literature on (financial) contracting that looks at the possibilities of avoiding conflicts between principals and agents in the first place, or at mitigating their negative consequences should they occur. The focus of this literature is on contractual arrangements aimed at aligning the principal's and the agent's interests, and to incentivise the agent (e.g. to put in more effort). This might involve, for instance, the appropriate allocation of cash-flow-rights (cash-flow models), voting- and board-rights (control-models), and/or liquidation-rights (debt-models) (Kaplan & Strömberg; 2001, 2003).[16]

Whilst developed in the context of the mature firm, the logic of the agency theory also appealed to researchers examining the VC-entrepreneur relationship - where the VC is usually assigned the role of the principal, and the entrepreneur the role of the agent.[17] In fact, this theory arguably is the most commonly employed concept in research on venture capital.[18]

Indeed, the suitability of the agency theory in the context of venture capital seems obvious. Firstly, there is no doubt that uncertainty is a characteristic of almost all VC investments. Secondly, both VCs and entrepreneurs can be assumed to be rational individuals who might have different risk preferences and different utility functions and try to satisfy different self-interests. (For instance, most VCs will be primarily interested in the maximization of their internal rate of return of their investments; but whilst most entrepreneurs will also be interested in the monetary outcome of their projects, they might have additional intentions such as 'on the job consumption', 'independence', and/or 'developing a track record'). Thirdly, in VC-backed ventures conflicts of interest are likely to emerge over specific issues such as valuation, exit timing, and the allocation of resources and efforts (Sapienza et al., 2000). Fourthly, information asymmetries are likely to exist between the VC and the entrepreneur because of the difficulty and costs of day to day monitoring and the technical nature of the activities conducted by the entrepreneur (Amit et al., 1998). The entrepreneur is likely to know more about his project and its likely success, or failure; and he is also likely to know more about his own ability and motives than the investor (Bygrave, 1988; Gompers & Lerner, 1999).[19]

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[16] For more on the principal-agent theory in financial contracting see also: Hart, 2001.

[17] In addition, there is also said to be another principal-agent relation, where the VCs serve as agents to their investors (e.g. Amit et al., 1990; Bergemann & Hege, 1998; Brettel et al., 2001).

[18] Authors that have either explicitly or implicitly referred to this concept in the venture capital context are, for instance: Admati & Pfleiderer, 1994; Amit et al., 1998; Arthurs & Busenitz, 2003; Barney et al., 1989; Barney et al., 1994; Barry et al., 1990; Bruton et al., 2000, Busenitz et al., 2004; Fiet et al., 1997; Gompers, 1995; Gompers & Lerner, 1999; Gorman & Sahlman, 1989; Hellmann, 1998; Kaplan & Strömberg, 2001, 2002, 2003; Lerner, 1994, 1995; Ruhnka & Young, 1991; Sahlman, 1990; Sapienza et al., 1996, 2000; Sapienza & Gupta, 1994.

[19] The VC literature has discussed some of the reasons for possible manipulations of information by entrepreneurs. For instance, the entrepreneur might be afraid that negative information makes the VC decide against (further) investments in the venture. Similarly, the entrepreneur might be afraid

At the same time, as mentioned before, principal-agent theory strives to identify not only causes of potential conflict between principal (VC) and agent (entrepreneur) but also suitable means to prevent or deal with their negative consequences. Kaplan and Strömberg (2001) point out that theory has identified three primary ways for the VCs to mitigate possible agency risks: pre-investment screening, financial contracting, and post-investment monitoring and advising. We mention these in passing but will return to these and other features of the VCs' investment approach in the next section.

In sum, contrary to financial intermediation/signaling theory that focuses on the information asymmetries between entrepreneurial ventures and third parties, agency theory focuses on agency problems resulting from likely information asymmetries (i.e. the VC's lack of knowledge compared to the entrepreneur) and opportunistic behaviour by the entrepreneur, which have the potential to result in severe problems for the venture and suggests means to alleviate these problems.

However, there is a growing body of literature that suggests that the principal-agent theory neglects important aspects of the VC-entrepreneur relationship. For instance, it is argued that it is a one-dimensional view of the relation between the VC and the entrepreneur. Sahlman (1990) for example, notes that, although VCs seem to retain much of the power in the relationship with entrepreneurial ventures, there are in fact checks and balances in the system: VCs who abuse their power will find it hard to attract the best entrepreneurs, who have the option of approaching other VCs or sources other than venture capital. Forbes and Milliken (1999), furthermore, point out that an agency theory – although identifying problem areas and suggesting possible means to deal with those problems - does not take into account how decision-making processes themselves can affect the perception and resolution of problems.[20]

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that negative information makes the VC replace the management team completely or reduce its rights (Fried & Hisrich, 1995; Macmillan et al., 1988). In both cases there is an incentive for the entrepreneur to keep back negative information and to present himself to the VC in the best possible way (Wright & Robbie, 1998). This in turn, might lead to the problem of adverse selection of 'low-quality' projects, because it is hard for investors to distinguish between good-quality and poor-quality projects (Amit et al., 1990). Similarly, the problem of moral hazard (due to hidden action) might result in the entrepreneurial setting because the investor is not able to observe whether the entrepreneur is working hard and making sensible decisions, or whether he is planning to 'take the money and run' (Amit et al., 1990; Brettel et al., 2001).

[20] As a consequence, an increasing number of scholars recommend alternative/additional theoretical theories and models. For instance, a recent stream of literature suggests that there might be a

On the other hand, the agency theory and the related contracting theories fall short of explaining two, arguably even more important, issues in the venture capital context. Firstly, agency theory focuses mainly on the VCs' role as financiers, and on contractual arrangements to mitigate VCs' downside potential when investing in entrepreneurial ventures. But it has little to say about other key contributions of VCs to their investee ventures: the provision of non-financial, value-added resources. Hellmann and Puri (2002), for instance, argue that – although the traditional financial theory tends to focus on the information-based roles of financial intermediaries, dealing with the alleviation of moral hazard or adverse selection, and emphasizing the monitoring role of VCs, who gather information about the firms they finance - the role of VCs extends beyond that of traditional financial intermediaries like banks; they play a broader role in the professionalization of the companies they finance. Secondly, the agency theory treats VCs as a homogenous group, without acknowledging likely differences between them (Hsu, 2003). As such, it cannot explain the apparent differences in the performance of VC firms. When a group of competing firms choose similar (contractual) approaches to agency problems, these approaches cannot be sources of competitive advantage for any one firm (Barney & Hesterly, 1996).

Both the deficiencies of agency theory are addressed, to some extent, in the final strand of theoretical oriented literature we shall discuss, namely the resource-/knowledge-based theory, which follows in the next section.

C.I.3. Resource-based theories

The *resource-based theory* views the firm as a unique bundle of heterogeneous resources or factors of production (Barney, 1991; Penrose, 1959; Wernerfelt, 1984); and builds on two basic assumptions about a firm's resources: 1) that they can vary significantly across firms, and 2) that such differences can be

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'double-sided moral hazard' problem (e.g. Casamatta, 2000; Inderest & Mueller, 2001; Repullo & Suarez, 1998). Some scholars also argue that a 'prisoner's dilemma' model is a more appropriate conceptual lens for understanding the VC–entrepreneur relationship than agency theory, which emphasizes their potentially competing interests and monitoring costs (e.g. Cable & Shane, 1997). Others furthermore point out that while the agency theory might provide a good fundament for explaining structural and compositional elements of control, it has limited ability to explain how the parties behave in their ongoing and reciprocal relationship - where aspects of cooperation might be at least equally important than aspects of competition. As a consequence, some scholars recommend concepts such as 'Procedural Justice Theory' to ground research on venture capital (e.g. Busenitz et al., 1997, 2004; Sapienza & Korsgaard, 1996; Sapienza et al., 2000).

sustained due to resource immobility. Thus, no two companies are alike; and a firm will have a competitive advantage if it possesses unique bundles of resources that are valuable, scarce, hard to imitate, hard to replace, and that enable the firm to perform its activities better, i.e. more efficiently or effectively, than competitors (e.g. Amit & Shoemaker, 1993; Barney 1986, 1991, 1994; Conner, 1991; Dierickx & Cool, 1989; Peteraf, 1993; Spender, 1993).[21]

In this theory, candidates for the relevant resources can vary widely but it is common to distinguish between two main groups: *tangible resources* (e.g. financial resources, physical assets, infrastructure) and *intangible resources* (e.g. knowledge, reputation, human resources, culture). In this context, it is often argued that in today's world of rapidly converging technologies it is difficult to replicate the *knowledge resources* of firms that are vital for their competitive advantage (Davenport & Prusak, 1998).

Therefore, it is also common to distinguish two main types of knowledge: explicit and tacit (Nonaka & Takeuchi, 1995). *Explicit knowledge* can be observed, communicated, transferred and imitated relatively cheaply and quickly. Similar to 'information' explicit knowledge is often considered a public good that is not relevant to individual wealth creation. *Tacit knowledge*, on the other hand, is observable but is difficult to communicate and transfer, and can be imitated, if at all only in a costly and prolonged process. Similar to 'know-how' tacit knowledge is often considered a private good essential for individual wealth creation.

Consequently, many suggest that the most important resource of a firm is the tacit knowledge embedded in the firm because this is often scarce, costly to replicate, heterogeneously distributed across firms, difficult to transfer and gives rise to complex appropriability issues (Barney, 1991, Spender, 1996).

[21] As Teece et al. (1997) note, the resource-based theory has much in common with the work on organizational ecology and commitment, as it sees firms as heterogeneous because of their different resource endowments and because those resources are 'sticky'. This is distinctive from previous dominant approaches as advocated, for instance, by Michael Porter, who emphasized the importance of industry characteristics to explain performance differences of firms, arguing that any competitive edge achieved by firms in an industry will be short lived due to the high mobility of their rent-producing resources that can be bought and sold in factor markets. Numerous writers became critical of this market-based view of strategy. They argued that if a firm's position in an industry was the key determinant of firms' success why then did firms in the same industry and occupying similar market positions differ considerably in their performance (Rumelt, 1984; Barney, 1986)? The resource-based view of the firm, by contrast to the industry-based concepts, argues that the attractiveness of an industry cannot be evaluated independently of the unique skills and abilities that a firm brings to that industry (Barney, 1994).

Emphasising the increasing awareness amongst academics of the role of knowledge as a key commercial resource, there is now a rapidly growing body of literature that deals with what is known as the *knowledge-based view of the firm* (Grant, 1996).[22]

In this context, the related concept of a firm's (*core*) *competencies* or *capabilities* must be mentioned. This concept assumes that resources are not normally productive on their own (Hamel & Prahalad, 1992). Instead, most tasks require that several resources to collaborate closely together to form competences that differentiate it from its competitors. Thus, the interest is not in resources or capabilities *per se* but in those capabilities that provide a competitive advantage *relative to other firms*; and, as Grant (1998) points out, from this theory, it is the management's core task to match a firm's unique resources or capabilities to the opportunities that arise in the external environment.

It should however be mentioned that from a resource-based perspective, the characterization of a valuable resource tends to be ex post (Foss et al., 1995); and the resource-based literature has far less to say about the emergence of these distinctive capabilities (Levinthal & Myatt, 1994). In other words, such resources tend to be taken as given and their emergence is not explained. Furthermore, as Teece et al. (1997) point out, the resource-based theory recognizes but does not explain the nature of isolating mechanisms that enable rents and competitive advantage to be *sustained*.[23]

This not withstanding, the resource-based theory has now become a dominant paradigm for strategic management research in the context of the mature firm (Grant, 1996; Barney, 2001a/b).

In the entrepreneurial context, however, it has so far amounted to little more than providing a 'research setting' for empirical work (Alvarez & Busenitz, 2001).

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[22] Further key contributions in this context stem from: Barney, 1991, 2001a/b; Kogut & Zander, 1992a/b, 1996; Leonard-Barton, 1992, 1995; Nelson & Winter, 1982; Nelson, 1991; Prahalad & Hamel, 1990; Stewart, 1997; Teece 1998a/b, 2001, Teece, et al., 1997; Winter, 1987; Zander & Kogut, 1995.

[23] Also more recent developments of the resource-based theory do only partially address this issue. For instance, the concept of *dynamic capabilities* extends the resource-based view by incorporating evolutionary theory; and it emphasizes the need of many organizations to adapt to rapidly changing environments. However, for this purpose, the concept focuses primarily on the exploitation and (re-) deployment of *existing* internal and external firm specific competences, but not on the development of (new) knowledge or competencies (Teece et al., 1997; Teece, 1998b).

This is even more marked with respect to research on venture capital, where the concept has been mentioned explicitly only by a few scholars. Bygrave (1987: 139), for instance, emphasizes 'knowledge is an important distinctive competence of venture capital firms. That knowledge includes information such as innovations, technology, and people in specific industry segments'. Similarly, Locket and Wright (1999) argue that although the VC firm has been traditionally viewed as a financial intermediary it may also be thought of as a 'collection of productive resources'.

Nevertheless, as we will see in the next section, the resource-/knowledge-based theory has been referred to at least implicitly by a number of empirical studies, which indicate that VCs differ in their ability to identify and/or develop successful companies.

Indeed, the applicability of this concept in the area of venture capital in general and with a view to answering our own guiding research question is obvious. To begin with it is plausible to argue that VCs – as all other companies - need certain resources to develop (*core*) *competences*, which help them to differentiate themselves not only from the more traditional investors but also from their peers. For this purpose, tangible - financial - resources might be considered as one part of the bundle. After all, the VC's main activities are attracting financial resources from investors (or generating them internally) and investing those funds into promising projects to generate profits. But taken alone, financial resources are clearly insufficient for VC success since such resources need to be managed effectively. They are often scarce (depending on the stage of the cycle and the nature of the venture) but usually not 'unique'. In other words, these resources are not specialised to a particular company or VC. Instead, they are transferable between firms at low costs, and as such 'imitable'. As equity resources they have (unlike debt) no time dimension and hence can be considered 'durable'. Of course they are always at risk when invested in a business with a view to earning profits. Thus, financial resources are not sufficient to provide a competitive advantage to a VC.[24]

[24] In this context, it should also be noted that if financial resources were the main determinant of investors' success, there should be little reason for large investors to involve any third parties such as VCs, and to pay fees and to share potential profits whilst – in most cases – even bearing the full risk. Instead, large investors should safeguard against risk associated with investing in high-risk/-return ventures via contractual arrangements and/or diversification; and their success might be mainly due to economies of scale. But the fact that large investors are willing to do so, and the sheer

Because VCs usually have no other tangible resources but cash to offer a venture, it must be their intangible resources, and particularly their knowledge or capabilities, that not only allow VCs to differentiate themselves from more traditional investors but also successful VCs from their less successful peers. This might happen, for instance, by making them more capable of dealing adequately with the risks, uncertainties, and information asymmetries associated with investment opportunities.

But the applicability of the resource-/knowledge-based to the venture capital context can also be understood with view to the ventures, and particularly so when referring to another resource-centred concept, the *resource-dependence theory*.

This concept emphasizes the constraints on the organization's strategic choice especially in situations of resource scarcity and environmental turbulence (Pfeffer & Salancik, 1978). According to this theory many firms do not control all the resources they need. This might be, for instance, because environmental uncertainty makes it impossible to own all relevant resources. Also, a firm's strategy might be particularly resource demanding such as is the case with fast-growth, high-innovation ventures that aim for an IPO. For those companies acquisition of resources and reduction of resource dependence becomes a vital activity.[25]

To explain this, the resource-dependence theory suggests, inter-organizational association strategies are key. Among those strategies the adequate choice and composition of the board of directors is said to be particularly efficient for small firms, which cannot devote huge amounts of time and money to inter-organizational relations strategies (Daily & Dalton, 1992, 1993; Pfeffer & Salancik, 1978).

The applicability of the resource-dependence theory in the venture capital context is obvious. From our discussions in the introduction further above it is evident that one – if not *the* – key problem of many entrepreneurial ventures is their lack of many intangible resources vital for successful development. And, as also discussed earlier, the 'liability of newness/smallness' of those ventures

fact that VCs exists as intermediaries in the financial markets suggests that, in many cases, there will be more to the investor's success than just money.

[25] In this context, a peculiarity of resource dependence theory, as opposed to neoinstitutional theory, is its reliance on the effectiveness of managerial action and on inter-/organizational practices, which is seldom recognized as having an impact by neoinstitutional scholars.

tends to make outsiders reluctant to become engaged with them, and to provide them with the relevant resources.

In this context Aldrich and Martinez (2001), for instance, emphasize the importance of 'social capital' that allows firms to obtain resources that are otherwise unobtainable to them, such as knowledge, capital, clients, and access to suppliers; and the authors also note that VCs can be seen as one important part of the social capital for entrepreneurial ventures. Indeed, as we will show in more detail in the next section, the assertion that VCs could be key provider also of non-monetary resources to ventures finds at least indirect support from several other scholars.

Fried et al. (1998), for instance, highlight that the board of directors of VC-backed ventures - as suggested by the resource-dependence theory – plays an important role in the acquisition of resources. VC-backed firms are usually young and small, so that board members, if sufficiently knowledgeable about the firm's business, could make a substantive contribution. Also the fact that both inside directors (founder-managers) and outside directors (VCs) have significant ownership in the firm could provide an incentive for the two parties to work closely together to ensure the success of their venture.

Hellmann and Puri (2002) further point out that, on a theoretical level, one needs to recognize that VCs may gather information not merely *about* firms, but also *for* firms – exerting costly effort to give inputs, which increase the value of the firm.

Similarly, Jääskeläinen et al. (2003) note that there are two perspectives that look at why VCs get involved in their portfolio ventures: monitoring needs and value-added assistance/support. Monitoring needs result from agency risk, which gives rise to the VCs' governance with a need to monitor the activities of the ventures to ensure that the conduct of the management is aligned with the interests of the VC. However, while the governance of ventures concentrates on the value of reduced risks and prevention of undesired outcomes, the assistance/support perspective considers the VCs' involvement as a valuable *resource* for the focal ventures. VCs contribute *resources* that serve the development of the company as an additional input.

In the same vein Busenitz et al. (2004) note that VC information may be valuable to startup managers because VCs bring a variety of experiences with them from earlier investments. Theoretically, therefore, input from VCs – for instance on strategic issues - should lead to decisions that are better than those that a startups could have generated otherwise. Furthermore, VCs may even serve as intermediaries on behalf of essential factor providers. Those VC-provided contacts have the potential to provide startups with a more informed view of their business options. Thus, to the extent that VCs provide information to startups on strategic issues, one might expect that it would be related positively to improvements in venture performance (Busenitz et al., 2004).

In sum, from a resource (-dependence) perspective it seems reasonable to assume that at least (some) VCs could have developed certain competences that distinguish them not only from more traditional investors but also from each other by allowing them identify and realistically assess the most promising investment opportunities, to deal more appropriately with the risks and uncertainties associated with investments in high-risk/-return ventures, and to provide missing/complementary resources to them. This might not only become manifest in different investment approaches by VC with different knowledge, but it might also translate into different performances of VCs and/or their investments.

Thus, one might further argue that the resource-/knowledge-based theory is complementary to the previously discussed concepts (i.e. the financial-intermediation/signalling and the principal-agent theories) in that having superior resources or competencies should help a VC to better fulfil his role as a financial intermediary and to deal with possible information asymmetries more appropriately.

As we will see in the following section - although not with explicit reference to the resource-/knowledge-based theory – much empirical research in venture capital seems to support the view that VCs' intangible, knowledge-based resources play a central role in understanding their investment activities, and possibly also the outcome of these activities.

C.II. Empirical literature

Within the empirical literature on venture capital, one can differentiate between two main strands of relevance to answering our guiding question.[26]

Firstly, this is the literature that takes an *ex ante* approach to examining what VCs actually do. Secondly, this is the literature that takes an *ex post* approach to

[26] To recall, our guiding question for the general literature review was: 'What role does VCs' knowledge play for financing entrepreneurial high-tech ventures; and how does it affect their investment approach and the performance of their investments?'

examining whether/how VC backing is related to the performance of VC investments.

These main strands in the literature are illustrated below in Figure C-1, which will serve as a structure for our literature review.[27]

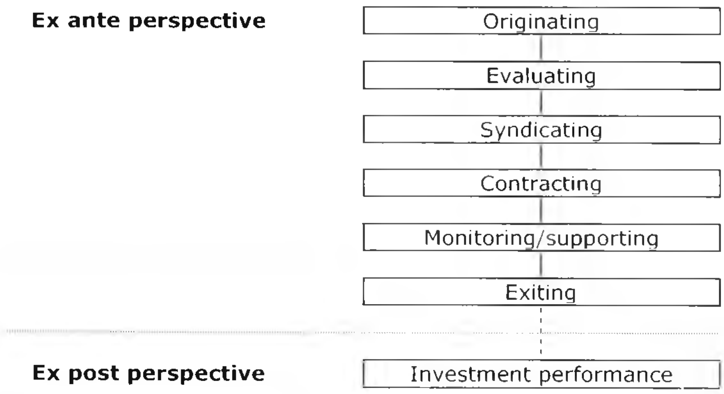

Figure C-1: Main strands and topics of the literature on venture capital

Within the substantial body of literature on venture capital, there is only a very small literature directly related to our guiding question by examining the impact of VCs' 'knowledge' on VCs' investment approach and/or the performance of VCs' investments.

Few studies do differentiate between VCs in general, and even less between VCs' knowledge. However, there is some limited literature that differentiates between VCs on the basis of VC characteristics (VC 'differentiators; such as the VCs' age or size) that might also serve as proxies for VCs' 'knowledge'. This is the literature we will primarily focus on in the following sections.

At this stage it should be noted that we summarize those VC 'differentiators' and discuss their suitability as proxies for VCs' 'knowledge' at the end of the chapter.

C.II.1. Ex ante perspective

A sizeable body of literature looks at what VCs 'typically' do, and how their investment approach differs from that of other investors (e.g. Bascha & Walz, 2001; Bygrave & Timmons, 1992; Fried & Hisrich, 1995; Gompers & Lerner, 2001; Gorman & Sahlman, 1989; Hellmann & Puri, 2002; MacMillan et al., 1985;

[27] With view to the ex ante literature, it must be emphasized though, that, in practice, the individual steps of VCs' investment approach are less well defined. For instance, there are overlaps between 'evaluation' and 'syndication', and between 'contracting' and 'monitoring'.

Sahlman, 1990; Tyebjee & Bruno, 1984). In this context, as illustrated in Figure C-1 above, one can broadly distinguish six distinct features in VCs' investment approach, which we use to structure our subsequent review of the literature, namely, their roles in: a) originating, b) evaluating, c) syndicating, d) contracting, e) monitoring/ supporting, and f) exiting deals.

C.II.1.a) Originating deals

The first distinctive feature of the VCs' investment approach concerns the origination of deals. As outlined earlier, VCs' investment candidates are usually small and therefore not easily visible. But their quality varies considerably. This makes it essential for VCs to have a large 'deal flow' (stream of new proposals) to choose from (Lockett & Wright, 1999; Sorenson & Stuart, 2001; Timmons & Bygrave, 1996; Tyebjee & Bruno, 1984). However, keeping this deal flow sufficiently high is difficult. Many VCs have a narrow investment focus, and are interested in early-stage, rapid-growth, high-tech ventures that have an above-average upside potential (Hellmann & Puri, 2000; Manigart et al., 1997; Sahlman, 1990; Valliere & Peterson, 2004).

It seems plausible to assume that VCs' knowledge – such as regarding recent developments in certain industries or technologies – is essential for identifying promising investment candidates and increasing the deal flow.

But only a few studies have looked at the relation between VCs' 'knowledge' and the origination of VCs' investments, and none examines in detail the relation between all three aspects, VCs' knowledge, deal origination, and performance of VCs' investments.

Sorenson and Stuart (2001), for instance, examine the role of VCs' 'knowledge' as one of the factors determining VCs' geographical and industry investment 'reach'. Differentiating between VCs on the basis of their *age*, their '*general experience*', and '*industry experience*', the authors conclude that a VC's experience increases the geographic scope of his investment reach through the development of networks.[28]

Hsu (2003) studies the relation between first round lead VCs' 'reputation' ('*industry deal experience*', '*network resource rating*', and '*industry reputation*

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[28] Sorenson and Stuart (2001) approximate VCs' '*general experience*' by the number of previous investments overall, and VCs' '*industry experience*' by the VCs' number of previous investments in the same industry as a particular venture under consideration.

rank') and, the likelihood of ventures accepting offers from VCs.[29] He finds that offers made by high-reputation VCs are three times more likely to be accepted; and high-reputation VCs acquire startups' equity at a discount. This, Hsu (2003) argues, implies that entrepreneurs are attracted by and willing to pay a price for the VCs' reputation. Furthermore, because high-reputation VCs are more likely to win a tender for interesting ventures and have to pay less for the same equity share than lower-quality VCs, VCs with a better 'reputation' are likely to perform better financially than their less reputable peers.

C.II.1.b) Evaluating deals

Another distinct feature in the VCs' investment approach concerns the evaluation of potential deals. Many of the most promising investment opportunities for VCs are characterized by a lack of tangible assets and are associated with substantial uncertainty. This obviously requires particularly diligent evaluation processes and criteria.

There is abundance of literature dealing with these criteria and processes. Overall, this literature suggests that VCs use a broad range of often qualitative rather than quantitative measures when evaluating proposals. Commonly cited evaluation criteria are, for instance: business strategy, competitive position, customer adoption, deal structure, financial markets / exit opportunities, fit in portfolio, market size and growth, product and technology, quality of management.[30]

However, to our knowledge, no study examines in detail the impact of VCs' 'knowledge' on their evaluation processes and criteria - or how the latter, in turn, are related to investment performance. Instead, as Shepherd and Zacharakis (2002) note, although researchers have described in detail the evaluation criteria used by VCs, they have typically *assumed* that VCs are

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[29] Hsu (2003) approximates (lead) VCs' *'industry deal experience'* by a dummy variable equal to 1 if the number of previous investments the VC has made in the startups' industrial segment places the VC above the sample median, the (lead) VCs' *'network resources rating'* by a dummy variable equal to 1 if a VC firm received the maximum Likert-scale measure (entrepreneurs' assessment) in at least one out of five entrepreneur-rated VC network resources: recruiting resources, contact with customers and suppliers, contacts with investment banks, and the (lead) VCs' *'industry reputation rank'* on a Lkert-scale (entrepreneurs' assessment)

[30] For studies on the VCs' evaluation processes and criteria see, for instance: Fried & Hisrich, 1994; Hall & Hofer, 1993; Kaplan & Strömberg, 2001, 2002; MacMillan et al., 1985; Poindexter, 1976; Robinson, 1987; Sahlman, 1990; Sandberg et al., 1988; Timmons et al., 1987; Tyebjee & Bruno, 1984; Wells, 1974; Zacharakis & Meyer, 1995 (for an overview see: Zacharakis & Meyer, 1998).

capable of identifying promising startups and asked VCs only to report these criteria - without exploring whether their criteria are actually related to subsequent startup performance. This is despite, as Aldrich and Kenworthy (1999) note, the high failure rates of VC-backed companies could suggest that many VCs are unable to discover a 'predictive template'.

Nevertheless, a few studies provide some interesting insights, mainly based on experimental settings though.

Zacharakis and Meyer (1998), for instance, observe – 'within the confines of a controlled experiment that greatly reduces the amount of information considered' - that some VCs apparently use fewer criteria than previous studies suggested, and less than VCs themselves think they use. Whilst VCs believe to be evaluating all available information, in fact they tend to rely on their intuition. This not only leads them to be overconfident but it also can impede their learning because they cannot make accurate adjustments to their evaluation processes if they do not truly understand them. Furthermore, the authors suggest, it can impede the performance of their investment portfolio.[31] Indeed, in a different experimental study the same authors further find that even relatively simple 'equal weighting models' decision models can outperform VCs (Zacharakis & Meyer, 2000).[32] Baum and Silverman (2004) arrive at a similar conclusion. Also using experimental evidence, they suggest that VCs do not always base their investment decisions on criteria actually correlated with venture performance.

These findings are not confined only to experimental settings. For instance, Valliere and Peterson's (2004) empirical study suggests that VCs' evaluation process might not always be rational. Based on interviews with 57 VCs that were active during the 'Internet Bubble' (from 1998 to 2001; when many VCs apparently were willing to pay irrationally high premiums for unproven business models), the authors find that at least some of these VCs realized the high level

[31] Into the same direction points yet another experimental study by Zacharakis and Shepherd (2001), which shows that some VCs tend to be overconfident in their prediction of venture success. This 'optimism bias' is likely to inhibit learning and improving the decision process. Overconfident VCs may not fully consider all relevant information, nor search for additional information to improve their decision. This may encourage them to limit information search and fund lower potential investments (or prematurely reject a stronger potential investment). Thus, the authors propose, more information creates greater confidence, but it also leads to lower decision accuracy.

[32] 'Equal weighting models' aim to capture the cues used by individuals in decision-making processes, but assume that each cue is of equal importance to the judgement being made.

of uncertainty; but many of them believed that the 'rules of the investment game had changed'. This led to a self-reinforcing cycle of market and investor hype, with escalating commitments and a suppression of risk assessment controls. In this situation, Valliere and Peterson (2004) note, some investors could be accused of having reacted irrationally to the potential for quick and easy financial gains; but many investors also appear to have tried making rationalized - although logically flawed – decisions. Here, the authors also emphasize the role of investors unfamiliar with the sector as an important underpinning of the Internet Bubble and its burst. New, inexperienced VCs in that period were more prone to fall for the market-hype than more experienced VCs, at least some of which left the market when realizing that the valuations have reached unrealistic heights (Valliere & Peterson, 2004).

C.II.1.c) Syndicating deals

'Syndication' - the joint investment by two or more VCs in the same venture – is another very distinct but common feature of the VCs' investment approach.[33]/[34] But although syndication is commonplace in the VC industry, it has attracted only very limited research (Bygrave, 1987, 1988; Lerner, 1994); and Lockett and Wright (1999: 304) note 'the problem remains, why do venture capitalists syndicate private equity when there exists the possibility of re-insurance and when the practice of syndication may create ex post managerial problems?'.

However, syndication of investments is interesting from the perspective of our project because it is one of the few features in the VCs' investment approach

[33] Each 'syndicate' is temporary in nature, with the financing structure constructed specifically for that transaction, with possible staging of additional finance to enable the investee to develop towards a subsequent flotation or sale to a third party. 'Lead' VCs usually serve as the main point of contact between the investor group and the venture, and are more involved in the venture-related post-investment activities (MacMillan et al., 1989; Wright & Lockett, 2003). VCs also often perform repeat syndication arrangements over time with a network of partners, sometimes acting as the lead while at other times acting as a non-lead (Bygrave, 1987, 1988).

[34] Barry et al. (1990), for instance, find in a study of 433 VC-backed ventures that went public between 1978 and 1987 that those ventures received 1,264 investments, or an average of three per venture; and only one quarter of the ventures in their sample received investments from a single VC. Pointing into the same direction, a study by Kaplan and Strömberg (2002) finds – in a sample of 213 investments in 119 portfolio companies by 14 VC firms in the U.S. – that the median number of VCs involved in each investment is four. Syndication furthermore seems common not only in the U.S. but also in Europe (Manigart et al., 2004). Statistics of the European Venture Capital Association (EVCA), for instance, show that almost 30 percent of the amount invested and of the number of deals by European VCs were syndicated in 2001.

where empirical research has explicitly taken into account the role of VCs' 'knowledge'. As a consequence, we will build upon this extant literature in one of our research hypotheses below (see Chapter F), where we also review the available literature in more detail. At this stage therefore, we look only briefly at studies that explicitly examine VCs' 'knowledge' in the context of syndication.

Some of these studies suggest that VCs' 'knowledge' could play a major role for their syndication behaviour.

Bygrave (1987, 1988), for instance, in an empirical study on VCs' syndication, differentiates between VCs on the basis of their '*size*' and '*investment preference*'.[35] Based on his findings Bygrave (1987, 1989) concludes that there is evidence that the primary reason for coinvesting is the sharing of knowledge rather than spreading of financial risk.

To a similar conclusion comes Lerner (1994) in an empirical examination of VCs' syndication behaviour. He distinguishes between established and non-established VCs based on their '*age*' and '*size*'.[36] Additionally, with a view to later round investments, he also categorizes VCs based on the *number of their previous investments* in biotechnology, the focal industry of his study. His findings suggest gathering additional information for ex ante decision-making and selection of investments is a particularly relevant motive for syndication.

Also Hopp and Rieder (2004), in a working paper, come to a similar conclusion. They study the relation between VCs' experience and their 'syndication ratio' (proportion of syndicated to unsyndicated investments).[37] Whilst the authors

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[35] Bygrave (1987, 1988) approximates VCs' '*size*' by their funds under management, and VCs' '*investment preference*' by the proportion of their investments in high- and low-innovation technology ventures and the absolute number of ventures they had invested in his sample (based on this he identifies a group of 61 VCs that fall into one of the following three categories: 21 HIVCs (firms that had the highest proportion of high- to low-innovation portfolio ventures and the highest number of high-innovation portfolio ventures), 19 MICVs (firms that were among the 61 firms with the highest number of portfolio ventures but that did not specialize primarily in low- or high-innovation investments), and 21 LIVCs (firms that had the highest proportion of low- to high-innovation portfolio ventures and the highest number of low-innovation portfolio ventures).

[36] Lerner (1994) approximates the VCs' '*size*' as their relative funds under management, i.e. the capital committed to them as a percentage of the total venture capital pool in a given year, and then divides the VCs in size quintiles. Similarly, he also uses the relative age of the VCs compared to their peers in a given year, and then distinguishes between five age quintiles.

[37] Hopp and Rieder (2004) approximate the VCs' experience by their number of investments, and they categorize VC in groups of 'one time investor' (1 investment), 'very small VC' (2-3 inv.), 'small

themselves point out that the results of their study have to be taken with some caution (which we will come to further below in our Chapter F on syndication), it is nevertheless interesting that they find some indications for a negative relation between the VCs' 'knowledge' and syndication ratio. Furthermore, the authors also find that more 'specialized' VCs have lower syndication ratios than their less specialized peers.[38] Hopp and Rieder (2004) interpret their findings as suggesting that less experienced VCs are more inclined to syndicate as they might not have the necessary expertise; and they further take this as support for the *resource-driven motive for syndication that intends to overcome informational asymmetries*.

However, contrary to the above studies, other studies suggest that acquisition of knowledge may be a less important motive for syndication than financial aspects.

Lockett and Wright (1999, 2001), for instance, in an empirical study of syndication, categorize VCs by their *'industry expertise'* and *financing-stage expertise'* and their *'minimum investment size preferences'*.[39] From their findings, they conclude that, overall, *syndication is more a response to the need to spread the financial risk (i.e. portfolio diversification) and to gain additional financial resources than to share information and manage investments.*

Similarly, Manigart et al. (2004), in an empirical examination of VCs' syndication motives, categorize VCs according to their *venture development-stage and industry investment preference.*[40] They conclude that *risk sharing, portfolio diversification, and access to larger deals are more important motives for VCs to syndicate than selection and monitoring of deals.*

VC' (4-6 inv.), 'lower middle field VC' (7-10 inv.), 'upper middle field VC' (11-20 inv.), 'large VC' (21-50 inv.), and 'very large VC' (> 50 inv.).

[38] It is not quite clear how Hopp and Rieder (2004) define VCs' 'specialization'; but it seems like this is the categorization used by the provider of the database the authors employ for their study.

[39] Lockett and Wright (1999, 2001), approximate VCs' *'industry expertise'* and *'financing-stage expertise'* by the surveyed VCs' self-assessment (on a five-point Likert-scale) and their *'minimum investment size preferences'* according to whether their self-stated investment size preference is above or below £5Mio.

[40] Manigart et al. (2004) approximate VCs' *'venture development-stage investment preference'* by a dummy variable indicating whether the average age of their previous investments was above or below the average age of the overall sample, and the VCs' *'venture industry investment preference'* by VCs' self-assessment on a 5-point Likert scale.

Finally, it should be noted that - although there is some indication that better networked VCs might perform better (both in terms of the returns to their funds and in terms of the survival of their portfolio ventures (Hochberg et al., 2004) - to our knowledge, no empirical study has yet demonstrated a relation between syndication of individual investments and investment performance.

C.II.1.d) Contracting deals

Another distinct feature in the VCs' investment approach is the way VCs design investment contracts (Amit et al., 1990; Bergemann & Hege, 1998; Gompers, 1995, 1998; Hellman, 1998; Sahlman, 1990). The peculiarities of VC contracts are a consequence of the particular type of risks associated with their investments. An in-depth pre-investment assessment might provide some valuable information about a venture's external risks (e.g. market size, customer adoption, competition etc.), but it will reveal little about its internal risks (e.g. regarding the quality and 'true' intentions of a management team that often has no 'track record'). Furthermore, the initial due diligence cannot safeguard against the risk of project-failure inherent in many science-based high-technology projects. Those types of risk cannot be assessed initially but need time to be resolved. Therefore, Kaplan and Strömberg (2002, 2003) note, VCs' contracts typically focus on the latter type of risks, by carefully allocating cash flow, liquidation, and control rights between VC and entrepreneur.[41]

Broadly speaking, VC contracts have two main purposes: (i) incentivising the entrepreneur's effort whilst de-incentivising potential misbehaviour, and (ii) enabling the VCs to continuously/periodically re-assess the venture's progress.

With respect to the latter, furthermore, it is also important to note that the contracts determine the ventures' financial 'lifeline' – i.e. the time before they have to approach VCs again for a new cash-injection. This is because VCs typically do not provide all the funds required for the development of their investee companies en block. Instead, funds are usually invested in 'stages', wherein money is dispersed in increments depending the passing of VC-set 'milestones', such as the formulation of a business plan, development of a prototype, first production, and so on. Thus, most ventures in fact have to go through several investment rounds, which might or might not involve the same investors; and at each round the VCs have the opportunity to continue or

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[41] For a more detailed discussion of the issues dealt with in VC contracts it should be referred to the overviews in Gompers and Lerner (2001), and Sahlman (1990), as well as to the particularly insightful studies by Kaplan and Strömberg (2001, 2002, 2003).

abandon a venture. This 'staging of investments' is said to provide the basis for the most potent control mechanism VCs have over the venture and has the structure of a real option (Sahlman, 1990; Bergemann & Hege, 1998; Cressy, 2005a).

Although it seems evident that VCs' knowledge could be related to the contractual design (and staging) of deals, this aspect has been almost completely neglected in the literature.

With a view to the relation between VCs' knowledge and general contract design, one exception to this rule is a study by Kaplan et al. (2004). These authors are interested in whether the financial contracts observed in the US are also 'optimal' in other legal/institutional environments where other contracts prevail. To examine this, they compare the contractual features of 201 US and 145 non-US investments. In this context, they differentiate between VCs on the basis of their *'size'*, *'age'*, and *'familiarity with the US VC industry'*.[42] Based on this, the authors find that larger and older VCs as well as VCs with more exposure to the US implement US contract characteristics across all countries and legal/institutional systems. At the same time, non-US VCs show more variation in their contract design than their US peers; but they seem to have less control, liquidation and exit rights, as well as less high-powered cash flow incentives. Finally, the authors find evidence that the US-style contracts are indeed optimal even outside the US legal/institutional environment: there is a significant positive relation between the use of US-style provisions and VC survival.[43] Overall, therefore, the authors conclude that their findings indicate that it is possible to 'learn' (adapt/replicate) US-style contractual mechanisms elsewhere; but learning about optimal contracts might take time and should involve considerable fixed costs.

With respect to the relation between VCs' knowledge and *staging* (as one particular aspect of VCs' contractual arrangements), however, to the best of our

[42] Kaplan et al. (2004) approximate the VCs' *'size'* by a dummy variable taking the value of 1 if a VCs' funds under management puts him above the sample mean of $200 million, *'age'* by a dummy variable taking the value of 1 if a VCs' age puts him above the sample mean of 4 years, and *'familiarity with the U.S. VC industry'* by a dummy variable indicating whether the lead VC is based in the U.S., had previously syndicated with U.S. VCs, or had no U.S. experience at all.

[43] Specifically, Kaplan et al. (2004) find that, within the overall sample of 70 lead VCs, none of the 37 funds that exclusively used convertible preferred (and U.S.-style contracts) has failed. In contrast, of the 11 funds that have failed, all but one never used convertible preferred (or: from the 29 VCs that never used preferred stock, 34% have failed).

knowledge no study has dealt with this issue in any detail. Only one case study exists, namely Steier and Greenwood (1995), which indicates that staging, particularly if involving inexperienced syndicates, might present a serious obstacle for the development of viable ventures.

Because staging apparently is (one of) the most potent control mechanism VCs have over ventures but has not been dealt with from the perspective of VCs' knowledge, it seems a particularly interesting area for our research; and we consequently will deal with this issue in one of our research hypotheses (see Chapter H), where we also review the general literature available on this topic in more detail.

C.II.1.e) Monitoring/supporting deals

Another, arguably most distinct, feature of the VCs' investment approach is often said to be the type and level of their post-investment involvement in investee companies. Fried and Hisrich (1995), for instance, point out that VCs are 'relationship investors'; and Hellman and Puri (2000: 959) argue 'if one thinks of financial institutions on a spectrum from 'arm's length' to 'relational' investors, VCs are typically viewed as lying on the latter extreme'.

Reflecting its perceived distinctiveness, VCs' post-investment involvement has attracted very substantial research, which we cannot hope to fully review here.

Overall, extant literature suggests that VCs are indeed involved in a wide range of post-investment activities. But there also seems to be considerable variance regarding the type and intensity of VCs' involvement - reaching from occasional hands-off monitoring of to continuous hands-on support for the investee ventures. Those differences have been found to be due to different types, preferences and/or policies of VCs (e.g. Bottazzi et al., 2004; Elango et al., 1995; Gorman & Sahlman, 1989; MacMillan et al., 1989), and/or to the VCs' perception of the risks associated with the particular characteristics of the investment they are confronted with, such as a venture's development stage, its performance, or its management's experience (e.g. Barney et al., 1989; Busenitz et al., 1997; Ehrlich et al., 1994; Fredriksen et al., 1997; Gomez-Mejia et al., 1990; Gorman & Sahlman, 1989; Hellmann & Puri, 2002; Lerner, 1995; Morris et al., 2000; Sapienza & Gupta, 1994; Sapienza et al., 1996).

As regards the relation between VCs' type and/or intensity post-investment involvement and investment performance, however, literature is ambiguous.

For instance, with a view to the *type* of VCs' activities, some studies suggest a positive relation between some VC activities and performance of investment companies (e.g. Fried & Hisrich, 1995; Gomez-Mejia et al. 1990; MacMillan et al., 1989; Murray 1996; Sapienza, 1992; Sapienza & Timmons, 1989; Schefczyk & Gerpott, 2001); other studies find no relationship (Barney et al., 1996; Busenitz et al., 2004; Fried & Hisrich, 1995; Rosenstein et al., 1989); and yet other studies note that there might be, at least in specific cases, a negative relation between VC some activities and investment performance (Barney et al., 1996; Busenitz et al., 2004; Fried & Hisrich, 1995).

Also with a view to the *intensity* of VCs' involvement and investment performance, some studies suggest a positive relation (Fredriksen et al., 1997; Manigart & Vermeir, 1996; Ruhnka et al., 1992; Sapienza, 1992; VDI et al., 2000), whilst other studies find no relationship between the two (MacMillan et al., 1989; Sapienza et al., 1996; Sweeting & Wong, 1997).

However, some studies suggest that even if there is a positive relation between the type/intensity of VCs' involvement and investment performance, this may be due to VCs following 'home run' strategies, putting greater effort/resources into ventures promising the greatest pay-off (Kaplan & Strömberg, 2002a; Sapienza & Timmons, 1989; Sapienza et al., 1996; Schefczyk & Gerpott, 2001). But at the same time, some authors also suggest that some VCs could be 'firefighters' allocating their scarce resources to portfolio ventures with problems (Fredriksen et al., 1997).

As regards to our guiding question, it seems very plausible to assume that VCs' knowledge could be related to the type/intensity of VCs' post-investment involvement; and both, in turn, could be related to the performance of VCs' investments.

However, only very few studies have looked at the relation between VCs' 'knowledge' and VCs' post-investment involvement.

Gomez-Mejia et al. (1990), for instance, conclude from 10 interviews with paired VCs/CEOs that VCs with *operations experience*, particularly those who had previously been entrepreneurs, are perceived to have 'more influence' over the venture than VCs with only financial management experience.[44]

A more detailed study by Bottazzi et al. (2004) produces similar findings. These authors examine the relation between *VCs' degree of specialization* and their level of involvement in their portfolio ventures. Based on a survey of 124

[44] Gomez-Mejia et al. (1990), however, specify neither the level nor the type of VC experience in question and they do not examine the impact of that experience on investment performance.

European VC firms (518 partners, from various countries) making investments between 1998 and 2001, they find that the more specialized VC firms show a more active investment style, providing more governance and support to their portfolio ventures.[45]

Similarly, only very few studies have looked at the relation between, on the one hand, VCs' knowledge and post-investment involvement, and, on the other hand, the performance of VCs' investments; and those studies that do result in ambiguous findings.[46]

Sapienza et al. (1996) are interested in the relation between VCs' post-investment activities and VCs' value added. They differentiate between two types of VC knowledge, *VC experience* and *new venture experience*.[47] They hypothesise that VCs with greater experience measured in this way require less interaction with their ventures but add more value. Based on interviews with and surveys of over 220 VCs, the authors find mixed support for these hypotheses: VCs with greater 'VC experience' require less interaction with their ventures but do not perceive (self-assessment) to add significantly more value than those VCs with less 'VC experience'. By contrast, VCs with greater 'new venture experience' interact more frequently with their ventures than do VCs without such experience, and they perceive to add significantly more value to their portfolio companies than those without such experience.

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[45] Bottazzi et al. (2004) approximate VCs' degree of 'specialization' on the *firm level* by several 'organizational' variables such as 1) 'type' (dummy variables indicating whether the VC firm is independent, bank-related, corporate-related, or public), 2) 'size' (funds under management), 3) age, 4) market focus (dummy variable for exclusive focus on venture capital deals), and 5) 'deal focus' (number of investments per partner). Furthermore, they approximate VCs' degree of 'specialization' on the *investment manager level* by several 'human capital' variables such as 1) 'venture experience' (years in VC industry), 2) 'business experience' ('1' = experience in finance, accounting, consulting, legal, or industry), and 3) 'science education' ('1' = business, humanities, engineering/science, law or social sciences) (each operationalised as a) the average for all partners in a firm, and b) for the specific partner responsible for a particular investment under consideration).

[46] In this context, it should also be referred to the subsequent section that reviews the literature, which takes an 'ex post' perspective on the relation between VC backing and venture performance. Furthermore, it should also be mentioned that we look at the relation between VCs' knowledge and performance of VCs' investments, from an ex post perspective in our third research hypothesis (Chapter I), where we review the relevant literature in more detail.

[47] Sapienza et al. (1996) approximate VCs' '*VC experience*' by the number of years a VC has spent in the VC industry, and VCs' '*new venture experience*' by the number of years a VC has with operating experience in the industry of a particular portfolio venture under consideration.

Busenitz et al. (2004) examine the relation between the quality of *strategic advice given by VCs* to their ventures (as an indirect proxy for VCs' knowledge) and the ultimate outcome of those ventures at the end of the study.[48] They hypothesise that the strategic information VCs provide to the managers of their portfolio ventures will be positively related to the performance of the ventures. To examine this, they conduct a survey of 183 ventures that received venture capital between 1987 and 1989, and then follow these ventures through early 2000 collecting data on the eventual status of the ventures. However, their analysis yielded a non-significant result for the effects of strategic information on venture exits; and the authors acknowledge that their results fail to support the long-term positive influence of VCs' strategic information on the quality of venture exits.[49]

C.II.1.f) Exiting deals

The final distinctive feature of the VCs' investment approach identified in the extant literature concerns the exiting of deals. As mentioned before, VCs often focus their investments on fast-growing high-tech ventures, which are expected to experience a substantial increase in value, particularly during their early development. Therefore, VCs will rationally leave their portfolio companies when they become more mature (Barry et al., 1990); and, compared to more traditional investors, VCs usually have a relatively short investment horizon – typically five to seven years (Gorman & Sahlman, 1989).

Broadly speaking, there are five main exit routes for VCs from their investments (e.g. Gladstone, 1988): 1) sale of shares in a IPO ('IPO') 2) sales of shares to another company ('trade sale' or 'acquisition'), 3) sale of shares to another investor ('secondary buyout'), 4) 'repurchase of shares by the company ('buyout'), and 5) 'liquidation of the company ('liquidation').

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[48] Busenitz et al. (2004) approximate the 'quality of the VCs' strategic advice' by asking the ventures' top-management whether their VCs (1) gave 'sound business advice' (2) provided 'excellent financial advice', and (3) provided 'sound management advice' (using a Likert scale); and the authors categorize the ventures' ultimate status– in order of increasing 'desirability' – as: 'out of business', 'still private', 'merged or acquired', or 'IPO'.

[49] Busenitz et al. (2004) provide an interesting explanation for why the findings of their study failed to support the idea that VCs, on average, do add value by providing strategic information: Even though this study used a large sample, non-significant findings do not prove the null hypothesis. Furthermore, it may be that some VCs do indeed add value. Some VCs may possess keen insights and perhaps some unique business experiences that enable them to add value to at least some of the ventures in which they invest.

But many VC-backed ventures officially remain private, but are cut off from funding, and are in fact 'dysfunctional/inactive'. Those ventures are sometimes referred to as 'living dead' (Bourgeois & Eisenhardt, 1987; Ruhnka et al., 1992).

Because VC-backed ventures are usually associated with high risk and are prone to fail, to make an overall profit on their portfolio VCs strongly depend on above-average returns from a few investments to compensate for the loss-makers. To this end, VCs often play an active role in directing the company towards a merger, acquisition, or – ideally - a public offering (Tyebjee & Bruno, 1984).[50]

It seems plausible to assume that VCs' knowledge could also be related to their exiting of investments. However, as we will see in the next sections, whilst a considerable number of studies have taken an ex post perspective on the performance of VC-backed ventures, at or after the VCs' exit, hardly any studies have looked at the actual exit event from an ex ante perspective.

One exception in this context is a study by Lerner (1994b), who examines VCs' ability to time the IPO of their portfolio ventures depending on how favourable the markets are for an IPO. For this purpose he differentiates between VCs' knowledge on the basis of their *age* and *size*.[51] Using a sample of 750 financing events in 350 privately held VC-backed biotech firms, he finds that more 'seasoned' (i.e. larger and/or older) VCs indeed seem able to time the IPO of their portfolio ventures near market peaks, but prefer private placements when the markets are low.

Gompers (1996), furthermore, examines the relation between VCs' *age* and the level of underpricing of VC-backed IPOs.[52] He finds evidence that younger VCs are more likely to bring ventures to IPO market (too) early, arguably in order to

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[50] This is explicable when looking at the returns of different exit routes. A Venture Economics (1988) study, for instance, finds that a $1 investment in a firm that goes public provides an average cash return of $1.95 beyond the initial investment with an average holding period of 4.2 years. The next best alternative, an investment in an acquired firm, yields a cash return of only 40 cents over a 3.7-year mean holding period (Lerner, 1995). Similarly, Barry et al. (1990), based on data from the Venture Capital Journal, find that of 544 VC investments, 35 % used an IPO, whereas the next most common outcome, acquisition by another company, accounted for only 22%; and almost all (96%) of the IPOs, but only 59% of the acquisitions by another company provided positive returns for the VCs.

[51] Lerner (1994b) approximates the VCs' '*size*' as their relative funds under management, i.e. the capital committed to them as a percentage of the total venture capital pool in a given year, and then divides the VCs in size quintiles. Similarly, he also uses the relative age of the VCs compared to their peers in a given year, and then distinguishes between five age quintiles.

[52] 'Underpricing' is the spread between the issuing and the offering price shortly after trading begins.

'showcase' their successes to investors. Ventures, however, 'pay' for their VCs' 'grand-standing' as they experience larger under-pricing. At the same time, Gompers (1996) also finds that young venture capital firms have been on the board of directors a shorter period of time at the IPO, hold smaller equity stakes, and time the IPO to precede or coincide with raising money for follow-on funds.

C.II.2. Ex post perspective

Turning to the second major strand in the literature on venture capital, a sizeable body of empirical literature has taken an ex post - or 'black box' - perspective on the relation between VC-backing and investment performance. This is, it looked at the relation between VC-backing and venture performance without considering VCs' pre- or post-investment activities in detail.

Broadly speaking, this ex post literature falls into three further categories: 1) studies that look at the performance of *ventures backed by VCs overall*, 2) studies that compare the performance of *VC- vs. non-VC-backed ventures*, and 3) studies that analyse the performance of *ventures backed by different VCs*.

As we will see in the following, none of these three categories provides a clear indication regarding the relation between VC-backing and venture performance in general, and between VCs' knowledge and venture performance in particular.

It might be argued that the first two of the above categories should be less relevant for our guiding question because they do not differentiate between different, and differently knowledgeable, VCs. However, we briefly review them in the following because they (could) provide insights on the impact of VCs' knowledge, particularly if one follows the widespread assumption that VCs are greater experts in identifying and/or managing investments than other investors.

The third category of studies, by contrast, could be particularly relevant with view to our guiding question in that they (could) provide insights into the impact of differences in VCs' knowledge on the performance of VC investments.

At this stage it should be noted that we take a closer look at some of those studies from the above mentioned third category of ex post literature in our Chapter I on the relation between VCs' knowledge and venture performance, where we will also describe in more detail the various measures for the performance of VCs' investment employed in the existing literature. In the following sections, however, our main focus will be on the proxies for VCs' knowledge employed in the existing literature.

C.II.2.a) Performance of VC-backed ventures overall

To begin with those studies that look at the performance of VC-backed ventures, they indicate considerable variance. Some VC-backed ventures perform well, but many don't.

Gorman and Sahlman (1989), for instance, find that most VC-backed ventures achieve only an average rate of return on invested capital. Similarly, also Sahlman (1990) points out that failure rates for VC-backed ventures range from around 15% to 35%. This finds further support by Ruhnka et al. (1992) who show that about 20% of a VC's portfolio fails to provide any return to the VC. Into the same direction also points Gompers' (1995) study on the outcome of VC-backed ventures, which finds – in a random sample of 794 VC-backed ventures – about 17% are liquidated or go bankrupt, and about 38% remain private after a minimum period of 30 months, 24% merge or are acquired, and 23% of the firms go public. Audretsch and Lehman (2002) analyze the survival of companies on the German Neuer Markt and find that the likelihood of firm survival decreases as the ownership share of the group of VCs increases, which could indicate a negative effect on the part of venture capital. Finally, also Valliere and Peterson (2004) observe - with view to the outcome of VC investments – that, of ten investments, two or three will fail and result in complete investment loss, six will survive but under-perform or provide no easy liquidity path for the VC firm, and only two will perform so spectacularly well as to result in acceptable overall portfolio returns.

C.II.2.b) Performance of VC- vs. non-VC-backed ventures

From some studies that compare the performance of VC- vs. non-VC-backed ventures, one might assume that VCs are indeed better – i.e. more knowledgeable – than other investors in identifying and/or building successful ventures. However, other studies also indicate that this is not necessarily so.

Some of the studies that compare the performance of VC-backed vs. non-VC-backed ventures ex post suggest that the former out-perform the latter.

For instance, Brophy and Verga (1989) examine and compare the initial stock prices and the variability of post-IPO stock returns for 210 VC-backed and 1,053 non-VC-backed ventures; and they find that ventures with VC backing indeed outperform those without VC-backing. Similarly, Megginson and Weiss (1991), in a matched sample of each 320 non-VC-backed and VC-backed ventures, find that VC-backed ventures on average have larger IPOs, show less under-pricing and underwriter compensation, leading to higher net proceeds from IPO.

Furthermore, VC-backed ventures go to IPO faster, are able to attract higher quality underwriters and auditors, as well as a greater interest from large institutional following compared to non- VC-backed ventures (Megginson & Weiss, 1991).[53] Hellman and Puri (2000) further find, based on a comparison of 170 VC- and non-VC-backed high-tech ventures, that ventures pursuing an innovator product strategy are more likely to receive VC-backing than those ventures pursuing an imitator product strategy; and venture capital backing is associated with significant shorter times to bring products to market, especially for innovators. Furthermore, based on the same sample Hellman and Puri (2002) find that VC-backing is related to faster professionalisation of ventures' HR functions, adoption of stock-options plans, and hiring VPs for marketing. Also Kortum and Lerner (2000) find that VC-backed ventures show a greater innovativeness (in terms of ventures' number of patents and patent citations) than their non-VC-backed peers. Hsu (2004), finally, based on a matched sample of 701 VC- vs. non-VC-backed high-tech ventures, finds that the former have more co-operations and are more likely to experience an IPO than their not-VC-backed peers.

However, not all ex post studies suggest that VC-baked out-perform non-VC-backed ventures.

Cherin and Hegert (1988), for instance, examine the cumulative and risk-adjusted returns of a 24-month period after IPO for 71 VC-backed ventures and 59 non-VC-backed ventures; and they find both sets to be realising negative returns during this period, with no statistical difference between the two groups. Also Barry et al. (1990), who examine and compare the (post-) IPO performance of 433 ventures backed by 210 VCs and 1,123 non-VC-backed ventures, find

[53] Megginson and Weiss (1991) interpret their findings as a proof for VCs' certification role in the capital markets by their ability to reduce information asymmetries between their portfolio ventures and third party IPO participants. In this context, they point out that one assumption inherent in the 'Certification Hypothesis' is the degree of repeat business VCs have with the offering participants (i.e. auditors, underwriter and institutional investors). However, the authors do not examine this aspect in detail. Instead, they argue that their results indicate that larger venture capitalists 'tend' to use the same underwriters with greater frequency; and in 'many cases' the VC uses the same underwriter for more than one issue. At the same time the authors also note that many of the ventures in their sample have syndicates of both VCs investing in them and syndicates of underwrites involved in their offerings. For this reason, the authors acknowledge that there is some double counting in the number of issues brought to market by each venture capitalist as well as in the frequency of underwriting in their sample. Together this casts some doubt about the overall results of the study, particularly since the authors do not control for/examine the actual amount of the VCs' repeat-business (e.g. the number of previous investments and/or IPOs).

- contrary to their own predictions - that VC-backing is even associated with a significantly smaller average offering size and with significantly greater aftermarket volatility. Also, the average initial-day return of VC-backed IPOs is not significantly different from that of non-VC-backed IPOs – possibly contradicting the hypothesis that VC-backing should reduce information asymmetries for outside investor, which in turn should lead to lower under-pricing. Fried et al. (1998), in a survey of 68 VCs, find some indication (VCs' own assessment of their investments' performance) that VC-backed ventures perform better than non-VC-backed companies - but the authors note that a statistical assessment was not possible. Franzke (2001), however, finds that venture-backed IPOs are more underpriced than non venture-backed IPOs. Manigart et al. (2002) moreover, comparing the survival rates of 565 each VC- and non- VC-backed Belgium ventures, show that VC-backed ventures, overall, even have a lower – although not statistically significant - survival rate than non- VC-backed ventures; and VC-backed companies have significantly higher bankruptcy rates than non-VC-backed companies.[54] Finally, Florin (2005), based on a sample of 277 US ventures that went public in 1996, finds that the post-IPO 2-years share-price performance of VC- and non-VC-backed ventures does not differ significantly.

From the first two strands of ex-post literature, there seems considerable variance also in the performance of VC-backed ventures. However, this is either not explained or explained in only very general terms i.e. by the presence or absence of a VC backer but without taking into account likely differences between VCs, and their knowledge. This is despite it seems possible that differences in the performance of ventures backed by VCs overall as well as differences in the performance of VC- vs. non-VC-backed ventures, could be due to the greater knowledge of (some) VCs – compared to non-VC investors or less knowledgeable VCs.[55]

[54] Manigart et al. (2002) suggest two main explanations for their findings: 1) the best – i.e. longest surviving - companies might find funding from other, cheaper sources than VCs, or 2) VCs might be interested more in managing the return to their overall portfolio rather than in the survival of individual companies, and therefore be willing to accept high failure rates as long as some investments provide spectacular returns.

[55] In addition, it should also be noted that one problem with the majority of ex post studies that use share price data to measure venture performance is that they presuppose a model of share pricing, whereas no generally agreed upon model exists. This means that the findings on VC performance will almost certainly vary with the choice of underlying share price model.

By contrast, the third strand of ex post literature, which we will come to next, differentiates between VCs also on the basis of VC characteristics that *might* be understood as proxies for VCs' knowledge.

C.II.2.c) Performance of ventures backed by different VCs

Similarly to the two previously discussed types of ex post studies, also those studies that look at the performance of ventures backed by *different* – and possibly differently 'knowledgeable' - VCs are ambiguous with respect to our guiding question.

Before we look at this literature, at this stage, it should be mentioned that in this chapter our focus is on the VC 'differentiators' that might serve as proxies for VCs' knowledge. But it should also be referred to our literature review in Chapter H, which provides further details, for instance, on the 'performance' measures of the studies reviewed here.

Some studies suggest a positive relation between VCs' 'knowledge' and the performance of VCs' investment, but also acknowledge issues of causality in this context and/or point out that this positive relation might be moderated by additional factors. Furthermore, many of these studies also use stock price based measures of performance making the choice of pricing model critical to the findings.

Stein and Bygrave (1990), for instance, examine the relation between VCs' reputation and the returns to VC-backed IPOs. Distinguishing between *top-20* VCs and *non-top-20* VCs, they find that that ventures backed by a top 20 VC enjoyed higher returns on invested capital at IPO.[56] However, the authors note that ventures backed by a top-20 VC commonly are also backed by a top underwriter, and the separate effects of the VCs and the underwriters could not be distinguished.

Similarly, also Lange et al. (2001) study the relation between VCs' quality and market capitalization and the subsequent returns to VC-backed ventures going public. Differentiating between *top* and *non-top* first round lead VCs, the authors find that ventures backed by top-20 VCs have a longer time to IPO but higher market capitalizations.[57] Those ventures also have higher returns over six

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[56] Stein and Bygrave (1990) identify as '*top*' VCs those 20 VCs (out of 91) who hold the largest number of seats on the board of the 77 ventures in their sample.

[57] Lange et al. (2001) define 'top' first round lead VCs as those 16 VCs (out of 106 VCs in their sample) that have been involved in the greatest number of IPOs. At the same time, those 16 'top'

months post-IPO than ventures backed by non-top-20 VCs. Furthermore, the top-20 VC-backed ventures have higher revenues in the year prior to the IPO and more employees. However, the authors note that most of the ventures backed by top-20 VCs are also brought to the market by top underwriter, making it impossible to separate out the two effects.

Manigart et al. (2002), differentiating between *independent/captive vs. government-owned VCs* and between *old/established vs. young/not established* VCs, find that ventures backed by the two oldest/most established government-owned VCs have a higher survival rate than the rest, and in some cases a higher survival rate than ventures backed by private/captive VCs. At the same time, these authors acknowledge that, with respect to the VCs' investment performance, their analysis reveals that what is going on, is more complex than hypothesized.

Gulati and Higgins (2003) are interested in the relation between VCs' *prominence* and the IPO success of VC-backed ventures.[58] They find a (marginally) significant positive relation between the prominence of a venture's VCs and a venture's IPO success; but they also find that this relation is moderated by an interaction between VCs' prominence and contextual factors, namely the situation in the equity markets. Thus, it is again impossible to be sure whether they have established a relation between VCs' 'knowledge' and venture performance.

Kaplan and Schoar (2003) investigate the performance of VCs in terms of return to their funds compared to the S&P500. In this context they distinguish between different VCs based on their *size* (funds under management) and between subsequent funds raised by the same VC. They find a positive, concave relation between VCs' size and returns. Furthermore, they find that returns persist across funds by the same VC, both for the top and the bottom performers, but improve in subsequent funds raised by the same VC. Better performing funds are more likely to raise follow-on funds and raise larger funds than funds that perform poorly. However, the authors also find considerable heterogeneity in returns

VCs were the most frequent investors in the first rounds of the 162 sample ventures, being involved in 57 – or 35% - of the first rounds in the sample.

[58] Gulati and Higgins (2003) approximate VCs' '*prominence*' by the VCs' total amount invested overall until the year prior to the venture's IPO.

over time at the industry level, arguably due to the presence of boom and bust cycles during their sample period.[59]

Hsu (2004), finally, examines the impact of different VC *reputation* on both the cooperation-intensity and performance (approximated by whether a venture experiences an IPO or not) of VC-backed high-tech ventures.[60] He finds a significant positive relation between VC's reputation record and both the co-operation intensity and performance. Here, Hsu (2004) assumes that VCs' reputation facilitates ventures cooperation activities, which, in turn, translate into positive venture performance; but he cannot show whether this is actually the case. It is equally possible that more 'knowledgeable' VCs are just better in picking well-performing and co-operating ventures or that those VCs actually contribute to the co-operation intensity of their investee ventures.

Other studies, however, indicate a positive relation between VCs' 'knowledge' and the performance of VCs' investments for some proxies of VCs' 'knowledge' but not for others.

Barry et al. (1990), for instance, examines the relation between the underpricing of VC-backed IPOs and several aspects of VCs' 'quality' such as the *age* of the lead VC, the *number of previous IPOs* by the lead VC, and *the size/funds under management* of the venture's VCs; and he finds a negative relation between the underpricing of ventures' IPOs and the first two proxies for VCs' quality, but not the last.

Stuart et al. (1999) study the relation between ventures' IPO performance (time to IPO and market capitalization) and their VCs' *prominence*.[61] They find that

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[59] Specifically, Kaplan and Schoar (2003) find - at the industry level - considerable heterogeneity in returns over time: new partnerships seem more likely to be started and to raise bigger funds in periods after the industry has performed especially well; but funds and partnerships started in boom times are less likely to raise follow-on funds, suggesting that these funds subsequently perform worse. So, aggregate industry returns are lower following a boom, but most of this effect is driven by the poor performance of new entrants, while the return of established funds (i.e. latter funds of the same partnership) are much less affected by these industry cycles. As the authors note, this suggests a boom and bust type cycle in which positive market-adjusted returns encourage entry that leads to negative market-adjusted returns etc.

[60] Hsu (2004) approximates VC' 'reputation' as '*IPO track record*' by a dummy variable that takes the value of 1 if the VC's previous IPO record up to the time of funding the target startup placed it in the upper half of the sample.

[61] Stuart et al. (1999) approximate VC's '*commercial prominence*' by their normalized degree score in the network of strategic alliances (deals): the network is represented by a – quarterly updated - symmetric matrix of all VCs (who had at least one previous biotech alliance/deal) and all biotech

differences in VCs' *'commercial prominence'* but not in their *'technological prominence'* correlate with differences in the performance of subsequent investments in ventures from this industry.

In a similar vein, Chang (2004) examines the time-to-IPO of Internet ventures backed by VCs of different 'reputation', approximated by their *IPO success rate* and by their *previous number of investments*.[62] He finds that the VCs' IPO success rate is positively related to a venture's time to IPO but not their previous number of investments. Furthermore, Chang (2004) also finds that other variables such as 'total amount of VC funding raised prior to the IPO' and 'startup age' are significantly positively related to time to IPO.

Dimov and Shepherd (2004) study the relation between the proportion of ventures in VCs' portfolios that go public and VCs' *general human capital* and *specific human capital*.[63] Their findings suggest that the VCs' general human capital is positively related to the proportion of the VCs' investments that go public, but - contrary to the authors' Hypothesis - it is also positively related to the proportion of bankruptcies in a VCs' portfolio. The specific human capital is

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ventures. The network's elements are the number of 'alliances' (deals) that exist between each pair at time t-1. A VC's normalized degree score then is calculated as the number of all alliances (deals) he is participating in at time t-1 divided by the total number of alliances (deals) at that time period. The interpretation of the normalized commercial prominence score for each VC therefore is the proportion of all biotech alliances (deals) in which he had participated in t-1. Similarly, the authors define *'technological prominence'* as a measure of success of a VC as a biotechnology innovator; technological prominent VCs are those that have 'developed' (are associated with) many influential biotechnology innovations. Technological prominence is measured in terms of a patent citation network in a way similar to that described above for commercial prominence. For each venture, then, the commercial and technological prominence scores of its VCs' are summarized and quarterly updated - to reflect the addition of new VCs. In unreported models Stuart et al, (1999) also use the average prominence scores of a venture's VCs - acknowledging that the addition of low-prestige VCs might downgrade the perception of the venture's quality. But the authors found high correlations between the summarized and average prominence scores of the ventures' VCs and overall consistency between the results based on the two measures.

[62] Chang (2004) approximates VCs' 'reputation by their *previous IPO success rate* (proportion of a Internet ventures in a VC's portfolio that went public, averaged for all VCs invested in a venture) and by their *previous number of investments* (in his sample industry, Internet, averaged for all VCs in syndicated deals).

[63] Dimov and Shepherd (2004) approximate VCs' *'general human capital'* by their top managements' proportional educational background in science and humanities, as well as its professional experience in running an entrepreneurial venture; and VCs' *'specific human capital'* by their top managements' proportional educational background in business, law, and/or finance as well as its professional background in those areas and/or consulting)

negatively related to the proportion of investments that goes bankrupt, but is - contrary to the authors' hypothesis - not positively related to the proportion of investments that goes public.

Finally, Hochberg et al. (2004) study the relation between, on the one hand, VCs' network positions, and, on the other hand, VCs' fund performance and portfolio ventures' performance (in terms of ventures' survival from the first to the third round and/or the time-to-IPO/-acquisition). In this context, the authors also control for various proxies for VCs' 'experience', namely the VCs' previous *amount invested*, *number of rounds participated in*, *portfolio size*, and *age*.[64] Here, the authors find that VCs who enjoy more influential network positions enjoy significantly better performance as measured by the proportion of portfolio ventures that are successfully existed through an IPO or trade sale. Furthermore, portfolio ventures of better-networked VCs are significantly more likely to survive to subsequent rounds and to eventual exist. However, their study generates mixed findings on the impact of lead VC experience: VCs' fund performance is significantly and positively related to all examined proxies for the lead VCs' experience; but venture survival is negatively (significantly in the first round) related to the lead VC's age, positively to the lead VCs' previous number of investments, positively to the lead VCs' cumulative amount invested, and negatively to the lead VCs' portfolio size. Furthermore, the ventures' time-to-IPO/-acquisition is negatively related to the lead VCs' cumulative amount invested, suggesting that more experienced VCs successfully exit their investments faster. However, when both the VCs' network positions and the proxies for VCs' experience are included simultaneously in their models, the authors find that the effects of VCs' experience is reduced and sometimes eliminated.

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[64] Hochberg et al. (2004) focus only on lead VCs, and they approximate their 'network position' by their *degree*, *closeness*, and *betweenness* in the VC network, and their *'experience'* by the *previous cumulative amount invested*, *number of rounds participated in*, *number of portfolio ventures*, and *age since foundation*. However, they consider experience only as a control variable for their analysis of the impact of the lead VCs' network position; and they use all four proxies of the VCs' experience only when studying the VCs' fund performance and investee ventures' survival; but, for their analysis of investee ventures' time-to-IPO/-acquisition, the authors only approximate the VCs' experience by their cumulative amount invested. They justify the use of the VCs' cumulative amount invested as the only proxy for VCs' knowledge for this part of their study by the fact that it had shown the largest economic effect in the previous sections of their study.

C.III. Summary and discussion

In this section we summarize and evaluate the theoretical and empirical literature reviewed above with respect to our key question ('What role does VCs' knowledge play for financing entrepreneurial high-tech ventures; and how does that knowledge affect their investment approach and the performance of their investments?').

C.III.1. Theoretical literature

The theories described above can be understood as underlining the importance of VCs' knowledge as one, but not necessarily the, potential determinant of VC activity and performance.

The *financial intermediation/signalling theory (IST)*, for instance, emphasizes the information asymmetries between entrepreneurial ventures without track record or reputation and investors in general. In this context, the IST could suggest that for VCs to fulfil their role as intermediaries efficiently they have to be (more) informed, i.e. (more) knowledgeable, about the ventures than other investors/external resource providers. But the IST hardly takes into account likely differences between VCs regarding their knowledge. Furthermore, the IST mainly focuses on the relationship between VCs and external resource providers but not on the relationship between VCs and entrepreneurial ventures. Finally, the IST hardly looks at the type of VCs' superior knowledge and how this is gained.

Similarly, the *principal-agent theory (PAT)* focuses on information asymmetries, but on those VCs and entrepreneurs. Emphasizing the VCs' lack of information (or: knowledge) relative to the entrepreneur, the PAT identifies possible causes of conflict and risk, as well as mechanisms to deal with them. As such, the PAT can help understanding the characteristics of VC contracts, and VCs' control/monitoring of investee companies. In this context though, the PAT focuses on the characteristics of different ventures that might impact the VCs' perception of the risk associated with an investment, and their corresponding actions. But the PAT largely ignores differences between VCs, for instance, regarding their knowledge, and how this might impact both the VCs' perceived/actual risk and their means to deal with it. Instead, it seems to *assume* that (all) VCs are experts who are capable of choosing the most appropriate investment approach – totally neglecting variations in types of knowledge, and of course how this knowledge might be gained.

Finally, the *resource-/knowledge-based theory (RKT)*, in contrast to the previous concepts, explicitly acknowledges the importance of intangible, knowledge-based, resources in venture capital investments. According to this theory, valuable resources/knowledge are those that help organizations, including VCs, to gain a competitive advantage by performing their business activities more effectively/efficiently than competitors. As such, the RKT explicitly acknowledges the likelihood of (knowledge) differences between VCs, and the relevance of those differences to VCs' activities and their outcomes. However, the RKT takes a rather static view at the (VCs') knowledge. In fact it is based on the understanding that differences in firms' resources, including firms' knowledge, are 'sticky'; and managers' task is mainly to adapt the best strategy in an (changing) environment, given the existing resources. Thus, the RKT also ignores the issue of how resources, including knowledge, are developed in the first place, and how they can be developed/accumulated further.

Thus, with view to answering our key question, these concepts are of limited value: they do not suggest what kind of knowledge is relevant for VCs, and how this knowledge could best be measured/approximated.

C.III.2. Empirical literature

The empirical literature reviewed above provides ambiguous answers to our guiding question.

On the one hand, VCs have apparently evolved an investment approach that is distinct from that of more traditional investors in several respects, and one presumably tailored to dealing with the particular challenges and risks associated with investing in entrepreneurial high-tech/fast-growth ventures. In this vein a number of empirical studies suggest that VC-backed ventures perform better than non-VC-backed companies, and that some VC-backed ventures perform spectacularly well. As such, one might assume VCs are indeed experts in identifying and/or managing promising investments.

On the other hand, there is also evidence that a positive relation between VC backing and investment performance cannot in general be taken for granted. Only few VC-backed ventures perform extremely well; and the overall failure rates even of VC-backed ventures are high. Moreover, some studies cast doubt whether VCs behave fully rational when evaluating investment opportunities; and VCs apparently can even have a detrimental impact on the development of their investee ventures.

But even those studies that suggest a positive relation between VC-backing and investment performance hardly provide evidence as to the causality at work. Some types/intensities of VCs' activities might be positively related to venture performance, but not others; and also the same VC activities are not always positively related to venture performance. Similarly, some VCs seem to do well despite adopting a hands-off approach whilst others seem to do less well despite a hands-on approach.

In sum, there seems to be considerable variability in both the VCs' investment approach and in how this translates into the performance of VCs' investments; but there is very little understanding of what causes this variability.

Whilst this ambiguity in the findings of the empirical literature may have several explanations, one plausible one is the heterogeneity of VCs' characteristics in general, and of their knowledge in particular: only some ('knowledgeable') VCs may be capable of undertaking the appropriate activities at an adequate intensity, and this in turn may translate into superior performance of their investments; but other ('less knowledgeable') VCs may be incapable of doing so, with a corresponding negative effect on the performance of their investments.

Up until the present differences between VCs' characteristics in general, and in their knowledge in particular have been given scant attention in the empirical literature.

The majority of studies treat VCs as a homogenous group, and where studies look at differences between VCs, they commonly focus on differences in 'what VCs *do'*. Differences in VCs activities are often seen as a consequence of different investment policies and/or different investment situations - for instance, in response to certain venture characteristics that might be associated with different levels of risk, and therefore 'trigger' different VCs activities.

Very little research, by contrast, takes into account differences in 'what VCs *know*' and how this relates to VC activities and to investment performance. In doing so, this research presumes that (all) VCs have the appropriate type and level of knowledge for their activities.

This is not withstanding the fact that the few studies that do differentiate between VCs on the basis of VC characteristics (VC 'differentiators') interpretable as *potential* proxies for VCs' 'knowledge' suggest that such differences could indeed be important.

However, even those studies fail to provide a clear indication as to how VCs' 'knowledge' is related to VCs' investment approach and/or the performance of their investments.

This might be because the VC 'differentiators' used to distinguish between VCs are either fundamentally inappropriate as proxies for VC knowledge or because the way in which they have been used is inappropriate to the task. Either way, they could conceal the 'true' impact of VCs' knowledge.

To illustrate this, in the following, we shall critically examine the most commonly used VC 'differentiators' *potentially* interpretable as proxies for VCs' knowledge

Table C-1 summarizes the limited literature reviewed above that differentiates between VCs.

*** INSERT TABLE C-1 HERE ***

As column 1 in Table C-1 shows, in the existing literature one can identify six main groups of VC 'differentiators': the VCs' 1) age/years of activity, 2) size/funds under management, 3) reputation/network characteristics, 4) IPO track record, 5) human capital, and 6) number and/or type of previous investments.

However, as column 2 in Table C-1 shows, each of these six 'differentiators', in turn, has been operationalised slightly differently by different researchers. For instance, VC age has been operationalised as the absolute age since foundation of an individual VC or as the VC's relative age compared to his peers in a given year (in most cases, column 2 only shows simplified versions of the actual operationalization, the detailed description of which is to be found in the literature review above).

Furthermore, as is evident from columns 3 and 4 in Table C-1, researchers have sometimes used these 'differentiators' in studies with different foci; and they have also sometimes used several differentiators simultaneously in the same study (column 4 refers to the sections in the above review of the empirical literature where further details on each study are to be found).

Overall, as is clear from column 5 in Table C-1, these studies show that it indeed makes sense to differentiate between VCs. Almost all studies that do so reveal that differences in VCs' 'knowledge' are related to differences in the dependent variable(s).

With view to our key question however, the crucial issue is whether the 'differentiators' used in the literature and the methods by which they have been employed are suitable to proxy VCs' knowledge, and hence to examine the impact of VCs' knowledge on VCs' investment approaches or on the performance their investments.

To address this issue, the last column in Table C-1 provides our overall assessment of the suitability of each VC 'differentiator' (in the way it has been operationalised) and the method in which it has been employed as a proxy for VCs' knowledge.

To illustrate, some 'differentiators' could in principle serve as suitable proxies for VCs' knowledge (indicated by a '+'), but the specific method, in which they have been employed in a particular study is inadequate (indicated by a '-'), for instance, because the study only focussed on the first rounds of ventures, or only on a particular industry sector.

It must be emphasized that in making this assessment it is impossible in most cases to arrive at a simple 'thumbs-up' or 'thumbs-down' conclusion, particularly with view to the measurement of something as intangible as knowledge. Therefore, our assignment should be understood as indicative rather than definitive.

We shall subsequently sketch out the detailed rationale behind this assessment devoting separate sections to each VC 'differentiator'. Then, in the next chapter we shall describe what we feel is the most suitable way to measure VCs' knowledge, at least for large-sample studies.

Age / years of activity

Several studies differentiate between VCs on the basis of *age* (e.g.: Barry et al., 1990; Bottazzi et al., 2004; Hochberg et al., 2004; Kaplan et al., 2004; Lerner, 1994, 1995; Manigart et al., 2002; Sorenson & Stuart, 2001) or the *time the firms' investment managers have spent in the VC industry or in the industry of the venture under consideration* (e.g. Bottazzi et al., 2004; Sapienza et al., 1996).

Sorenson and Stuart (2001), for instance, explain the rationale for using the VCs' age as a proxy for their knowledge by arguing that the age of a venture capital organization captures at least four dimensions of tenure in the industry: 1) as firms get older their members probably extend their networks both within the venture capital community and amongst entrepreneurs; 2) even without forming new ties, the spatial reach of a venture capitalist's contact network likely increases over time; 3) as they age, venture capitalists also accumulate experience in evaluating business proposals and entrepreneurs that could improve their ability to perform these tasks at-a-distance; 4) long-tenured firms in the industry often become widely known, increasing the likelihood that other VC firms will bring good investment opportunities to them.

However, as Lerner (1994) notes, the VCs' age 'is not an obvious way to distinguish between established and marginal VC organizations. While many influential VC organizations, such as Greylock and TA Associates, date back to the 1960s, others of today's leading VCs did not close their first fund until the 1980s. Furthermore, a substantial number of venture organizations have operated for some time without ever becoming major factors in the industry' (Lerner, 1994). This argument also finds support by Lange et al. (2001), who find that from the top 14 VCs identified in the study by Stein and Bygrave (1990) for the period between 1979 and 1987 only four were still amongst the top 16 identified in their own study for the period between 1998 and 1999.

Furthermore, one might argue that when looking exclusively at a very young high-tech industry, such as biotechnology, using VCs' age as a proxy for their experience becomes even more questionable. In such new industries it might make a difference whether a VC is 2 years or 20 years, but much less of a difference whether a VC is 20 or 40 years old.

Similar arguments could be made with view to the studies that used the length of time an individual VC has spent in the industry, since this provides us with no idea about the number or the types of deals a VC has made during this time.

Size / funds under management

Several studies differentiate between VCs on the basis of the VCs' *size*, commonly operationalised as their *funds under management*, (e.g.: Barry et al., 1990; Bottazzi et al., 2004; Bygrave, 1987, 1988; Kaplan et al., 2004; Kaplan & Schoar, 2003; Lerner, 1994, 1995) or as funds invested in the year prior to the time of the investment under consideration (e.g. Gulati & Higgins; 2003; Hochberg et al., 2004).

However, VC size also seems a questionable proxy for VCs' knowledge. Gorman and Sahlman's (1989) survey of 43 VC firms, for instance, shows that there are wide variations in the reported rate of new investments, ranging from a high of 30 to a low of 4, with a mean of 11.2 per year (SD 5.6). But, as the authors note, the rate of new investments is *not* strongly correlated with firm size. Instead, the authors find that small VCs, despite their size, often make a substantial number of new investments per year, relative to medium-size firms, whereas many large firms make surprisingly few investments. One explanation for this might be that VCs prefer larger investments for their economies of scale. Hence, one might assume that many larger VCs actually have made fewer investments relative to their funds than younger (and smaller) VCs.

Lerner (1994) also notes that the VC size does not necessarily provide an indication of industry expertise. Big VC firms are not necessarily experienced in specific sectors and/or stages of investee companies, because they prefer a diversification approach, providing them with little expertise in specific sectors.

Furthermore, the knowledge of (many) VCs that specialise in certain segments such as early-stage high-tech ventures might not be closely related to the funds under management, because those investments might often not require substantial funding.

Another argument against the use of VC size as a proxy for knowledge is that in the last years of the Internet-frenzy investors were willing at times to provide substantial funds to new – and inexperienced - VCs.

Finally, the findings by Jääskeläinen et al. (2003) and Kaplan and Schoar (2003), which indicate an curvilinear relation between a VC's portfolio size and success rates respectively and the return to VC funds, indicate that size as such is not necessarily a good proxy for VCs' success, and also not for VCs' success-relevant knowledge.

Reputation / network characteristics

A few empirical studies distinguish VCs by their *reputation* or *network characteristics* (e.g. Stuart et al., 1999; Hochberg et al., 2004; Hsu, 2003).

However, whilst these differentiators may capture certain knowledge-relevant aspects (e.g. the VCs' knowledge as perceived by third parties), we shall argue that the way this measure has been used in the extant literature casts some doubt on whether it is really a suitable proxy for VCs' knowledge.

Stuart et al. (1999), for instance, arguably present the most sophisticated calculation of a VC's network-position. They distinguish VCs based on their relative technological and commercial *prominence* (measured as 'degree scores', for details see further above). However, although more sophisticated than most measures, VCs' 'prominence' seems imprecise if one is interested in the relation between VCs' knowledge and their investment approach, or the performance of their investments. Instead, as intended by the authors, this measure of prominence might rather be seen as a proxy for VCs reputation and for their ability to 'signal' to outside investors, than for their actual knowledge. This is for several reasons. To begin with, the proxies for VCs' prominence – both commercial and technological - are proportional values, which reflect the prominence of a VC relative to that of other VCs at a particular point in time. However, it does not provide any information about their absolute knowledge at that point of time. Another issue with their measure concerns the fact that these prominence proxies are exclusively based on 'prominence' in a certain industry (biotechnology). Whilst there are good arguments to believe that prominence in a particular industry is important, there are also good arguments to believe that the general prominence – resulting from investments overall – might be of relevance, too.

The remaining authors' approaches to differentiating between VCs on the basis of their reputation seem to be of very limited value when one is interested in VCs' knowledge.

Hsu (2003), for instance, approximates a VC's reputation by the entrepreneurs' assessment of his *network resources* and *industry reputation rank* (as described in more detail before). Whilst this might provide some insights, it seems also reasonable to argue that a startup entrepreneur will not necessarily have a good overview over the resources actually available to a VC. As such, proxies exclusively based on the entrepreneurs' perception might be considered unreliable, at best. Furthermore, it should be noted, Hsu (2003) only focuses on the reputation of the lead VCs in syndicated deals (65% of his sample); whereas it does not seem implausible to assume that also the knowledge/reputation of other syndicate members plays an important role from the entrepreneurs' perspective. Finally, Hsu himself differentiates between this measure and the more 'objective' measure of 'industry deal experience' (discussed further below).

Hochberg et al. (2004), in contrast, differentiate between VCs on the basis of their *position in the overall network of VCs* (degree, closeness, and betweenness). However, also those measures seem imprecise, at best, if one is interested in VCs' actual knowledge. For instance, a VC might develop a great network. But if he never takes on the role of a lead VC, he is unlikely to learn from his investments as much as VCs that do. Indeed, the authors also acknowledge that the VCs' network position not necessarily reflects the VCs' experience, for which they control separately – by the lead VCs' cumulative amount invested, number of previous rounds, number of previous portfolio ventures, and age (discussed in the sections further above and below).

Human capital

A very small number of studies focus on the *human capital* of VC firms' investment managers or partners (Bottazzi et al., 2004; Busenitz et al., 2004; Dimov & Shepherd, 2004).

Bottazzi et al. (2004), for instance, approximate VCs' degree of *specialization* on the overall firm level and the investment manager level by several 'human capital' variables such as 1) *business experience* (experience in finance, accounting, consulting, legal, and industry), 2) *science education* (business, humanities, engineering/science, law and social sciences), and 3) *venture experience* (years in VC industry). Whilst certainly an interesting approach, it is also not without its limitations. Most noteworthy in this context, the authors measure both the business background and the educational background of partners simply by a variable that takes the value of 1 if a partner has the respective knowledge, and the value of 0 if he hasn't; and they then average those values for all partners in a firm. Clearly, this is a very crude measure of the partners' or firms' actual human capital since it assumes additivity across individuals. With a view to the time a VC manager has spent in the VC industry, the reader is referred back to our discussion of the 'age' of the VC firm where the same criticisms apply.

Dimov and Shepherd (2004) differentiate between VCs *general human capital* (top managements' proportional educational background in science and humanities, as well as its professional experience in running an entrepreneurial venture) and the *specific human capital* (top managements' proportional educational background in business, law, and/or finance as well as its professional background in those areas and/or consulting). However, whilst interesting, this approach is also not without problems. Most obviously the study uses the *proportional* background of the VCs' management teams (prevalence of a certain type of human capital within the management team). As such, at team would be assigned a score of, say, 0.4 for its background in science if 2 out of 5 team members had an educational background in science, or if 20 out of 50 team members an background in science. Similarly, the study looks at qualitative effects of VCs' knowledge, but it ignores the quantitative aspects. Thus, it would make no difference to the measure whether a VC's top-management team had acquired sector-specific experience from investing in ten or just in one venture from that sector in a given period of time. However, the qualitative categorization used in the study is also not convincing. For instance, contrary to the authors, one might argue that an educational/academic background in science is a specific – rather than a general - aspect of human capital when it comes to evaluating and managing a science-based venture. Furthermore, the study neglects the impact of staff fluctuations, which arguably could have a severe impact on the knowledge base, particularly of small VC firms. For instance, the study wouldn't consider a potential positive impact of a very experienced VC who had recently left the firm. Related to this, the study seems to have inconsistencies in the units of analysis: it uses the human capital of a VC firm at the time of the analysis; but it analyses the investments made by those VC firms over the past 5 years. Clearly, given the likely fluctuation in human capital in those firms, one might assume that the actual human capital available to a firm at the time of an investment might be different to that available at the time of the analysis. Finally, and more generally, the approach of this study raises the question of the relative importance of individual vs. organizational knowledge and learning, a topic which we shall deal with in detail in the next chapter.

Busenitz et al. (2004) examine the relation between the quality of *strategic advice given by VCs* to their ventures (interpretable as an indirect proxy for VCs' human capital or knowledge) and the subsequent outcome of those ventures. They ask each ventures' top-management team to rank the information-based advice obtained from their VCs regarding business, financial, and management advice.

However, this approach also seems inadequate in an examination of the role of VCs' knowledge. Most obviously, the assessment by often inexperienced entrepreneurs of the quality of advice obtained from their VCs is likely to be a very subjective and imprecise measure for VCs actual knowledge. Furthermore, if at all, it can by definition only capture knowledge in form of the advice the VCs are willing to provide to their investee ventures, and is unlikely to provide insights about the knowledge VCs actually possess. For instance, some knowledgeable VCs might have investment policies, which prevent them from getting actively involved in their portfolio ventures. This might also explain why the authors don't find the hypothesised relation between VCs' advice and venture outcome.

IPO track record

A few studies use the number of VCs' *previous investments that went public* as a criterion to distinguish between VCs (e.g. Barry et al., 1990; Chang, 2004; Hsu, 2004; Lange et al., 2001).

Once again, the way in which this proxy has been used in previous research makes it questionable as a proxy for VCs' knowledge.

Barry et al. (1990), for instance, use the *absolute number of IPOs* in a VC's portfolio. Clearly though, this measure is only of limited value for assessing a VCs' actual success without knowing the absolute number of ventures in a VC's portfolio. A VC would be considered equally knowledgeable if he achieved 10 IPOs out of 100 investments than if he achieved 10 IPOs out of ten investments. In addition, as Barry et al. (1990) themselves point out, there might be correlations between the VC's age, his funds under management, and his number of IPOs. Older VCs are likely to have more funds under management, and consequently might achieve more IPOs, for instance, because they might invest in more ventures (law of large numbers) and/or they invest more in their ventures. However, assuming that VCs – as indicated above - generally prefer larger investments (economies of scale), one might also assume that older (and larger) VCs actually have made fewer investments relative to their funds than younger (and smaller) VCs. So, although the total number of IPOs might be higher for older/larger VCs their relative number of IPOs might be smaller that of younger/smaller VCs. This, in turn, might also impact their ability to learn from different investments.

Similar arguments could be made with a view to Lange et al.'s (2001) approach who differentiate between two *top* and *non-top* VCs in their sample of 106 VCs on the basis of the absolute number of IPOs these VCs have been involved in.

Chang (2004), by contrast, uses not the absolute but the VCs' *relative IPO success rate* with view to investments in Internet related sectors (proportion of a VC's investee ventures that had an IPO, averaged for all VCs invested in a venture). However, using *relative* IPO success rate means that a VC with 1 IPO out of 2 investments would be considered as knowledgeable/well-reputed as one with 50 IPOs out of 100 investments (since both have 50% success rate). This assertion seems questionable, at best. In addition, also the exclusive focus on one sector is unlikely to reveal much about the overall IPO success rate, or the knowledge, of VCs in Chang's (2004) sample.

Hsu (2004), furthermore, uses the *VCs' IPO track record* to date as a proxy for knowledge (dummy variable = 1 if the VC's previous IPO record up to the time of funding the target startup placed it in the upper half of the sample). This approach again falls short of capturing VCs' 'true' knowledge. To begin with, Hsu (2004) only refers to the VC's IPO track record; but it is not evident how he deals with the likely fact that many ventures are backed – in several rounds -

from syndicates of VCs and not just from one-time ('lone') investors (as a matter of fact it remains completely unclear how many different VCs are included in his analysis overall). Furthermore, he develops the VC reputation dummy variable without acknowledging possible differences regarding the industries in which those IPOs took place. In this context one might argue that VCs' reputation – and knowledge – might be quite different if all of their previous IPOs have taken place in the same industry as the one of the particular venture now under consideration, or if they have taken place in very different contexts. So, this measure does not provide further insights, for instance, into the relevance of VCs' specialization in particular sectors. In addition, with a view to the IPO success rate as a proxy for knowledge, one might also add that the number of IPOs a VC might achieve in his portfolio is likely to be determined by environmental factors, such as the 'windows of opportunity' in the markets. Without controlling for those factors (which is difficult taking into account that a VCs' portfolio ventures, if at all, don't' go public at the same time, and under the same market conditions), it might well be that a young and ignorant VCs manages to bring several ventures to the market within a very short period of time, whilst an knowledgeable and long-established VCs, over his lifetime, might have brought relatively less ventures to the market (but might have profitably sold them instead to third parties during the many times when the window of opportunity was closed).

Furthermore, as suggested by Lerner's (1994) study, it might also be the case that, particularly large and cash-rich, VCs try to 'window-dress' by investing in later (pre-IPO) rounds of well performing ventures to impress their own investors. Again, this would not necessarily predict a strong relation between VCs' actual knowledge and their IPO success.

Finally, and quite importantly, it seems plausible to argue that VCs – as everyone else – should learn not only from past successes, but also from past failures.

Type / number of previous investments

Several studies use the *actual or preferred type or number of previous investments* to distinguish between lead VCs or simply VCs' 'knowledge' (for the former see e.g. Bygrave, 1987, 1988; Lockett & Wright, 1999, 2001; Manigart et al., 2004; for the latter see e.g.: Hochberg et al., 2004; Hopp & Rieder, 2004; Lerner, 1994; Sorenson & Stuart, 2001). A related measure is the number of seats held by VCs in different portfolio ventures (Stein & Bygrave, 1990).

For reasons we will describe in the next chapter, we believe that the VCs' type and/or number of previous investments are arguably the most appropriate proxies for VCs' knowledge. However, the way in which most of these proxies have been used in extant literature seems once more of limited value in answering our key question.

Bygrave (1987; 1988), for instance, categorizes VCs, in a random sample of VC investments from the Venture Economics database, according to their *investment preference* (high- or low-innovation ventures). This approach seems insufficient to proxy for VCs' knowledge for several reasons. To begin with, by focussing only on the proportions of high- to low-innovation investments and the absolute number of either high- or low-innovation investments, it neglects all the other investments a VC might have made. So, if at all, this categorization of VCs' knowledge provides only a vague clue about the VCs' relative specialization, but not about the VCs' absolute (specialist) knowledge. Also, a VC with a very large number of high-innovation investments would not appear in the 'high-innovation VC' (HIVC) group as long as he does not simultaneously have a very high proportion of high- to low-innovation investments; instead, he might appear in the medium innovation VC (MIVC) group. At the same time, a VC with a smaller number of high-innovation investments might appear in the HIVC group as long as he simultaneously also has a high-proportion of high- to low-innovation investments. In fact, the actual proportions of high- and low-innovation investments made by the VCs in the overall sample are quite different from those Bygrave uses in his sample. Finally, even if one accepts that Bygrave's approach is suitable for measuring the relative level of specialization, one has to note that he uses the term 'high-innovation' for a variety of industries as different as communication, electronics, and genetics. Clearly though, each of these sectors requires very different types of knowledge and specialisation to realistically assess an investment opportunity and to provide adequate post-investment resources to it. Indeed, Bygrave (1988: 139) himself acknowledges that in different industries, there is different uncertainty: 'all industries have a degree of uncertainty; but some industries face more uncertainty than others. For example, it is clear that an emerging high technology industry such as genetic engineering faces much more uncertainty than a low mature technology industry such as candy manufacturing'.

Stein and Bygrave (1990), in contrast, differentiate between non-/top-20 VCs' on the basis of the *number of seats* they hold on the board of directors in their 77 sample ventures. The shortcomings of this approach for approximating VCs' knowledge are obvious. Even if one accepted that there is a relation between

VCs' knowledge and their holding of seats on their portfolio companies' boards, Stein and Bygrave's (1990) study is clearly limited in that it only considers the seats held by the (top-20) VCs in a small sample of ventures. It is obvious that the picture might be very different when looking at the seats held by the (top-20) VCs in all their portfolio ventures. In addition, this approach does not take into account that many ventures are funded not just by one VC but also by syndicates of VCs, and in several rounds. As such, the composition of a venture's board can – and often does – change in the course of several investment rounds. At the same time Stein and Bygrave (1990) note that ventures backed by a top-20 VC commonly are also backed by a top underwriter; and the individual effects of the VCs and the underwriters could not be distinguished. Thus the method used fails to identify the role of VC knowledge as distinct from underwriter knowledge/reputation in venture performance.

Lerner (1994) categorizes VCs based on the *number of their previous investments in biotechnology*. Again, as we shall mention below, this measure might be a suitable partial proxy for VCs' knowledge. However, taken alone, it seems insufficient because it provides no indication of VCs' *general* level of knowledge and experience in the venture capital industry *as a whole* and thus assumes that only industry specific experience is relevant. Furthermore, Lerner (1994) uses his proxy for an analysis only of later round syndications, excluding first round and multiple round syndications for no obvious theoretical reason; and his discussion of the methodology he adopts is rather sketchy.

Lockett and Wright (1999, 2001) approximate VCs' level of specialization by their *self-reported industry and deal-size preferences*. Apart from the general problems regarding the reliability of survey-based self-assessments, this categorization obviously tells little about the VCs' *actual* level and type of knowledge. For instance, it tells us little about their knowledge of a particular industry sector or of a certain venture's development stage. All it tells us is that the VC *believes* it has certain preferences for those investments. But whether this preference actually materializes in investment decisions, and if so, in how many, remains an open question.

Sorenson and Stuart (2001) use the *number of previous ventures a VC has invested in* (*overall or in a particular industry*). However, they use these proxies only to examine the impact of VCs' knowledge on the VCs' 'investment reach' i.e. their likelihood of investing in geographically distant opportunities. As such, this study provides interesting if limited insights into how VCs' knowledge impacts on a particular feature of their investment *behaviour*, but none into how VCs' knowledge impacts investment *performance*. Furthermore, one might argue that the number of ventures a VC has invested in fails to take into account the fact that VCs often make several investments in the *same* venture at *different* stages of its development; and that this might well offer additional experience from each of those investments.

Hsu (2003) also approximates the *first-round lead VC's reputation* by his 'industry deal experience' (a dummy variable equal to 1 if the VC's number of *previous investments* in the investee company's industrial segment places him above the sample median). But this approach also seems unsatisfying as a way of proxying VCs' knowledge. To begin with, whilst the VCs' 'industry deal experience' might capture an important type of VC knowledge, it neglects VC knowledge resulting from all other investments outside the immediate target sector of an offer. So, according to this categorization, a VC with 100 investments in various sectors but none in the target sector might end up as less 'well-reputed' compared to a VC with just one investment in the target sector but none outside. Furthermore, using a dummy variable that differentiates only between 'above and below median VCs' is clearly a rather imprecise measure. Another issue that is left unresolved in his study concerns the fact that in cases of syndicated offers, he uses only the reputation of the *lead* VC, thereby neglecting the potential relevance of other syndicate members' knowledge.

Chang (2004) approximates the *reputation* of VCs in their sample by their *previous number of investments in Internet ventures*, averaged over all VCs involved in syndicated deals. This also raises issues. Firstly, using only the number of VCs' previous Internet investments neglects the 'knowledge' VCs might have developed by investing in other, non-Internet-related ventures. (It may also explain why Chang couldn't find the hypothesized negative relation between VCs' reputation and a venture's time to IPO). Furthermore, one might argue that averaging reputation defined as the number of previous investments of all VCs in *syndicated* deals might seriously distort the actual reputation of *individual* VCs in the syndicate.

Hochberg et al. (2004), like Chang (2004), use the *number of the lead VCs' previous investment rounds* and *ditto portfolio ventures* as two proxies for the lead VCs' knowledge as control variables for their study of VC fund and portfolio venture performance. However, the authors focus only on the lead VCs' knowledge and fail to differentiate between different types of previous investments, such as those done in different industry sectors. Again, this might also explain why they fail to find a consistent or significant relation between the various proxies for VCs' knowledge and investment performance.

Hopp and Rieder (2004) approximate VCs' experience by their aggregate number of previous investments, but then categorize VCs in groups of 'one time investor' (1 investment), 'very small VC' (2-3 investments), 'small VC' (4-6 investments), 'lower middle field VC' (7-10 investments), 'upper middle field VC' (11-20 investments), 'large VC' (21-50 investments), and 'very large VC' (> 50 investments). Whilst this approach is interesting in that it takes into account the actual investment experience, it is limited in that it does not differentiate between different types of previous investments (i.e. different types of previous experience).

Kaplan et al. (2004) take a novel approach in differentiating between VCs' using a variable defined as *familiarity with investments in the US* (and with US-style investment contracts). The authors argue that exposure to the US, the most mature venture capital market in the world, should allow VCs to gain the most, and most efficient, knowledge as regards contractual design. So, assuming that US VCs are indeed more knowledgeable and that non-US VCs familiar with the US actually learn from the US, one might argue that this could be a suitable (or at least innovative) proxy for some types of VC knowledge. However, this approach also seems to suffer from deficiencies. To begin with, the authors use dummy variables (indicating whether the lead VC is based in the US, had previously syndicated with US VCs, or had no US experience at all). Clearly this is a very crude measure for VCs' actual familiarity with the US, as it does not account for quantitative aspects of the relationship. In addition, it seems fair to say that although 'familiarity with the US' might proxy for some aspects of VCs' knowledge (e.g. regarding contractual design), it certainly neglects many other important aspects of VCs' knowledge, such as expertise in certain industries or at certain venture stages.

Finally Manigart et al. (2004), categorize VCs according to their development stage preference (based on the relative proportions of their investments in early or later stages), as well as their self-reported relative industry specialization (Likert scale). Again also this approach seems insufficient when dealing with VCs' knowledge. With respect to the *development stage preferences*, one might note that a VC with just one investment in a venture that happens to be younger as the average of all sample ventures would be considered an early-stage investor, as would be a VC with 100 investments that are on average younger than all sample ventures. Furthermore, the authors find that whilst later stage investors are older than early stage investors and have more investments in their portfolio, they are less specialized in particular industries. This suggests that whilst there might be a positive relation between VCs' age and their total experience, there is no such relation between VCs' age and their particular expertise. With respect to the relative *industry specialization* as a means to categorize VCs, we refer back to our above critique of Lockett and Wright's (1999, 2001) approach. Indeed, Manigart et al. (2004) themselves acknowledge that their lack of more significant findings should be treated with caution, as they 'rely upon a crude measure of VC firm specialization. Research that uses a more refined measure of VC specialization might yield stronger conclusions'.

C.IV. Conclusion

The preceding review of literature leads us to several conclusions as to how to answer our guiding question: 'What role does VCs' knowledge play for financing entrepreneurial high-tech ventures; and how does it affect their investment approach and the performance of their investments?'.

Beginning with the theory, the three theoretical perspectives examined - the financial-intermediation-, the principal-agent-, and particularly the resource-/knowledge-based perspective - can all be understood as implicitly or explicitly emphasizing the relevance of VCs' knowledge for their investment approach and the performance of their investments. However, with view to answering our key question, these concepts are of limited value: they do not suggest what kind of knowledge is relevant for VCs, or how this knowledge could best be measured.

The empirical literature might be understood as suggesting a potentially important role of VCs' knowledge for VCs' investment approach and investment performance. But overall it provides an inconsistent answer to our research question. Findings from the literature reveal considerable secular variability in both VCs' investment approaches and in the performance of VCs' investments. But the driving forces behind this variability, and particularly the role of VCs' knowledge in this context, remain poorly understood.

On the one hand, there is no doubt that differences between VCs may relate to differences in VCs' investment approach and/or the performance of their investments. On the other hand, existing studies have distinguished between VCs, if at all, on the basis of 'differentiators' that are unsuitable proxies for VCs' knowledge; or they have employed those 'differentiators' in unsatisfactory ways in attempting to capture the impact of VC knowledge.

For example, some studies have focussed only on the 'knowledge' of lead VCs *or* on the average 'knowledge' of syndicates; some studies have looked only at the VCs' 'knowledge' overall *or* at their knowledge with respect to a particular focal industry; and some studies have looked only at the 'knowledge' of the VCs in first rounds but not in later rounds.

It therefore seems possible that some of the ambiguity in the empirical findings of the literature is caused by the inadequate proxying of VCs knowledge. Thus, it seems plausible to argue that, if approximated more adequately and systematically, VCs' knowledge could help to explain some of the ambiguity in the findings of existing research on VCs' investment approach and investment performance.

Furthermore, even when previous studies have used suitable VC 'differentiators' and methodologies, they have examined only limited aspects of VCs' investment approaches and the performance of VCs' investments. For instance, a few studies have examined the impact of VCs' 'knowledge' on their post-investment monitoring and supporting activities, but none has looked at the impact of VCs' knowledge on other aspects of VCs' investment approach such as the staging of investments. Similarly, a few studies have looked at the relation between VCs' knowledge and the post-IPO performance of their investments, but virtually no study has looked at the impact of VCs' 'knowledge' on the early stage development of their investments. This leaves a great deal of scope for further research in the area.

Based on the above conclusions, we begin in the next chapter to develop more adequate and systematic ways of measuring VCs' knowledge and its impact on investment approach and performance.

CHAPTER D: RESEARCH PROPOSITIONS

In the previous chapter we concluded that, if extant empirical literature has looked at differences between VCs at all, it has mostly used VC 'differentiators' that are arguably inappropriate to serve as proxies for VCs' knowledge, and/or employed those 'differentiators' in too unsystematic ways to capture all potentially relevant knowledge.

This, however, raises the question 'what are (more) suitable proxies for VCs' knowledge, and what are (more) systematic ways to use them?'.

Therefore, in this chapter, we set out to propose what we believe are more suitable proxies and more systematic ways to measure VCs' knowledge than have been used in most extant literature – as a fundament for our examination of several research hypotheses that will be presented in subsequent chapters.

D.I. Deriving proxies for VCs' knowledge

Taking into account the intangible nature of knowledge, defining suitable proxies and ways to measure VCs' knowledge clearly presents a major challenge.

For this purpose also the most commonly employed theoretical concepts in research on venture capital are not of much help. This is because they either neglect differences between VCs - including differences between VCs' knowledge - altogether, or do not specify the relevant knowledge in this context.

One plausible way to approach the above question though is to examine first how organizational knowledge is developed – as a precondition for developing adequate proxies for it.

This, in turn, leads us to another stream of literature, organizational learning, which has not yet been employed in the venture capital context but promises to provide valuable insights to the above question.[65]

In the following sections, we first review the literature on organizational learning in general, and then see how it might translate into the venture capital context.

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[65] In the research on venture capital, to our knowledge, only Busenitz et al. (2004) have explicitly referred to the literature on organizational learning. However, they don't use this concept to develop a proxy for VCs' knowledge.

D.I.1. Organizational learning in a general context

The notion of 'organizational learning' has become a prominent concept in management research. However, as Miller (1996: 485) notes, although organizational learning processes are being explored with increasing interest and vigour, 'it remains unclear just what learning is, how it takes place and when and why it occurs. [...] Part of the problem is that learning, as portrayed in the literature, is a haphazard and eclectic notion; researchers lump together processes that are strikingly different in their causes, effects, and domains'. Similarly, also Argote (1999) points out that the concept of 'organizational learning' is like an 'umbrella' for many related concepts from areas as different as economics, management, and psychology.

Overall, this has led to a variety of definitions of 'organizational learning' (Argote, 1999; Cyert & March, 1963; Huber, 1991; Levitt & March, 1988; Miller, 1996). But most definitions share at least one key assumption. This is that learning improves performance (e.g. Hagedoorn, 1995; Mezias & Glynn, 1993). For instance, Fiol and Lyles (1985) define organizational learning as 'the process of improving actions through better knowledge and understanding'. Similarly, Hitt and Ireland (2000) argue that organizational learning is 'the creation of new knowledge within the firm that can improve performance'.

Yet, having 'defined' organizational learning in this way, this still does not explain how organizational learning actually occurs. From the extant literature it seems that learning can take many forms and occur in many settings - in a highly complex process, influenced by a variety of factors - and interactions between them - such as the type of knowledge to be learned, the units of learning, the environment in which learning takes place etc. (Miller, 1996).

Whilst there is still little agreement on the key mechanisms of learning, one of the most well established concepts in this context is that of 'learning by doing', which we refer to as the key concept for our subsequent propositions.

D.I.1.a) The concept of 'learning by doing'

Already in 1936, Wright observed that the amount of labour it took to build an aircraft decreased at a decreasing rate as the total number of aircraft produced, the cumulative output, increased. This observation provided the basis for a phenomenon that became known as the 'learning curve'.[66] Simply put, this

[66] The classical form of an organizational learning curve is: $Y_t = ax_t^{-b}$; or, in logarithmic form: $y_t = a - bx_t$, where: Y_t = number of labour hours required to produce a unit of output at time t; $y_t = \ln(Y_t)$;

concept asserts that organizational performance increases with increases in experience from previous activities, i.e. from 'learning by doing'.[67]

In the early literature on the learning curve, the focus was on productivity increases due to learning phenomena; and most research took a 'black-box' approach, merely focusing on in-/out-put relations but largely neglecting the underlying reasons for productivity increases (Pisano, 1994).

More recent research also used other measures for the outcome of learning such as the quality of products produced (Argote, 1993), or organizational survival (Baum & Ingram, 1998), mainly concluding that those other outcomes follow a learning curve, too. Furthermore, some conceptual work has also started to 'dig deeper' by examining possible intra-organizational mechanism for performance improvements due to organisational learning.[68]

Overall, this literature suggests that past experience influences organizational behaviour (March, 1988), and organizational performance. Bowman and Hurry (1993), for instance, note that prior investment and its associated learning gives the firm experience and insight into the firm's own strengths and weaknesses, as well as the likelihood of success of a project; and Argote (1999) notes that experience can enhance organizational performance in three different ways: 1) improvements in the performance of individual employees including management, 2) improvements in the organizational technology; and 3)

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a = number of labour hours required to produce the first unit (unit cost of first unit*); b = learning rate; a = constant; t = time; x_t = *cumulative* number of units produced through time period t. In logarithmic form the relationship is a negatively-sloped straight line with slope b, the rate of learning. b shows the elasticity (proportionate response) of current productivity to cumulative output at time t. Thus, the greater the 'experience' of the workforce the greater the unit cost reduction from learning; and, plotting learning against time, the curve has an upward slope.

[67] Arrow (1962) built on this idea by formulating the theory as an optimising economic model of a monopolist manufacturer. He showed that if knowledge is approximated by cumulative output then to maximise profits the monopolist will at each instant in time set marginal revenue from output equal to the average discounted unit cost of output in the future, rather than the traditional current unit cost. This formulation takes into account the effect of learning on future costs via cumulative output (experience) and implies that the learning monopolist will produce a larger output than the non-learning monopolist. As a result, output will increase through time as the monopolist takes advantage of the cost savings from learning.

[68] See, for instance: Argyris & Schön, 1978; Autio et al., 2000; Busenitz & Barney, 1997; Daft & Weick, 1984, Gavetti & Levinthal, 2000; Krabuanrat & Phelps, 1998; Tversky & Kahneman, 1974; Weick, 1979.

improvements in the organizational structure, routines and methods of coordination.

But, at the same time, this literature also suggests that organizational learning is largely based on individual and/or group learning, which result also from previous experience in certain tasks.

For instance, research in the field of cognitive studies indicates a positive relation between *individual* learning and performance. Experienced decision maker ('experts') might learn to focus attention primarily on the key dimensions and to ignore extraneous variables (Choo & Trotman, 1991; Weber, 1980); they create categories of information based on a deep structure that involves more and stronger links between concepts (Gobbo & Chi, 1986); and they adopt decision policies that utilize these rich connections (Frederick & Libby, 1986). In short, in a given task, experienced decision maker may make more efficient and more effective decisions than inexperienced ones (Dreyfus & Dreyfus, 1986; Nosofsky, 1987).[69]

Similarly, also research on *group* learning suggests - in line with the 'learning by doing' model - a positive impact of experience. As Argote (1999) describes, the general pattern found on a variety of tasks is one of group performance improving with experience (Argote et al., 1995; Goodman & Leyden, 1991; Guetzkow & Simon, 1955). Groups become better at sharing information (Wittenbaum, 1996) and developing more complex understandings of phenomena (Gruenfeld & Hollingshead, 1993) as they gain experience. With experience, groups also become better at identifying expertise and who knows what and who can be counted on in the group (Liang et al., 1995) and at recognizing and accepting the correct solution proposed by a group member (Laughlin & Hollingshead, 1995).

As such, there is little doubt that individual and/or group learning/knowledge is an important ingredient for organizational learning to occur (e.g. Mahoney, 1995; Mezias & Glynn, 1993; Nelson & Winter, 1982).

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[69] However, it should also be mentioned that the empirical support for a positive relationship between education of individual employees and performance at a particular task is mixed. For example, while there is a positive relationship between education and productivity (Corvers, 1997; Jones, 2001) and between education and survival (Pennings et al., 1998), there is no clear effect of education on other indicators of performance, namely, career progress (Wayne et al., 1999) and job attainment (Dolton & Vignoles, 2000). Similarly, in the entrepreneurship literature, the findings for a positive association between education and business startups (Bates, 1990), and between education and the discovery and exploitation of opportunities (Davidsson & Honig, 2003) have been mixed.

However, less clear is *how* individual and/or group learning actually translate into organizational leaning. Here, the problem is that because individuals' (and groups') knowledge often is tacit, dispersed, fragmented and sometimes even contradictory, for it to be used efficiently by the organizations it has to be codified in form of 'organizational knowledge' which then can become part of the 'organizational memory' (Nelson & Winter, 1982). Yet, until today, our understanding of this aspect is limited.

Dimov and Shepherd (2004), for instance, argue that human capital represents the knowledge and skills that individuals bring to an organization. As it is developed through both education and personal experience, it contributes to both the explicit and tacit knowledge of the firm. However, 'although all knowledge has an explicit component, personal knowledge is often tacit in nature, reflecting a person's unique social environment and past experience. While explicit knowledge can be articulated, codified, and more easily transmitted across people and organizations, tacit knowledge tends to stick to particular individuals or firms in ways that make their actions and decisions difficult to replicate. Therefore, as Dimov and Shepherd (2004) point out, although the basic tenet of human capital theory is that the greater the human capital, the better the performance at a particular task, the nature of this proposition changes at the firm level and in the context of firms with significant amounts of human capital. Specifically, as it is the collective (organizational) tacit knowledge that makes the organization distinct, one needs to examine the extent to which individual tacit knowledge is developed into a collective one.

In sum, from the extant literature it seems that both organizational behaviour and organisational performance are related to experience-based organizational learning/knowledge. The latter, in turn, is also based on individual/group learning/knowledge. However, whilst it is not fully understood how individual/group learning/knowledge translates into organizational learning/knowledge, the two types of learning/knowledge are not identical, and individual/group learning/knowledge does not automatically lead to changes in organisational behaviour and performance.

D.I.1.b) The dichotomy between experience and expertise

So far, we have been mainly concerned with organizational learning and knowledge in general. But, as we will show in the following, it seems further appropriate to look in more detail at the different types of knowledge, namely *general experience* and *specific expertise*.

To begin with, it is often assumed that specific expertise in certain activities is of prime importance for learning to occur. For example, the concept of *absorptive capacity* assumes that the ability to learn is facilitated by the amount of previous knowledge in a particular field; i.e. the more one knows about a certain area, the easier it is to learn more in this area (Cohen & Levinthal, 1990). Into this direction also point Levinthal and March (1993), who note that those with more industry experience tend to develop decision rules or simplifications to identify the 'rules of the game'; and extensive experiences also tend to encourage a sense of specialisation or perceived competency. As a consequence, it is argued that the primary role of the firm is the integration of efficient, specialized knowledge (Conner & Prahalad, 1996).

However, there is also reason to believe that specialization is not always beneficial, at least not beyond a certain level. Into this direction points some literature in the area of cognitive and decision studies, which indicates that previous experience of *individual*s not indefinitely improves decision-making processes and performance. This might be because decision maker are boundedly rational (Cyert & March, 1963). Thinking in detail about various decision criteria requires a great deal of cognitive effort – much more than proceeding on the basis of an 'overall impression' of available data. Thus, decision maker – particularly if they are very specialized - might shift towards automatic processing; they devote less effort to systematically evaluating each component factor and respond instead to a 'gestalt' – an overall often 'gut level impression' of available information (Zacharakis & Shepherd, 2001). Furthermore, specialization might also lead to various biases in the decision-making processes (Fiske & Taylor, 1991); and experienced decision maker tend to rely on various heuristics and other forms of mental shortcuts to the same extent as those lacking experience. Also, as Shepherd et al. (2003) suggest, with high levels of experience, decision maker may become increasingly susceptible to the pitfall of cognitive and mental ruts. Their thoughts may tend to become increasingly channelled by their past experience. Such effects may make it more difficult for them to recognize new variables or to notice that the situation has changed and thus requires new approaches (Shepherd et al., 2003). Furthermore, particularly specialized decision-maker seem more likely to suffer from overconfidence (Fishhoff, 1982; Oskamp, 1982) and 'over-fitting' the world by drawing conclusions based on small samples of experience (Mahajan, 1992) and over-generalizing from them and they may be less likely to engage in counterfactual thinking (contemplating 'what might have been'; Roese, 1997), failing to attain important insights into how performance in various situations can be improved in the future. Thus, experienced decision maker may become increasingly trapped in current modes of thought and may fail to develop better decision policies that can improve future performance (Shepherd et al., 2003).

Into a similar direction also point research on *group learning,* which has shown that experience of groups in particular tasks likely but not necessarily improves learning and performance of the groups or the whole organization; and there are some important examples where groups make very poor decisions. This is often attributed to a phenomenon called 'groupthink'. Some suggest that experience can reduce the tendency of groups to engage in the groupthink phenomenon (Janis, 1972). However, others argue that groups with both experience on a similar task (task experience) and experience working together (team experience) perform more poorly than their counterparts lacking both types of experience - because of their tendency to focus on information that members hold in common rather than discuss unique information that different members possessed (Kim, 1997). Similarly, Katz (1982) found an inverted U-shaped relationship between group 'longevity' (average amount of time group members had worked together) and the performance of R&D groups. Performance initially increased and then decreased with increases in the average group experience. For these R&D groups, the best performance occurred with between two to four years of experience. Initially, performance improved as group members learned how to communicate and coordinate their activities. The observed decrease in performance at high levels of experience was attributed to the groups becoming too inwardly focused and not interacting with or learning from external sources. As Argote (1999) suggests, these results underscore both the benefits and costs of experience. Increases in experience can enhance group performance significantly by providing group members with opportunities to learn how to work together effectively. If increases with experience are also associated, however, with becoming isolated from external sources of knowledge, performance decrements can occur. As a consequence, Argote (1999) notes that having group members with different expertise can be an important pre-condition for groups to learn and performance to improve.

In addition, also on the *organizational level*, there is said to be a tension between exploiting old competencies and exploring new possibilities; and maintaining the right balance between exploitation and exploration is key to organizational survival and prosperity (March, 1991). Too much emphasis on exploitation can lead an organization to fall into a 'competency trap' (Lant & Mezias, 1990; Levit & March, 1988) whereby it persists in a strategy it perfected that may no longer be optimal. Too much emphasis on exploration, in contrast, can lead to a lack of depth or distinctive competence for a firm.

Therefore, it seems, there is a dichotomy between specialist and generalist knowledge. Although specialized knowledge might be beneficial in general, it might be of less value if it does not coincide with at least a certain level of general knowledge. To apply specialist knowledge there is a need for breadth of knowledge and not just depth of knowledge. The specialist may often not fully recognize the value of his knowledge or how to turn that knowledge into profit. The ability to recognize the value and the opportunity, i.e. the ability to recognize how to exploit specialized knowledge and create wealth often will depend on the availability of knowledge breadth. The breadth of knowledge can help identifying where the knowledge specialist has imperfections that keep him from obtaining profit or generating wealth (Kirzner, 1973).

Finally, it should also be mentioned that, similar to individuals, also organizations are prone to 'forget' what they have learned (Argote, 1999). Whilst this might not suggest a negative impact of too much specialization, it nevertheless indicates that experience and/or expertise tend to 'expire' at least to some degree over time.

In sum, from the general literature on organizational learning and knowledge, it seems that one way by which organizations develop knowledge is based on 'learning by doing' - both on the individual, group, and organizational level. In this context, furthermore, particularly specialized *expertise* might lead to increases in efficiency and/or effectiveness; but general *experience* is likely to be of value, too.

D.I.2. Organizational learning in the VC context

With view to the above, it must be emphasized that our overall understanding of organizational learning/knowledge is still very limited. Only in recent years research began to focus on the underlying mechanisms in more detail. Furthermore, most of its insights so far were derived from studies on mature firms. In contrast, little is known about how smaller and/or younger firms learn; and hardly anything is know about how VCs learn, and how this might impact their behaviour and/or performance.

Lockett and Wright (2001: 389), for instance, point out that whilst 'there is extensive research on the information used by venture capital firms in screening potential investments [...] there is little information on the processes by which venture capital firms acquire information and the sources of this information'.

Pointing into a similar direction, Shepherd and Zacharakis (2002) note that there has been no research on how VCs learn.

Nevertheless, as we will describe in the following, it seems plausible to propose that the basic principles of 'learning by doing' described above, also hold in the venture capital context.

D.I.2.a) The concept of 'learning by investing'

To begin with, it seems plausible to assume that VCs - as other firms too - learn from their past experience. However, given the usually limited age and size of most VC firms, when being interested in VCs' knowledge and learning, an obvious question to ask is: what knowledge, if any, is more important that of individual investment managers or that of the whole VC firm?

In this context, there is little doubt that the knowledge of individual investment managers, which might be based on their educational and/or professional experience, is important. For instance, a VC investing in the IT or the biotech sector is likely to have a better understanding of the underlying technologies, problems and opportunities if he has studied the particular area. This might facilitate the VC's screening, evaluation, and due diligence activities; and it might also allow him, at least to some degree, to pass on some 'value-added' knowledge to the investee company.

Jääskeläinen et al. (2003: 18), for instance, note that, 'the experience and operations of a venture capital firm are embodied to its partners and due to the knowledge intensive nature of the work, tasks are generally non-divisible. Managing partners are the key contact between the VC partnership and the portfolio company'. Similarly, also Dimov and Shepherd (2004) argue that VC firms typically consist of a small number of people (the partners of the firm) who have great deal-making and value-adding skills, and who have typically entered the VC industry after extensive experience in other industries. In this context, the same authors further point out that theory posits that individuals with more or higher quality human capital achieve higher performance in executing relevant tasks.

However, some scholars also argue that the individual investment managers' knowledge might not necessarily be a guarantee for the firm's success. Kramer (1984), for instance, notes that 'venture capital firms tend to hire very bright guys out of graduate schools in their late twenties, smart as hell and hard working [...] Every Venture guy thinks he is a strategist [...] So many of them have been educated in the two or three top business schools that they all think alike – not necessarily correctly, but alike' (cited in Bygrave, 1987: 153).

In this context, it might also be argued, that many VC investments operate at the forefront of high-technology sectors (after all, this is why VCs are interested in them). This, however, could mean that individual VCs' educational/academic background in a certain field is likely to become rapidly out-dated, particularly when compared to the scientists working on cutting edge technology in an entrepreneurial venture. Furthermore, the VC business is said to be very interdisciplinary oriented, involving knowledge from a variety of different areas - such as science, technology, finance, marketing, and management - which cannot be studied as one single academic subject.

Therefore, not withstanding the fact that a relevant educational/academic background in certain areas might be helpful for an individual VC, there is a common saying that the venture capital business is an 'art rather than a science', which has to be acquired over time not by studying by doing it – very much in an 'apprenticeship' manner (Gorman & Sahlman, 1989). But even with considerable experience in the VC business, it still will be difficult for individual VCs to cover the full breadth and depth of the relevant knowledge to make the appropriate decisions and to undertake the relevant activities. As such, he still will have to closely cooperate with other experts within or outside his organization. This could also explain why even different VC firms co-operate in form of syndicates.

Therefore, and not withstanding the possible relevance of individual investment managers' past (educational or professional) experience, there are reasons to believe that VC learning (also) occurs on an organizational level; and several scholars support this assertion. In this context, it should also be referred to the above-mentioned study by Bottazzi et al. (2004) who examine the relation between VCs' degree of specialization - on both the overall firm and the individual partner level - and VCs' involvement in their portfolio ventures.[70]

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[70] Bottazzi et al. (2004) approximate VCs' degree of 'specialization' on the *firm level* by several 'organizational' variables such as 1) 'type' (dummy variables indicating whether the VC firm is independent, bank-related, corporate-related, or public), 2) 'size' (funds under management), 3) age, 4) market focus (dummy variable for exclusive focus on venture capital deals), and 5) 'deal focus' (number of investments per partner); and they approximate VCs' degree of 'specialization' on the *investment manager level* also by several 'human capital' variables (operationalised as a) the average for all partners in a firm, and b) for the specific partner responsible for a particular investment under consideration) such as 1) 'venture experience' (years in VC industry), 2) 'business

These authors find that - when examined separately - specialization on the level of both the VC firm and the VC partners is positively related to greater involvement in portfolio ventures. However, the effects seem stronger for the specialization on the firm level than for those on the individual partner level; and when both the firm's and the individual partner's specialization are included simultaneously in the models, the partners' human capital still matters, but it does not add much to the explanatory power of their models regarding the involvement of VCs in their investee companies.

Thus, a few scholars suggest that also in case of VCs there should be learning curves effects to be observed on an organizational level, which are based on previous experience, i.e. on 'learning by investing'. Sahlman (1990: 500), for instance, argues that

> '[...] learning-curve effects are often significant to a venture capital management company [...]. Venture capitalists and their support staffs benefit from learning-curve effects as they become adept in dealing with each other and with other resource suppliers, such as law firm, accounting firms, investment bankers, and management recruiting firms. They cultivate a deal flow based on networks of contacts and relationships. The venture-capital organization develops a reputation that has economic value. The ultimate effect is to make the firm more efficient as time passes and experience accumulates.'

In addition, Sahlman (1990: 501) also notes that learning-curve effects can explain why the same VCs create multiple funds over time: 'keeping the venture capital management company in existence preserves the learning that has taken place'. Furthermore, it should also be mentioned that VC firms often have a longer 'history' in the business than their individual employees.[71] In this context, Hochberg et al. (2004) argue that - since VC funds have a limited life whilst the VC firms managing those funds have no predetermined lifespan - it is reasonable to assume that 'the experience acquired in the running of one fund carries over the firm's next fund' (consequently, the authors measure VC experience on the level of the VC parent firm rather than the VC fund level). Kaplan and Schoar (2003), furthermore, provide convincing evidence of

experience' (experience in finance, accounting, consulting, legal, and industry), and 3) 'science education' (business, humanities, engineering/science, law and social sciences).

[71] Gorman and Sahlman's (1989) survey of 43 VC firms, for instance, shows that the average/median experience of the investment managers in those firms was about 7.4/5.0 years, whilst the firms themselves had an average/median age of 13.9/13.0 years.

persistence in returns across a sequence of funds managed by the same VC firms, which arguably highlights the importance of investment skills and experience. At the same time, Kaplan et al. (2004) argue that adapting certain investment approaches (such as US-style contractual provisions) 'takes time and effort' or 'fixed costs of learning'. As such, there are reasons to believe that VCs learn, also as organizations, over time and based on their previous investments. Cressy (2004a, 2005a) formalizes this idea. He derives a model of the VC as a learning organization, which is based on VC 'learning by doing investments' a la Arrow (1962) and on Jovanovic's (1982) view of entrepreneurship as a Bayesian learning experiment. He envisages learning by doing in the VC firm occurring as a result of investment; and a VC's experience therefore could be proxied by cumulative number of his investments to date.[72] Pointing into a similar direction, Dimov and Shepherd (2004) argue that because VC investments are often in emerging industries, their success is influenced by their ability to accumulate new knowledge, which, in turn, is dependent upon the existing stock of knowledge.

Thus, from the above, it seems reasonable to assume that experience - based on previous investments - plays (also) an important role in the venture capital context, arguably making the number of VCs' previous investments a valid proxy for their knowledge.

D.I.2.b) Experience vs. expertise in the venture capital context

Referring back to our discussion on organizational learning/knowledge in the general context, it seems worthwhile to look not only at the quantitative aspects of (VCs) knowledge but also on the qualitative aspects.

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[72] Here, Cressy (2004a) explains that, in Bayesian terms, inexperienced decision maker have dispersed posterior estimates and as a result may judge themselves to be good or bad 'too early'. However, prior estimates are updated over time according to experience (observation) and the estimate of the mean becomes more precise as more observations are added. In the limit the true value of the parameter is known with probability one. In the VC context, for instance, it seems reasonable to assume that both the VC's perception of the risk associated with an investment and his investment approach – as well as ultimately also the outcome of his investment - depend on his (perception of his own) ability to assess the 'true' potential of the investment (i.e. to make the right investment decision), to safeguard against potential problems, and/or to actively contribute to the successful outcome of the investment. Thus, Cressy (2004a) argues that whilst the costs of an investment are simply the current interest foregone, the returns to an investment are spread out over future time. This occurs because additional current expenditure raises the stock of knowledge not merely next year but for all future years. This in turn increases the chances of the VCs' investments performing increasingly better in future periods.

Shepherd et al. (2003), for instance, point out that 'experience' in the VC industry comprises different types of experience that might result from investing in start up ventures in general and/or by investing in startup ventures of specific stages of development and in certain sectors. Similarly, Dimov and Shepherd (2004) note that in contexts where firms possess large quantities of human capital, differences in quantity may matter less than differences in quality: the nature of VCs' tacit knowledge may be distinguished less by the amount than by the domain.

Therefore, and building upon our discussion of the dichotomy between general experience and specific expertise further above, one might ask: what, if any, type of VC knowledge is more relevant in the VC context, the VCs' *general experience* in financing/managing entrepreneurial ventures overall or the VCs' *specific expertise* with view to a certain venture under consideration?

As we will see in the following, there are arguments for the importance of both, VCs' specific expertise and VCs' general experience.

Value of VCs' specific expertise

To begin with, several scholars suggest that VCs specific expertise might play a particularly important role, for instance, with view to their pre- and/or post-investment activities, and also the performance of their investments.

Some authors emphasize the importance of specialist knowledge for the identification and evaluation of investment candidates. Tyebjee and Bruno (1984), for instance, note that VCs typically have small staffs. As a result, these firms must screen the relatively large number of potential deals available and consequently invest only in a fraction of the deals brought to their attention. Their screening criteria therefore usually reflect a tendency to limit investments to areas with which the VC is familiar, particularly in terms of the technology, product and market scope of a venture. Also Bygrave (1987) argues that, assuming VCs concentrate on what they do best, more expertise in certain types of investments should facilitate the screening and monitoring processes as it allows the VC to better assess the potential of investment opportunities, the current and future competitors, and/or the threats of product substitution. Overall, Bygrave (1987: 153), therefore suggests that 'expertise, especially industry-specific knowledge on markets and technology, is an important - perhaps the dominant - determinant of venture capitalists' investment behaviour'. Similarly, Gompers and Lerner (2001a: 44) argue that:

> 'Specialised knowledge lets a venture capital firm gauge an opportunity's promise. For example a healthcare venture firm will know how to discover the number of potential patients affected by a particular disease, estimate the cost of conventional treatments to combat that disease, assess the potential of alternative treatments [...] [and] specialized knowledge also supports the due-diligence and screening process in other ways. Once a venture group develops a track record of identifying hot opportunities in particular industries, entrepreneurs with promising ideas for that market segment will flock to that firm to present their business propositions. This ability to attract a steady stream of business plans in a particular area has several key benefits. The venture capital firm will likely be the first to see all the best deals, and can thus evaluate those proposals gassings alternative investments as such; the firm will likely capture most of the 'big fish'. [...] The steady stream of business plans lets the venture group keep its finger on the pulse of the market place. The firm thus accumulates better information than any other market player'.

Also Sorenson and Stuart (2001) point out that a VC's prior experience in a particular industry should affect the extensiveness of his contact network among entrepreneurs and other investors in that industry. This, in turn, should facilitate the identification of new investment opportunities, adding further to the VCs' specialization. At the same time, experience may also hone VCs' ability to appraise potential investments. As they evaluate more business plans and directly observe more early-stage companies, VCs may gain a better understanding of the factors that lead to success and failure in general and within a particular industry. This, finally, might also enhance their competence in recognizing the signs that forewarn of problems at the companies in which they invest, and in corresponding activities such as writing effective contracts to minimize problems. With focus on VCs' decision-making accuracy, Shepherd et al. (2003) further add that 'experienced decision-makers in a given task may indeed utilize superior decision processes relative to those with less experience, and, by extrapolation, that VCs may become more accurate in choosing the 'right' companies as their experience increases'. VCs' intuition, the authors suggest, develops after making numerous venture investment decisions. Indeed, Shepherd et al. (2003), in an experimental setting, find that for relatively inexperienced VCs, increasing experience is associated with improvements in reliability and performance relative to a benchmark model. Dimov and Shepherd (2004) finally note that one of the key factors contributing to VCs' risk perception is problem domain familiarity: there is less perceived risk in familiar domains than in unfamiliar ones.

Other authors further point out the relevance of specific expertise for VCs' post-investment *monitoring and supporting activities*. Barry et al. (1990), for instance, suggest that the VCs' specialized industry knowledge, combined with their privileged position as corporate insiders, should facilitate their monitoring role. Fiet (1995a), furthermore, note that because VCs often focus their investments on selected industries, they are experts in the evaluation of market risk; and their industry experience seems to be an important factor affecting the transfer of specific, learned information from VCs to their portfolio companies. Sapienza et al. (1996), furthermore, argue that VCs with industry expertise appear to add more value. In an empirical study, these authors find that VCs in the US and the UK (the two countries of greatest VC expertise) were most involved in their ventures and they believed to add the most value. VCs in France appeared to be the least involved and believed to add the least value. Sorenson and Stuart (2001) further point out that also effective monitoring requires insight into the link between effort and outcome, which practice cultivates. Thus, knowledge regarding the target's industry should allow the VC to oversee investments more efficiently and more effectively, in part because industry experience enhances the VC's ability to recognize signs of trouble at an early stage. In addition, the authors suggest, greater expertise may make the VCs' advisory function more valuable, since more experience in the target firm's industry should enable the VC to provide more industry specific expertise. Into this direction also points Hsu (2003: 7-8), who assumes that:

> '[...] as a venture capitalist gains more investment experience in a particular sector, he or she is more likely to acquire the expertise needed to help startups in their portfolio acquire resources for successful development [...]. In addition, VCs acting as information brokers may assist a startup in business development in different ways depending on the stage of the enterprise'.

Finally, Chang (2004) suggests that VCs with a particular reputation for their experience in certain industries could be of value in the post-investment phase for investment companies in those industries because they ease access to other resource provider such as the public markets at IPO.

Value of VCs' general experience

Not withstanding, the likely importance of VCs' specific expertise, several scholars suggest that also the VCs' *general experience* should be valuable.

Gompers and Lerner (2001a) for instance, point out that for a VC focussing on a single industry could mean substantial risk if the industry moves out of favour.

Sorenson and Stuart (2001: 1558), furthermore, argue that although one might expect stronger experience effects when venture capitalists consider investments within the same industries as their prior investment, one can also expect a positive impact of a VC's investments in other industries. For example, some aspects of monitoring might require knowledge specific to a particular industry, but others should apply generically to the monitoring of any business venture. Similarly, a portion of the evaluation of any entrepreneurial venture involves aspects of the business plan and the capabilities of the founding team not specific to any particular industry. With a focus on the evaluation of investment candidates, Shepherd and Zacharakis (2002) point out that VCs operate in an information rich and highly uncertain environment that strains information processing capabilities, involves high levels of emotion, and imposes extreme time constraints, which might increase the occurrence of heuristics, and associated problems such as mind set or group think. Indeed, Shepherd et al. (2003), find - in an experimental setting - that for relatively inexperienced VCs increasing experience is associated with improvements in reliability and performance; but beyond a specific point, further gains in experience are associated with actual reductions in reliability and performance.[73] As the authors suggest, the reason for the decline in decision effectiveness might be that beyond the optimum point, VCs might begin to rely on automatic information processing to such an extent that they become increasingly susceptible to various sources of cognitive error. Instead of evaluating all of the pieces of information surrounding the proposed venture, experienced VCs may focus on those characteristics that match past successes or failures. As a consequence, Shepherd et al. (2003) suggest that 'one important key to improving an experienced VCs' decision process may lie in somehow inducing them to process information about new ventures systematically instead of automatically. This might be accomplished by somehow inducing them to operate outside their 'comfort zone' – outside the realm of knowledge with which they are most familiar. For instance, Shepherd et al. (2003) suggest, if a VC has spent a career focusing on biotechnology deals, have that person take a lead on the newest b2b Internet prospect. There, the authors argue, it is less likely that the VC will

[73] At the same time, Shepherd et al. (2003) acknowledge that their study only investigated 'experience' in the VC industry. But within this general form of experience are experiences with portfolio companies at specific stages of development and certain industries. The authors suspect that also those experiences follow a curvilinear pattern with respect to their impact on decision accuracy, but they admit that this remains an empirical question and further research could also compare the optimal industry experience with these other more specific types of experience.

quickly reach a 'first impression' that will bias the overall decision. Instead, they may be more inclined to look at the component parts of the decision and then recombine numerous small decisions into an overall invest or not invest decision. Finally, Hsu (2004: 5) argues that if 'VCs are active in a range of activities and functions that span industrial segments, they are likely to be aware of the threat and opportunities in this business environment; and they can therefore act as information intermediaries; and each additional investment extends the VC's network of information and contacts.

In sum, from the above it seems plausible to argue that VCs' specific expertise is likely to be particularly important for their investment approach and the performance of their investments; but there are also reasons to believe that VCs' general experience is of relevance, too.

D.II. Propositions for proxies for VCs' knowledge

Based on the above review of the literature, in this section, we develop several propositions for what we believe are more suitable proxies and ways to measure the impact of VCs' knowledge than have been used in most extant literature.

To begin with, from our review of the literature so far, it seems plausible to propose that *VCs' knowledge can make a difference - both for VCs' investment approach and for the performance of VCs' investments.*

However, it is also evident that VCs' knowledge could be related to all features in the VCs' investment approach (i.e. from the origination to the exiting of deals), which, in turn, could be – individually and/or in combination – related to the performance of VCs' investments.

Within the scope of our project though, it is clearly impossible to examine all the possible (inter-) relations. As a consequence, we focus on three separate research hypotheses for our large sample analyses in the three chapters after the next, where will describe the rationales behind those hypotheses in detail. At this point, we shall list these three hypotheses (in their short versions) to facilitate the understanding of our subsequent discussions:

H1. *There is a relation between VCs' knowledge and the syndication of VCs' investments*

H2. *There is a relation between VCs' knowledge and the staging of VCs' investments*

H3. *There is a relation between VCs' knowledge and the performance of VCs' investments*

From these hypotheses it is evident that the dependent variables in our different analyses vary. Accordingly, we will deal with them later on, in the Chapters on the individual hypotheses.

By contrast, the 'theoretical' (independent) variables in our research hypotheses, namely the proxies for VCs' knowledge, are closely related. Therefore, to avoid too much repetition in the subsequent chapters, we will deal with these theoretical variable(s) upfront, and refer back to our discussions here in the subsequent chapters.

At this point, it is essential to note that different research hypotheses involve different levels of analysis, which require different variations/aggregations of (the proxies for) VCs' knowledge. This results from the fact that many ventures receive funding not from an individual VC only but from a syndicate of VCs, commonly headed by one 'lead VC'; and, many ventures receive not one round of funding only but several rounds, which might or might not comprise the same (lead) VCs or syndicates. This is illustrated in Figure D-1 for three VCs that make a total of four investments in two rounds of one venture.

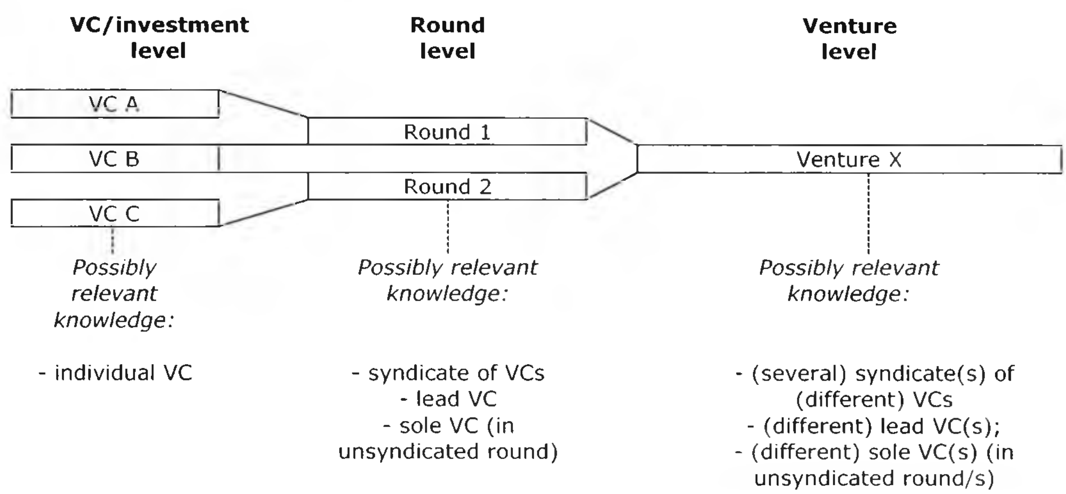

Figure D-1: Levels of analysis for different research hypotheses on VCs' knowledge

Therefore, one can think of three different levels of our analyses, where VCs' knowledge is aggregated to a different degree:

- the '*VC/investment level*' (involving only one individual VC); it is relevant, for instance, when being interested in the relation between the knowledge of an individual VC and those decisions a VC makes on his own such as whether he wants to syndicate with other VCs; it requires proxies for the *knowledge of the individual VC*;
- the '*round level*' (involving a sole VC or a syndicate of VCs); it is relevant, for instance, when being interested in the relation between the knowledge of the

VCs participating in a round and their (joint) decisions, such as those regarding the contract-design, or the amount of money invested in a round; it requires proxies for the *knowledge of the VCs participating in this round*;

- the '*venture level*' (involving one or several rounds, with potentially changing sole VCs, lead VCs, and/or syndicates); it is relevant, for instance, when being interested in the relation between the knowledge of all VCs or syndicates ever invested in a venture and the performance of this venture; it requires proxies for the *knowledge of all VCs invested in the venture*.

Those different levels broadly correspond to our different research hypotheses. This is, H1 involves the VC/investment level, H2 involves the round level, and H3 mainly involves the venture level. However, as will become clear in Chapter H on the relation between VCs' knowledge and venture performance, we conduct several additional analyses that involve the round level (instead of the venture level), for instance, because we are interested in the impact of the knowledge of a venture's first round VCs on its ultimate performance.

In the following, we describe the proxies for VCs' knowledge that we suggest should be used for examining research hypotheses involving the above different levels of analysis.

D.II.1. VCs' knowledge on the 'investment level'

Our most basic unit for measuring VCs' knowledge involves the knowledge of the individual VC on the VC/investment level (this proxy will then be aggregated for the round and venture level).

In this context, our proposition for a suitable proxy for the individual VC's knowledge follows directly from our above discussions of the literature on organizational learning (i.e. 'learning by doing/investing'). From this literature it seems plausible to assume that the number of a VC's previous investments could be a suitable basis to proxy for their level of knowledge.[74] Furthermore, from this literature, it seems also plausible that VCs develop different types of knowledge by investing in different types of ventures.

Together, this leads to our proposition:

P1 A VC's level and type of knowledge, at any point in time, can be approximated by the number of his previous investments in a

[74] Because learning takes time, we suggest considering only those investments made by a VC until the year prior to the investment under consideration.

particular type of venture: the more investments a VC has previously made in a particular type of venture, the higher his level of knowledge with view to this type of venture

With view to the second part of the above proposition, we suggest to differentiate between the 'type of venture' on the basis of its industry, industry-subsector, and development stage.[75]

Hence, we suggest **five main proxies for a VC's knowledge**:

- **VC's non-industry experience**: the number of previous investments made by the VC in ventures in industries other than that of the venture under consideration;
- **VC's total experience**: the number of previous investments made by the VC regardless of industry
- **VC's industry expertise**: the number of previous investments made by the VC in the same industry as the venture under consideration
- **VC's industry-stage expertise**: the number of previous investments made by the VC in the same industry and at the same development stage as the venture under consideration
- **VC's industry-subsector expertise**: the number of previous investments made by the VC in the same industry subsector as the venture under consideration

[75] In this context, it should be mentioned that (as we will describe in more detail further below), in our analyses we focus only on one particular industry, biotechnology, which has several sub-sectors. Therefore, in the following, non-industry experience refers to experience outside biotechnology; total experience refers to experience in both non-biotechnology and biotechnology; industry expertise refers to expertise in biotechnology in general; industry-subsector expertise refers to expertise in the same biotech-subsector as the venture under consideration; industry-stage expertise refers to expertise regarding biotech ventures of the same development stage as the venture under consideration. Furthermore, it should be mentioned that most VCs in our sample have made the majority of their investments outside biotechnology, and, by this, mainly gained general, non-biotech experience. However, all VCs in our sample – per definition – also must have invested at least in one biotech venture, and, by this, gained at least some biotech expertise. As a consequence, in most cases the VCs' total experience will be dominated by their non-industry experience, and only in those cases where VCs have exclusively invested in biotech ventures (true 'biotech specialists'), the VC's total experience is identical to his biotech (industry) expertise. Finally, with view to the latter, it should also be mentioned that we don't measure the relative level of specialization in the VCs' knowledge (e.g. the proportion of a VCs industry-experience to his total experience) but we measure only the VCs' absolute experience or expertise.

In addition, we acknowledge that previous research has used other VC characteristics that might also be understood as proxies for VCs' knowledge. We assume that most of these other characteristics present less accurate proxies for the VC's knowledge. Nevertheless, it seems interesting to compare and contrast findings based on these other proxies with those based on our main theoretical variables. For this purpose we examine the VC's age, which has been used by most previous studies to differentiate between VCs (e.g. Barry et al., 1990; Bottazzi et al., 2004; Gompers, 1996; Hochberg et al., 2004; Lerner, 1994, 1995; Manigart et al., 2002; Sapienza et al., 1996; Sorenson & Stuart, 2001).

Hence, our additional **sixth proxy for a VC's knowledge** is:

- **VC's age**: the number of years between the VC's foundation and the date of the investment under consideration.[76]

With a view to the different types of VCs' knowledge described above, and referring back to our review of literature on organizational learning, it seems plausible to assume that the relation between a VC's knowledge and his investment approach or the performance of his investments should be more pronounced the more specific, or the 'better matched', the VC's knowledge is with respect to a particular venture under consideration.

To illustrate this, one might differentiate between general experience and specific expertise.

More general *experience* (e.g. age, non-industry, and total experience) for instance, broadens a VC's network of contacts to other VCs. This, in turn, is likely to increase the 'deal flow', the access to additional expertise for evaluating investment candidates, and the access to additional funds for financing candidates. Furthermore, it might also enable the VCs to design appropriate

[76] Although we assume that 'age' is a less suitable proxy for VC's knowledge, following some previous researchers, such as Sorenson and Stuart (2001), we also acknowledge that VCs' 'age might pick some residual effects' from processes that are more directly related to gaining experience over time (e.g. developing networks, broadening spatial reach, becoming more proficient in the core activities, and/or being better known in the market). Those aspects might also affect the VCs' investment approach and/or the performance of their investments. For instance, older VCs might better access to promising ventures, either because those ventures are keen to get 'established' VCs on board, or because other VCs might want to syndicate with them for reputational reasons. Furthermore, older VCs' reputation might also make them appear trustworthier in the eyes of external resource owners, including underwriters or the financial markets in general. This, in turn, might further increase the likelihood of a venture backed by those older VCs to experience an IPO. Therefore, we will also test the VCs' age as an additional/alternative proxy for their knowledge in our subsequent analyses.

contracts, and to provide certain monitoring and support-activities as far as they are applicable to ventures from different industries – such as better access to more, and better, professional service provider as well to the financial markets, which in turn might facilitate the acquisition of further resources for the investee company.[77]

More specific *expertise* (e.g. industry, and industry-stage/-subsector expertise) in contrast, might play an even more important role because – assuming the same level (quantity) of knowledge - in addition to the above-cited benefits of general experience, specific expertise should also help the VC to assess more realistically the specific risks and uncertainties associated with a certain type/stage of a venture in the pre-investment phase. Furthermore, it should also help him to provide the most relevant non-monetary resources, such as specific advice and contacts to third parties. Taking the example of, say, drug-developing ventures in the biotech industry, it seems reasonable to assume that those ventures develop in distinct stages. Each of those stages, furthermore, is likely to be characterized by particular challenges, and many of them are likely to be quite different from the challenges faced by non-biotech ventures, or non-drug-developing biotech ventures. Those, challenges, in turn, are likely to require different knowledge on the part of the VCs investing in those (different stages/types of) ventures.[78]

Based on the above, given the same level of knowledge, we would expect the strength of impact of a VC's knowledge on his investment approach to increase as we move from the most general measure, namely the VC's age, to his general investment experience, to his industry expertise, and on to his industry-stage and industry-subsector expertise (where we feel, with view to the last to proxies, it is impossible to propose whether the VC's industry-stage or industry-subsector expertise should be of greater relevance).

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[77] Furthermore, more general experience might also help the VC to avoid the pitfalls resulting from heuristics-based decision-making, overconfidence, groupthink and the like. However, analysing this aspect would require information on the VCs' level of specialization, i.e. on the relative level of total experience to industry (-specific) expertise, which we don't have. Nevertheless, we acknowledge this possibility, which might further enhance the relevance of more general experience, even if we cannot test it.

[78] For instance, scientific/technological knowledge might be assumed to be particularly relevant in the early stages of target-identification and –evaluation to realistically assess the overall potential of a project. But other types of knowledge - such as with respect to organizing clinical trials, applying for drug-approval, and/or marketing the approved drug – are likely to become more important in later development stages.

This leads to our proposition:

P2 The VC's knowledge will be the more influential the higher its level; but given the same level of knowledge, it will be the more influential the better it is matched to the venture under consideration.

Because the above-outlined theoretical variables are likely to be correlated with each other (to some extent), and because we are interested in testing the specific relation between each of those theoretical variables and the dependent variable(s), we will test them in separate models, each based on the same units of analysis. This allows a comparison of the performance of the theoretical variables with respect to the size, sign, and significance of their coefficients as well as with respect to their impact on the overall model parameters (see Table D-1 in the summary of this section).

With a view to the above-proposed proxies for the individual VCs' knowledge, we acknowledge that a few previous studies have already employed the number of VCs' previous investments as a VC 'differentiator' (Chang 2004; Hochberg et al., 2004; Hsu, 2003; Lerner, 1994; Sorenson & Stuart, 2001).

Overall, those studies suggest that there indeed might be some relation between VCs' knowledge and both certain activities in VCs' investment approach and/or the performance of VCs' investments.

However, we have already highlighted the shortcomings of those studies as regards the operationalization of this proxy in our above review of the empirical literature and the corresponding discussion (see Chapter C).

To briefly recap, Sorenson and Stuart (2001) arguably have used this proxy in the most systematic way by differentiating VCs' based on both their previous investments overall and their previous investments in the same industry as the venture under consideration. However, these authors have only examined the impact of this proxy on the VCs' 'investment reach', but not on any other feature of the VCs' investment approach or the performance of VCs' investments. Lerner (1994), in contrast, examines this proxy in the context of a sub-question in his study on VCs' syndication only, and he calculates the proxy with view to the VCs' previous investments in biotechnology only.

The other cited authors examine the impact of this proxy on the performance of VCs' investments, but they operationalise it in arguably imprecise ways. Chang (2004), for instance, calculates this proxy imprecisely as the average number of previous investments by all VCs' in syndicated deals, and only with view to their previous investments in Internet companies. Hsu (2003), furthermore, transforms the VC's number of previous investments in the focal investee company's industrial segment into a dummy variable equal to 1 if the VC's number of previous investments places him above the sample median. Finally, Hochberg et al. (2004) only focuses on the lead VCs' knowledge, and they do not differentiate between different types of previous investments.

In sum, we are confident that our proxy for the individual VC's knowledge and the way we operationalise and test this proxy are more suitable and more systematic than what is to be found in the existing literature. Furthermore, we examine this proxy in the context of two features of the VCs' investment approach, syndication and staging, where it has not been employed at all in the existing literature.

D.II.2. VCs' knowledge on the 'round level'

So far, our arguments have focussed on the knowledge of individual VCs'. However, as described further above, one key feature of VCs' investment approach is the syndication of investments: the joint investment by several VCs in the same round of the same investee venture. Syndicates are usually headed by one 'lead VC' who often serves as the main point of contact between the syndicate and the investee venture.

Before we continue, it should be emphasized that we assume that the above propositions regarding the greater relevance of the more specific vs. the more general types of VCs' knowledge also hold on the round level.

However, if one is interested on the impact of VCs' knowledge on the round level, one has to ask which, if any, knowledge is more relevant in this context, the knowledge of all VCs or the knowledge of the lead VC participating in a round (obviously, this question is irrelevant in case of unsyndicated rounds).

Most literature on venture capital has neglected – or not systematically examined - this aspect. Chang (2004), for instance, uses the average knowledge of the syndicate whilst Hochberg et al. (2004) uses the knowledge of the lead VC; and there are plausible arguments for the potential relevance of either the syndicate's or the lead VC's knowledge in this context.

On the one hand, it seems reasonable to assume that the VCs in a syndicate jointly make many investment decisions and manage their investments. Indeed, extant literature indicates that part of the reason why VCs syndicate is their desire to get access to other VCs' knowledge (e.g. Bygrave, 1987, 1988; Lerner, 1994). This, in turn, could suggest that VCs in syndicates share their knowledge to make better decisions than the individual VCs would make on their own. Thus, one might use the combined knowledge of all VCs in the syndicate as a theoretical variable for analyses on the round level. This also finds some support in the extant literature. Wright and Locket (2003), for instance, note that although the lead VC is the most influential member of the syndicate in the decision making process, decisions are likely to be reached through a process of collective discussion and the reaching of consensus.

On the other hand, it seems also plausible to argue that the lead VCs' knowledge is most relevant in this context. The lead VC might ultimately be responsible for the initial investment decision, as well as for the subsequent management of the investment. Also this assertion finds support from several scholars. Hsu (2003), for instance, argues that whilst venture funding is available from many sources, entrepreneurs choose a *lead* venture partner to tap into practical experience, contacts, and reputations. Kaplan and Strömberg (2003), furthermore, note that in a typical financing, one VC leads the round by negotiating the terms. If the VC chooses to syndicate the round, other VCs typically invest on the same terms as the lead VC.

In conclusion, there is no clear answer from the literature as to whether the syndicate's or the lead VC's knowledge is the most appropriate theoretical variable for the empirical analysis at the round level.

However, an alternative hypothesis, not tested in the literature so far, would be that it is neither the syndicate's knowledge nor the lead VC's knowledge that is most relevant, but the knowledge of the most knowledgeable VC in the syndicate (or the knowledge of the sole VC in unsyndicated deals) that is the relevant theoretical variable.

The rationale behind this argument is that even if the most knowledgeable VC in the syndicate does not formally hold the position of the lead VC, he is likely to impinge the syndicate's decisions (although he might not make those decisions alone); and his influence might increase with his knowledge. Indeed, it seems unlikely that the most knowledgeable VC would agree with decisions made by his less knowledgeable syndicate partners unless he was convinced about the adequacy of those decisions. At the same time, it seems also plausible to assume that a) the less knowledgeable syndicate partners should be willing to listen to and accept suggestions made by their most knowledgeable peer, and b) the syndicate draws upon its most knowledgeable peer when it comes to the post-investment management and support of investee ventures.

Again, also this assertion finds some – indirect - support from scholars in the field. Lockett and Wright (1999, 2001), for instance, suggest that the lead VC is the party bringing the most resources to the syndicate in terms of the specific skills to identify, screen, and monitor the investment.

Since in the current dataset we have no certainty as to how to identify the lead VC in a syndicate, we shall in fact assume that the knowledge of the most knowledgeable VC in a syndicate - which we shall from now on refer to as the 'lead' VC - should have the strongest impact on the syndicate's investment approach, and ultimately therefore on the performance of the VCs' investment.

Whilst we assume that the knowledge of this (most knowledgeable) 'lead' VC in the syndicate should be of prime relevance, we acknowledge that also the overall syndicate's knowledge might have an impact, and therefore should be examined further.

For this purpose, however, we believe it is more adequate to look at the syndicate's average knowledge than the syndicate's cumulative knowledge. This is because, when taking the cumulative knowledge of the syndicate, one might also add together knowledge that was gained by different VCs investing jointly in the same venture(s) before. Clearly, when this is the case, the actual (unique) knowledge of the syndicate would be smaller than when all VCs in the syndicate previously had invested in different ventures. Hence the cumulative syndicate knowledge might overstate the relevant unique knowledge of the syndicate.[79] Therefore, although we acknowledge that taking the *average* knowledge of all VCs in the syndicate might 'reduce' the knowledge actually available to the syndicate (i.e. when one syndicate partner has a much higher level of experience than his peers), we believe this is the most adequate way to proxy the knowledge of the syndicate on the round level.[80]

Together with the previous propositions, the above leads to our proposition:

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[79] A similar argument could also be made based on some empirical research that indicates that (some) VCs join syndicates to reduce their due diligence efforts, and some even to the extent that they completely rely on their well-reputed/trusted syndicate partners' assessment of the investment opportunity (Valliere & Petersen, 2004). In other words, those VCs rather behave as 'free-rider' and are unlikely to contribute, or 'add', their knowledge to the syndicate.

[80] In this context, one might argue, the best solution would be to use the 'unique' cumulative knowledge of all syndicate partners, i.e. to add together only those previous investments that were made in different (stages of) ventures. Unfortunately though, we don't have the relevant information to do so.

P3 On the round level, the VCs' knowledge will be the more influential the better it is matched to the venture under consideration; but it will be more influential with respect to the most knowledgeable or 'lead' VC than with respect to the syndicate overall.

Similar to what has been said before with view to the proxies of VCs' knowledge on the VC/investment level, because the above-outlined theoretical variables are likely to be correlated with each other (to some extent), and because we are interested in testing the specific relation between each of those theoretical variables and the dependent variable(s), we will test them in separate models, each based on the same units of analysis. This allows a comparison of the performance of the theoretical variables with respect to the size, sign, and significance of their coefficients as well as with respect to their impact on the overall model parameters (see Table D-1 in the summary of this section).

D.II.3. VCs' knowledge on the 'venture level'

So far, our propositions focussed on the knowledge of the individual VCs (P1 and P2) and of the 'lead' VCs and syndicates in individual rounds (P3).

We assume that these propositions - regarding the greater relevance of the specific vs. the general types of VCs' knowledge, and regarding the greater relevance of the 'lead' VCs' knowledge vs. the average syndicate knowledge - also hold on the venture level.[81]

However, as described further above, many venture receive not only one but several rounds during their development. These rounds, furthermore, might or might not compromise the same ('lead') VCs.

This fact obviously must be addressed if one is interested in the impact of VCs' knowledge. For instance, one might ask 1) how can the knowledge of (different) VCs in several rounds be best approximated, by their cumulative or the average knowledge, and 2) is the VCs' knowledge equally important in all rounds, or is it more important in the first rounds than in later rounds?

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[81] At this stage, it should be mentioned that - because the relation between VCs' knowledge and VCs' investment approach obviously cannot be examined on the venture level, whilst the relation between VCs' knowledge and performance on VCs' investments can (not only but also) be examined on the venture level - in the following (and contrary to the previous sections), we will only refer the latter relation between VCs' knowledge and performance of VCs' investments.

These issues have not been dealt with in much detail in the extant literature, where studies either did not differentiate between different rounds at all, focused on the first round only (Hsu, 2003), used the average of the syndicates in each round (Chang, 2004), or the average knowledge of the lead VCs in each round (Hochberg, 2004). As such, there is room for some speculation regarding the best approach in this context.

With a view to the first of the above question, regarding the cumulative versus the average knowledge of the VCs in different rounds, we shall refer back to our previous arguments on the cumulative versus the average knowledge of the VCs in a syndicate. Extrapolating from those arguments, to us, it seems most appropriate to look at the *average* knowledge of all VCs ever invested in a venture. This is because, when taking the cumulative knowledge of all VCs one might overstate the actual knowledge of relevance, particularly in those cases where the same VC invests in several rounds. Furthermore, even if the VCs change in between rounds, it still is likely that they have been investing together previously, again 'inflating' the relevant unique knowledge.

With a view to the second part of the above question, regarding the relative importance of the VCs' knowledge in first versus later rounds, there are arguments for both.

To begin with, one can argue that the knowledge of all VCs' in all rounds could be related to venture performance, at least to some extent. This is, for instance, because in each new round a venture will have to 'convince' VCs that it is a worthwhile investment opportunity. Therefore, each additional round might be an additional 'test' and 'proof' of the venture's quality. Furthermore, one might argue that because different rounds in the same venture are likely to coincide with different stages in the venture's development, VCs in each round might make additional, and different, contributions to the venture's development. As such, particularly if there are different 'lead' VCs involved in a venture's rounds, there might be a relation between the knowledge of the 'lead' VCs in all rounds and venture performance.

However, it seems also plausible to argue that the knowledge of the 'lead' VC in the first round might be of greatest relevance. This is because, in first rounds, it should be particularly difficult for VCs to assess the potential of a venture, i.e. to 'pick a winner'. In first round investments, a VC will have no knowledge or only limited knowledge of the venture-specific factors associated with the investment and presenting considerable extra risk and uncertainty. Furthermore, first rounds are likely to involve early stage projects, which involve a high project-specific risk of failure, particularly in high-technology sectors. Whilst it might be impossible to predict the ultimate success, or failure, of those projects even for the most knowledgeable VC, one might nevertheless assume that a more knowledgeable VC is more capable to come up with a realistic assessment of a project's potential than an ignorant VC. But in any case, in first rounds, the VCs have to base their investment decisions mainly on their knowledge acquired during previous investments in other ventures (which we use as a proxy for VCs' knowledge). In subsequent rounds, however, VCs might have been able to collect information about the venture in the previous round(s) themselves and/or they may be able to rely on 'signals' from (e.g. reputation of) previous investors in the venture. At the same time, one might further argue that in first rounds (that usually occur in early stages of a venture's development) the venture will particularly lack vital non-financial resources. This, in turn, should make the knowledge of the VCs in the first round particularly valuable to 'build a winner'. Hence, one might assume that, if there is a relation between VC knowledge and venture performance at all, this should be more pronounced when looking at first rounds than when looking at later rounds. Finally, it seems also plausible to argue that the success, or failure, of a venture will be determined by a variety of factors during its development, and the relative relevance of VCs' knowledge - if there is any at all - is likely to get 'diluted' by those other factors during the venture's development. This assertion also finds some support by previous research. Hochberg et al. (2004), for instance, find in their study of the relation between the lead VCs' network position (and experience) and venture survival (from the first to the third financing round) that the pseudo R^2 of their models decreases from the first to the third financing round; and they interpret this as a sign that, as companies become more established, company-specific variables become relatively more important drivers of company survival.

Based on the above arguments we believe that - although it is reasonable to assume that also in later rounds, the 'lead' VCs' knowledge can have an impact - the knowledge of the 'lead' VC in the first round should be of greater relevance.

Together, the above leads us to our final proposition:

P4 **On the venture level, the VCs' knowledge will be the more influential the better it is matched to the venture under consideration; but it will be more influential with respect to the 'lead' VCs than the syndicates, and it will be more influential in the first round than in later rounds.**

Similar to what has been said before with view to the proxies of VCs' knowledge on the VC/investment and the round level, because the above-outlined theoretical variables are likely to be correlated with each other (to some extent), and because we are interested in testing the specific relation between each of those theoretical variables and the dependent variables, we will test them in separate models, each based on the same units of analysis. This allows a comparison of the theoretical variables with respect to the size, sign, and significance of their coefficients as well as with respect to their impact on the overall model parameters (see Table D-1 below).

D.II.4. Summary of theoretical variables

Since it is crucial for our subsequent chapters to be clear about the theoretical variables, we summarize their operationalization and calculation below.

D.II.4.a) Operationalization of theoretical variables

Table D-1 summarizes the operationalization of our proposed proxies for VCs' knowledge that will serve as theoretical variables (each in a separate model) for our large sample analyses of the three research hypotheses involving different levels of analysis.

Table D-1: Operationalization of theoretical variables for large sample analyses

	Level of analysis				
	Investment	**Round**		**Venture**	
Theoretical variable for:	**Sole VC** (at investment in focal venture):	**Lead VC** (in round of focal venture):	**Syndicate** (avg. in round of focal venture):	**Lead VCs'** (avg. over all rounds of focal venture):	**Syndicates'** (avg. over all rounds of foc. venture):
Non-industry experience	non-biotech investments	non-biotech investments	non-biotech investments	non-biotech investments	non-biotech investments
Total experience	non-biotech and biotech investments	non-biotech and biotech investments	non-biotech and biotech investments	non-biotech and biotech investments	non-biotech and biotech investments
Industry expertise	biotech investments	biotech investments	biotech investments	biotech investments	biotech investments
Industry-stage expertise	biotech investments in focal venture's stage	biotech investments in focal venture's stage	biotech investments in focal venture's stage	biotech investments in focal venture's stage	biotech investments in focal venture's stage
Industry-subsector expertise	biotech investments in focal venture's sub-sector	biotech investments in focal venture's sub-sector	biotech investments in focal venture's sub-sector	biotech investments in focal venture's sub-sector	biotech investments in focal venture's sub-sector
Age	age since foundation	age since foundation	age since foundation	age since foundation	age since foundation

D.II.4.b) Calculation of the theoretical variables

It is important to be absolutely clear about the calculation of our theoretical variables, and it is easier to understand with a bit of mathematical notation.

Let the *experience (i.e. the previous number of investments) of an individual VC j investing in venture i at a round t* be:

$$e_{ijt}$$

Then the *average experience of a syndicate investing in venture i at round t* is given by:

$$\bar{e}_{i.t} = \sum_{j=1}^{J_{it}} e_{ijt} / J_{it}$$

In other words the average is taken over all syndicate members in syndicate (i,t) and there are J_{it} such members. Obviously, in case of an unsyndicated round, the 'average' syndicate experience equals the absolute experience of the sole (lead) VC.

Then the *average overall syndicate experience for venture i* is obtained by averaging this last quantity over all rounds T_i of venture i:

$$\bar{e}_{i..} = \sum_{t=1}^{T_i} \bar{e}_{i.t} / T_i$$

where T_i is the total number of rounds of investment in venture i.

By contrast the *average lead VC experience in round t* is given by:

$$\bar{e}_{il.} = \sum_{t=1}^{T_i} \bar{e}_{ilt} / T_i \text{ and } \bar{e}_{ilt} = \max_j e_{ijt}$$

where l denotes the lead VC in the syndicate and e_{ilt} his experience.

To get the *average overall lead VCs experience for venture i*, we simply average this last quantity over all lead VCs investing in the company:

$$\bar{e}_{i..} = \sum_{l=1}^{L_i} \bar{e}_{il.} / L_i$$

where L_i is the number of lead VCs investing in the company and since by definition this is the same as the number of rounds (there is only one maximum experience by definition per round) we have $L_i = T_i$.

CHAPTER E: SAMPLING, DATA & EXPLORATORY OVERVIEW

This chapter provides an overview over those aspects of the sampling and the data that are of general relevance *for the large sample analyses* of our research hypotheses to be dealt with in the subsequent three chapters.[82]

In its two main sections, the chapter performs two functions: 1) to reduce repetition in the subsequent three chapters, where only those aspects of the sampling and the data will be dealt with that are specific to the examination of the individual hypotheses, and 2) to provide an exploratory overview of the units of analysis and key variables that will be examined in those hypotheses.[83]

E.I. Sampling and data

In this first section of Chapter E we deal with four main issues: 1) the sample industry, 2) the sampling sources, 3) the data structure, and 4) the data quality.

E.I.1. Sample industry – Biotechnology

As discussed above in our general literature review (Chapter C), one shortcoming of much of the extant research on venture capital is that it uses heterogeneous samples with respect to the industry or types of sample ventures.

The majority of studies implicitly assume that ventures from different industries have similar requirements and involve the same challenges for their investors; only few studies differentiate between industries (e.g. Bygrave, 1987, 1988; Giot & Schwienbacher, 2004; Lockett & Wright, 1999, 2001) or focus on a particular industry (e.g. Chang, 2004; Gompers, 1995; Lerner, 1994, 1995; Stuart et al., 1999).

However, several studies that do differentiate between industries suggest that VCs might act differently – e.g. with respect to syndication strategy - when confronted with ventures from, say, low- or high-tech industries (e.g. Bygrave, 1987, 1988; Lockett & Wright, 1999, 2001), and that VCs may have a different impact on the development of ventures according to the industry in which the

[82] We will describe our research methodology for the case-studies separately in Chapter I.

[83] Although the exploratory overview over our data in the second section of this Chapter refers to the data of our large sample analysis, it provides also an additional background for our case studies further below.

companies are located. Hellmann and Puri (2002), for instance, find that there is a significant relation between VC-backing and product-time-to-market for ventures pursuing 'innovator' product strategies, but not for ventures pursuing 'imitator' product strategies, these strategies having an industry dimension.

Thus, it seems plausible that the general neglect of differences in the ventures' industries – particularly in combination with the neglect of differences in VCs' knowledge - have contributed to the insignificant and/or ambiguous findings discovered in the existing literature.

Therefore, in our project, we focus exclusively on one particular industry, the biotechnology industry (and In the following, we use the terms 'biotechnology industry', 'biotech industry', 'biotechnology', and 'biotech' interchangeably).

We choose this industry for several reasons, which are particularly evident from the detailed background information to this sector provided in Appendix I, to which the reader is referred at this point.

In short, however, biotechnology is undoubtedly a very promising sector, considered to be one of the key technologies in the 21st century – one positioned to redefine our lives and to reshape virtually every other industry (Enriquez & Goldberg, 2000). Some even refer to the 21st century as the 'coming age of biotechnology' (Oliver, 1999). Equally important for our project, biotechnology ventures are crucially dependent on external funding from VCs for their operations (e.g. Alper, 1999; Bazley, 1999; BCG, 2001a; Berens, 2000; Dams, 2001; Ernst & Young, 1998; Freier, 2000). At the same time, biotechnology is a very complex sector that places particular challenges in front of its investors, and demand on their knowledge (Bengs, 2000). Finally, amongst the few venture capital studies concentrating on a particular industry some have also focused on the biotech sector to study, for instance, VCs' syndication behaviour (Lerner, 1994) or the impact of VCs on venture performance (Stuart et al., 1999). Thus, using the same industry context as these previous studies allows us some comparison of our own findings with theirs.[84]

[84] At the same time, it is evident that the exclusive focus on one industry potentially limits the generalizability of our findings across industries. Although some previous research (e.g. Lerner, 1994) suggests that this might not necessarily be the case, we will come back to this issue in our synthesis, in Chapter J.

E.I.2. Sampling sources and data collected

For the examination of our three research hypotheses we rely primarily on data obtained from a single source, the Venture Economics VentureExpert database.[85] In addition, we use several other databases to collect information on our control variables.

E.I.2.a) Venture Economics VentureXpert database

Venture Economics (VE) has gathered information on venture capital investments since 1977, and has subsequently backfilled the data to the early 1960s. This information stems from annual reports of venture capital funds, VE staff's personal contacts with funds' personnel, initial public offering prospectuses, and acquisitions announced in the media.[86] Today, the database contains information on over 210.000 private equity investments in ventures from all different kinds of industries (Jääskeläinen et al., 2003).

From this source, as we will describe in more detail below (see the section 'exploratory overview over the data'), we have collected *all* available information on biotech investments. Specifically, this is information on over 14.700 single investments by about 2.000 VCs in over 5.000 investment rounds of over 1.700 biotech ventures worldwide over the period from 1970 to 2003 (March). To our knowledge, this is one of the largest single-industry sample(s) ever collected from the VE database, and the largest and most recent sample for biotechnology.[87]

Our sample includes, for each VC in the VE database who has ever invested in biotech ventures during our sampling period:

VC-related information

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[85] Venture Economics is a division of Thomson Financial Securities Data Company (SDC).

[86] According to its own website, VE is the leading international provider of information, research and consulting on venture capital and corporate strategic alliances. VE provides publication (Venture Capital Journal, Buyouts, Investment Benchmarks, and Pratts Guide to Venture Capital), analytical, advisory and conference services to investors and corporations throughout the world; and much of the information in its database stems from these relationships as well as the relationships with the general parent community in the private equity industry. For the European component of the database, VE collaborates with member firms of the EVCA and the BVCA.

[87] For instance, Lerner (1994) and Gompers (1995) have also used VE data on venture capital investments in biotech, but only until the early-mid 1990s, i.e. way before the industry really took off in the late 1990s.

- firm type (e.g. private partnership, bank-affiliated VC, corporate VC)
- foundation date
- number of investments made to date
- aggregate dollar amount invested in ventures overall (updated per annum)
- aggregate dollar amount invested in biotech ventures (overall and in certain stages and/or sub-sectors; updated per investment).
- date of investments in biotech ventures

Furthermore, our sample includes, for each venture that has ever received venture capital during our sampling period:

Venture-related information

- 1. Basic information:
  - foundation date
  - industry sub-sector (according to the VE categorization, see Table L-1 in Appendix I),
  - ultimate 'outcome' (e.g. still privately held, IPO, acquisition, insolvency), and the date of the IPO where applicable
- 2. Information by financing round:
  - round number
  - round date
  - 'deal size' (total round amount invested by all VCs involved)
  - number and names of VCs involved in round
  - venture's age and development stage at the beginning of the round

Finally, our sample includes yearly updated information on the overall situation in the private equity markets:

Context-related (macro) data

- number of actively investing VCs
- total funds raised and disbursed by VCs
- number of ventures receiving venture capital
- total number of IPOs.

We have collected this information in a way that allows us to use it at different levels of aggregation. This involved a major effort consuming several months since VE does not allow to download all the information we needed for our various analyses en block. Instead, we had to download the information on individual ventures, rounds, and VCs and restructure and combine it manually in a form suitable for our purposes. However, as discussed in detail in the context of the 'propositions' in Chapter D, deriving the data in this format was critical because, depending on the particular hypothesis, we have to use different units (levels) of analysis: investments, rounds, and ventures.[88] Again, as far as we are aware, no other research dataset has this structure and detail.

E.I.2.b) Other databases

We obtained additional information on the stock markets such as on the Dow Jones industrial index, FTSE 100, Nasdaq, and Nasdaq Biotech, covering the whole observation period from 1970 to 2002 on a monthly and quarterly basis from Yahoo! Finance. We use this information primarily for our context-related control variables.

Furthermore, from the NBER (National Bureau of Economic Research; see: Jaffe & Trajtenberg, 2002) Patent-Citations Data, we have also collected substantial information on the number of patents, patent applications, and patent citations. However, we only could match this information to about 500 of our sample ventures, and only until 1999. Therefore, we only use it in some additional, but mostly unreported analyses.

E.I.3. Data structure

As mentioned before (Chapter D), the large-sample tests of our three main hypotheses involve different, but related, levels and units of analysis.

To facilitate the understanding of our subsequent discussions, this section provides an overview over the structure of our data taking into account these different levels and units of analysis, as well as their consequences for our analytical approaches.

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[88] In this context, it must be noted that, unless stated otherwise, we exclusively refer to and focus on the context of biotechnology. This is, if we refer to investments, rounds, and/or ventures we refer to investments and/or rounds made in biotech ventures by 'biotech' VCs (i.e. VCs who also but not necessarily exclusively invest in biotech ventures).

E.I.3.a) Levels and units of analysis

The three levels (units) of analysis we use are: 1) the VC/investment level (individual VC), 2) the round level (lead VC or syndicate in round), and 3) the venture level (lead VCs or syndicates in all rounds of a venture). Their interrelations are illustrated in Figure E-1.

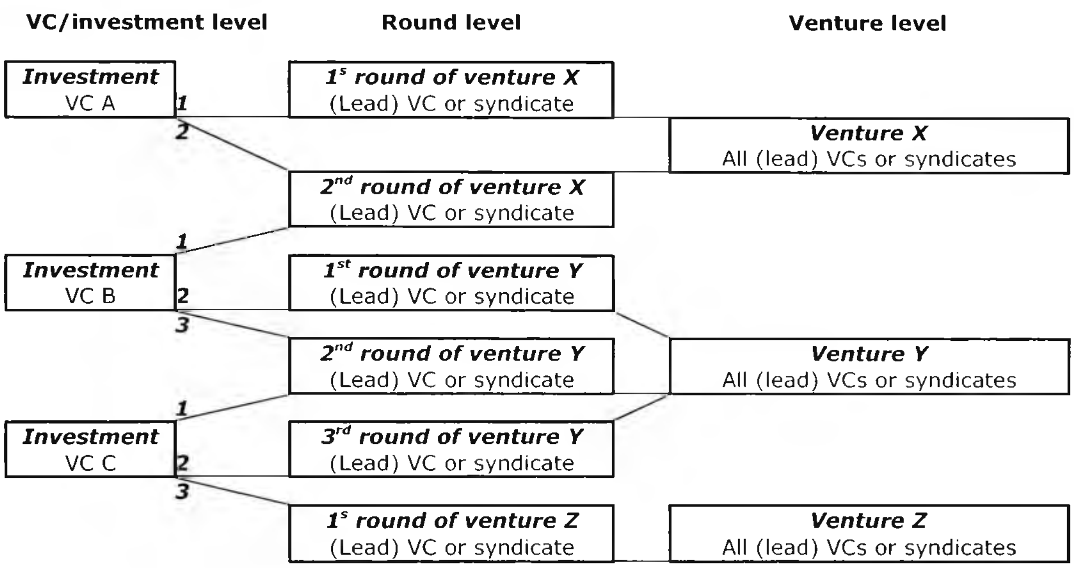

Figure E-1: Interrelations between levels and units of analysis

As Figure E-1 shows, the most fundamental interrelation between the three units of analysis is of the form: a VC makes an *investment* in a *round* of a *venture*.

At the same time, there are several possibilities for how the units of analysis could be interrelated, creating a complex network of relationships. For example, VC A might invest alone in the first round of venture X (since the first round of venture X comprises only one single investment by VC A, the investment level and the round level are identical in this particular case). However, for the second round of venture X, VC A might syndicate with VC B (in this case the round level and the investment level are not identical since the round comprises two investments). VC B, in turn, might invest alone in the first round of venture Y, but syndicate again in the second round of venture Y, this time, with VC C. VC C, finally invests alone in the third round of venture Y, and also in the first round in venture Z.

Furthermore, although not indicated in Figure E-1, it should be evident that the whole picture gets even more complicated if one simultaneously considers the time dimension. For instance, VC B might syndicate the second round in venture X with VC A *after* he had invested in the first round in venture Y. Similarly, VC C might have invested in the first round in venture Z *after* he invested in the second but *before* the third round in venture Y. Finally, the duration of each investment/round may vary; and, as mentioned above, all three VCs, might – at various times - also invest in a number of non-biotech ventures.

E.I.3.b) Analytical consequences

The above-described data structure, and the way we will analyze our data, involves an issue that shall be addressed at this point, namely, the issue of the statistical independence of observations in samples that pool observations at each level of analysis.[89]

One of the assumptions underlying regression analysis – the main statistical method we use to analyse our data - is that observations stem from different subjects and are statistically independent of each other (the errors are independently and identically distributed across observational units).

However, looking at Figure E-1, it is evident that, at each level of analysis, this assumption is at least questionable. For instance, the same VC might make several investments, either in different rounds of the same venture and/or in different ventures. Thus, at each level of analysis, some of the VCs and/or the ventures enter the analysis several times. Also the same VC-venture pairs might enter the analysis several times. Consequently, our observations are likely not always independent.

At first glance, with a time (round) as well as individual (firm, venture) dimension, our data seem to offer the prospect of Panel data analysis, which might seem to allow us to deal with the problem of non-independence of observations in a very simple way (robust standard errors estimation). However, such a 'Panel' would be extremely un-balanced. As will become evident further below (see 'exploratory overview over the data'), the number of observations in the cross-sectional samples (e.g. the VCs actively investing at a particular point in time) varies widely over the sampling period. Furthermore, also the time between two observations for individual cases (e.g. the time between one investment by a VC and his next investment) varies substantially, meaning that any fixed effects in that dimension would have to be interpreted as *round* effects rather than true *time*-effects. Finally, the number of observations we have for individual units of analysis varies greatly. For instance, for many VCs we have only one single observation (i.e. one investment), whilst for others we have far more observations than the average number of seven mentioned above.

[89] We will come back to this issue in the chapters that deal with our individual hypotheses.

Similar arguments could also be made with view to the round or the venture level. For example, many ventures in our sample have only received one round, whilst a few have received up to 20 rounds of funding. Therefore, a Panel data analysis of our data seems problematic, at best. At the same time, the 'unbalancedness' of our data set also prevents us from using a repeated measure design.

Therefore, we opted to pool our observations at each level of analysis. The main justification for this approach is that even if the same subjects enter our analyses several times, they will have changed with view to important variables. This is particularly obvious with view to the theoretical variables in our analyses (the proxies for VCs' knowledge). Per definition, the VCs' knowledge changes with each additional observation from the same VC entering our analysis.

However, we are aware that this doesn't 'solve' the potential problem of non-independence. In addition, we try to control for as many VC- and venture-related factors as possible. Moreover, we also control for several time-varying contextual factors where possible and appropriate. But we acknowledge that, to some degree, the problem of non-independence between some of our observations still remains.

As a consequence, we conduct several additional analyses for each hypothesis to examine the extent of a potential non-independence bias and to check the robustness of our findings from the main analyses.

We briefly outline those additional analyses at this stage, but we will come back to them in more detail in the chapters on the individual hypotheses.

Our main approach to examining the extent of potential problems resulting from non-independence between some observations consists in additional analyses that use only subsamples, and by this either significantly reduce or completely eliminate the problem of non-independence of some observations.

For instance, on the investment level, we conduct two additional analyses on two sub-samples of investments: 1) the first investments made by a VC in a particular venture, and 2) the last investment ever made by a VC during our sampling period. The first analysis eliminates the problem of non-independence of observations with view to the simultaneous entry of the same VC-venture pairing in our analysis (because each VC can only invest once for the first time in a particular venture); and the second analysis eliminates the problem of the multiple entry by the same VC in our analysis (because each VC can only have one last investment).

Similarly, on the round level, we conduct an additional analysis on a subsample of first rounds only. This approach reduces the extent of multiple entries by the same VCs in our analysis and it eliminates the problem of multiple entries by the same venture in our analysis (because each venture can only have one first round).

As we will see further below in the chapters on the individual hypotheses, those additional analyses result in qualitatively similar findings as our main analyses that comprise all observations, making us confident that the actual problem of non-independence in some of our observations does not introduce a significant bias into our findings and that our findings are robust across a range of subsamples.

Nevertheless, we acknowledge that we cannot fully exclude the possibility of some bias resulting from non-independence between observations. Furthermore, we also acknowledge that our additional analysis on sub-samples might introduce other problems such sample selection bias.

E.I.4. Data quality and completeness

Particularly because we primarily rely on one singly source of data (VE) it is recommended to take a closer look at issues regarding the completeness and accuracy of the data/information obtained from this source, which might influence the generalizability of our findings.

Taking into account the size of our sample, it is clearly impossible to check the completeness and accuracy of the information provided by VE - e.g. with view to its coverage of venture capital investments in general, and in the biotech sector in particular - in detail.

Therefore, in the following, we shall first refer to some authors that have dealt with the above issues to some extent, and, subsequently, we also describe our own analysis of 'suspect' cases in our data (e.g. those cases with considerable missing data), which might provide some additional insights into the reliability of our sample.

E.I.4.a) Assessment of the VE database by other researchers

To begin with, the VE database is widely recognized as a leading source of information on venture capital, and it has been used by several leading researchers in the field (e.g. Bygrave, 1987; Chang, 2004; Gompers, 1995;

Gompers & Lerner, 1999; Hochberg et al., 2004; Lerner, 1994, 1995; Podolny, 2001; Sorenson & Stuart, 2001).[90]

As such, one might consider our data to be, at least *comparatively*, complete and accurate.

This assertion is supported by Lerner (1994), who - analysing the completeness and accuracy of the VE database - concludes that the database is comprehensive, and accurately depicts the amount of funds disbursed.

However Lerner (1994: 19) also points out a noteworthy bias of the VE database: 'Single venture rounds, particularly in more mature firms, are often recorded as several observations. [...] While data accuracy has increased over time and Venture Economics has recently [i.e. before 1994] improved its data collection methodology to limit such problems in the future, the over-reporting of rounds is a significant factor in the historical Venture Economics data'.[91]

Gompers (1995: 1470) furthermore notes that 'the coverage of the [VE] data seems to be better for the latter half of the sample period [i.e. from the late 1970s onwards]. This may reflect increasing completeness of the Venture Economics database over time. During the 1970s VC investing was modest in size. The number of rounds per year, the number of new ventures financed, and the total venture investment show a dramatic rise after the liberalization of ERISA's 'prudent man' rule in 1979, which eased pension fund restrictions on investment in venture capital.' Gompers (1995) also points out that the VE data are generally limited, for instance, in that they do not provide any information on other types of financing the ventures might have received but venture capital.

Furthermore, and particularly relevant for us, Lerner (1995) examines the completeness of the VE data with respect to the inclusion of venture capital deals

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[90] The second most commonly used database for this purpose is that provided by VentureOne.

[91] Lerner (1994) suggests that there are three potential reasons why VE sometimes refers to a single round as multiple observations: First, a contract between a company and its venture financiers may call for the staged distribution of the funds in a single venture round, which may then appear in the database as several distinct venture rounds. Second, staggered disbursements arise without design. Venture capital funds typically do not keep large cash balances but, rather, draw down funds from their limited partners as needed. Limited partners will have between two weeks and several months to provide the funds. As several venture funds normally participate in a financing round, investments may be received over the course of several months and thus be recorded in the database as several rounds. Finally, VE aggregates information about venture investments from reports by pension fund managers, individual investors, and investment managers. If the date of the investment differs in these records, a single investment round may be recorded as two or more events.

in biotechnology. Specifically, to assess the completeness of 271 biotech firms in his sample, which - according to VE - had received venture capital between 1987 and 1989, he searches several other sources – such as the SEC filings, the records of Recombinant Capital and several industry directories - for (US) biotech firms that have received venture capital as privately held firms but are not in the VE sample. His efforts lead to the identification of an additional 37 US biotechnology firms (ca. 12% of the total sample), but evaluating those cases omitted in the VE database (e.g. with view to the patents and the total amount received by those ventures) Lerner (1995) concludes that the results suggests that the omitted firms are less significant than those included in the VE data; and he does not include all of the additionally identified ventures in his final analysis.

Again pointing into a similar direction, also Gompers and Lerner (1999) investigate the completeness of the Venture Economics database and conclude that it covers more than 90% of all venture investments.

Kaplan et al. (2002), furthermore, examine and contrast the accuracy of both the VE and the VentureOne databases by comparing 'real-world' contracts in 143 VC financings (143 VC investments in 98 portfolio companies by thirteen VC partnerships) to their characterizations in the databases (for instance, with view to whether the financings appear in the database and the financing amount). Doing so, the authors find that both databases exclude roughly 15% of the financing rounds and 20% of the funding committed, and that they over-sample larger rounds and California companies (and the VE database significantly so). Furthermore, the authors also note that both databases provide unbiased, but noisy measures of financing amounts (the average absolute error is in the order of 10%). However, Kaplan et al. (2002) also point out that – contrary to what one might expect – both databases show *no* bias towards including companies that subsequently go public.

Hochberg et al. (2004), finally, adds that 'occasionally, Venture Economics assigns more than one name for the same VC firm (e.g. 'Alex Brown and Sons', and 'Alex Brown & sons') – making it necessary to manually consolidate VC firm names where applicable.

Summarizing the above, we are confident that the information obtained from VE is relatively complete and accurate. Nevertheless, we acknowledge that there might be some relevant issues with these data, which potentially could bias our findings. In the following section, we describe how we deal with these issues.

E.I.4.b) Own assessment of data and corresponding actions

From the previous section it seems, the main issues with the VE data concern 1) the multiple listing (double-counting) of single rounds, 2) the 'confusion' of some VC names, and 3) their (in-) completeness (including missing information on some variables) particularly before the mid to end 1980s.

With view to the first issue, we amend the problem of double-counting of single rounds in our sample, as far as possible, by combining all those 'rounds' in the same venture that – according to VE – either occurred on the same date or within 90 days (this was the case for about 9% of our observations).

Similarly, we also amended the second issue, the 'confusion' about VC names, as far as possible. For this purpose, we checked our sample for suspiciously similar VC names, and where those were found we searched the Internet and VC-websites for the appropriate names. Doing so, we identify and amend the names of ca. 30 VC firms that turned up under slightly different names in the VE databases.

This leaves us with the third issue mentioned above, the incompleteness of the VE data, particularly before the mid to end 1980s. We are not too concerned that this substantially affects our findings because the vast majority of our observations (VC investments in biotech ventures) occurred after the mid 1990s (see 'exploratory overview over of the data' further below).

However, in preliminary analyses, we noted that there is a non-negligible proportion of cases with missing data on some variables in our sample; and, following Hair et al. (1998), we are aware that missing data are problematic because they not only reduce the number of observations available for analyses but also because they might be non-random. If this is the case, any statistical results based on these data are biased to the extent of the non-randomness or 'missing data processes'. This clearly can affect the generalizability of the results. Similarly, also Tabachnick and Fidell (2001: 58) point out, that the pattern of missing data is more important than the amount missing. Missing values scattered randomly through a data matrix pose less serious problems. Non-randomly missing values, in contrast, are serious because they affect the generalizability of results.

Thus, it is important to determine the extent of this problem with view to our data before the actual analyses; and we therefore deal with this issue in some more detail in the following section.

Furthermore, in the section after the next, we also briefly describe our analysis – and corresponding actions – with view to potential outliers and influential cases in our samples.

E.I.4.b.i. Overview over cases with missing data

For our analysis of cases with missing data, we focus on the VC/investment level, which is the most fine-grained level used in any of our analyses.[92] Here, we furthermore concentrate on those variables for which we find - in preliminary, unreported analyses - more than 10% cases with missing information. As Table E-1 shows, this is the case for all our theoretical variables (proxies for VCs' knowledge) and the finance-related control variable.[93]

Table E-1: Overview over cases with missing data (>10%) on the investment level (N=14,730)

Missing data on variable:	Number (%) of cases
VC total experience	2,439 (16.6)
VC non-biotech experience	2,439 (16.6)
VC biotech expertise	2,148 (14.6)
VC age experience	2,321 (15.8)
Relative investment size	4,015 (27.3)

The next step is to investigate possible reasons for cases with missing data, as a fundament for the appropriate course of action. Here, preliminary analyses show that, whilst missing data are scattered across cases, four main groups of cases

[92] As evident from Figure E-1, most variables used on other levels of analysis (i.e. round and venture level) merely represent aggregations of the data from the investment level. For instance, the age of the individual VCs (on the investment level) serves as a fundament to calculate the average age of the syndicate on the round level, and the average age of all syndicates invested in a venture on the venture level. At the same time, this means that the proportion of cases with missing data will be highest on the investment level.

[93] As we will explain further below (Chapter F), for our analysis on the investment level, we use the individual VC's 'relative investment size' as a finance-related control variable because VE only provides information on the actual investment size by each VC participating in a round in a very limited number of cases. We calculate this variable as the proportion of the current total 'round amount' (invested by all VCs in a particular round) to the individual VC's average previous investment size (round amount divided by number of participating VCs of the rounds a VC has previously invested in). As such, on the investment level, cases might have no information on the 'relative investment size' because the total round amount and/or the individual VC's average previous investment size is unknown. Since most rounds comprise several investments by individual VCs, this might also explain why our investment level sample comprises a higher proportion (27.3%) of cases with missing information on this finance-related variable than, for instance, Kaplan et al. (2002) who find that the VE data have no information on the *round* amount in about 20% of the cases.

account for a large proportion of cases with missing data.[94] They are depicted in Table E-2.

Table E-2: Main groups of cases with missing data on the VC/investment (N=14,730)

Main groups of cases with missing data	Number (%) of cases
Undisclosed VC	1,681 (11.4)
Unknown VC	758 (5.2)
Unknown round amount	994 (6.8)
VC who invested more than once in same round	1,261 (8.6)

As we explain in the following, Table E-2 provides some explanation for this sizeable proportion of cases with missing information shown in the previous Table E-1.

Cases of investments by 'undisclosed VCs': From Table E-2 it is evident that a considerable number (1,681, or about 11.4%) of all investments in our data were made by what VE calls 'undisclosed' VCs. This is, VE notes that a VC has invested in a venture (either alone or as part of a syndicate) but does not provide any further information about these VCs, such as their name, their type, their country of origin, or - most critical for us - their age and their non-/biotech experience.[95] Therefore, we have to exclude those cases of investments by undisclosed VCs from our analysis on the investment level. However, we account for those 'undisclosed VCs' in several calculations to adjust other variables in the analyses on the investment level, as well as the round and venture level. For instance, on the investment level, to calculate the average investment size per VC, we divide the round amount by the total number of VCs whether they are undisclosed or not. Furthermore, on the round level, if a round comprises two VCs of which one is undisclosed, we still consider it a syndicated round. Nevertheless, the large number of these cases could present a substantial problem for our analyses. Particularly if those cases of 'undisclosed VCs' were not randomly distributed this could substantially bias our findings. For instance, it might be that cases of undisclosed VCs are disproportionally frequent in small

[94] In this context, it should be mentioned, the four main groups of cases with missing data account for the majority but not for all of the cases with missing data. However, as preliminary analyses have shown, the remainder of cases with missing data seems randomly scattered and of little overall relevance (<5%).

[95] From VE's website, we understand that some VCs cooperating with VE do not want to have published any detailed information about their activities; and VE only uses the information provided by those VCs in its aggregate data (which are relevant only for our context-related control variables) but otherwise keeps the VCs confidential.

or large investment rounds, in certain countries, or in certain years – potentially distorting our findings with respect to those situations. Consequently, we conduct several tests to find out whether undisclosed VCs tend to fall into particular categories of investments and/or whether they are different in some other way from the 'disclosed VCs'. Those tests will be described further below.

Cases of investments by 'unknown VCs': Another group of cases with missing data on key variables is that of what we call 'unknown VCs'. Into this category fall VCs for which VE doesn't provide any further information but their name – and the number of appearances as investors in biotech ventures. Therefore, also for this group important information for our analyses is missing in most cases, such as their age, type, country of origin, and – again very critical to us – their non-biotech experience.[96] However, compared to the above-described cases of 'undisclosed VCs', cases of 'unknown VCs' have the advantage that they can at least be distinguished – from each other and from 'regular VCs' - by their name, and do not have to be treated as a homogenous group of anonymous VCs. As such it is possible to narrow down the cases of investments by 'unknown VCs'. For instance, whilst in our data there are 758 cases of investments made by 'unknown VCs', we know that those investments are in fact made by 'only' 350 individual VCs, or about 17% of all VCs in our sample.[97] At the same time, as described for the 'undisclosed VCs', we can use the information about 'unknown VCs' to adjust some important variables for our analyses – such as the syndicate size or the average investment size per VC in the syndicate. Nevertheless, because some important information is missing for the 'unknown VCs' it is still possible that also the 'unknown VCs' – similar to the 'undisclosed VCs' – introduce some bias into our findings, particularly if they are different in some un-random way from the 'known VCs'. Consequently, also for this group we conduct a number of tests to find out whether those 'unknown' VCs are particularly frequent in certain types of investments.

Cases of investments with 'unknown round amount': The third group of cases with a significant number of missing data is that of investments for which the

[96] In this context, it should be noted that because we don't have information about the non-biotech experience of both 'undisclosed' and 'unknown' VCs, the total number of cases without information on the non-biotech experience in Table E-1 above is the sum of these two (mutually exclusive) groups of VCs (1,681+758=2,439) in Table E-2.

[97] This is different from cases involving 'undisclosed VCs': the total number of investments made by undisclosed VCs, 1681, either could come from 1681 individual undisclosed VCs, or from one single undisclosed VC with 1681 investments, or from any number in between.

overall round amount ($) – and correspondingly the average investment size per VC – is unknown. Overall, 994 (or about 6.8%) of all investments in our sample fall into this category – which again might or might not comprise cases of other missing data described above. Together with the previous two groups of cases, this also explains the high number and proportion of cases/investments with missing information on the ratio between the round amount and the average previous investment size by a VC (4,015 or 27.3% of all cases). For most of it, this is a result of the cases for which we don't have the round amount and/or cannot calculate the VCs' average previous investment size (either because the VCs are undisclosed or unknown, or because we don't have the information on their previous investments although they are not undisclosed or unknown). Similarly to what has been described for the above groups of cases with missing data, also the group of cases with missing round amount could potentially bias many of our findings. This is because – although the focus of our interest is on the VCs' knowledge – finance-related aspects, such as the round-amount, arguably present important control variables for all our analyses (after all, the money is key to the VCs' activity). Thus, particularly if cases with missing round amount are non-randomly distributed, they might distort our findings, or at least the interpretation of our findings in the light of financial aspects. As a consequence, also for this group we test whether there are any evident patterns in the frequency of cases with missing data on the round amount.

Cases of 'VCs investing more than once in same round in same venture': The final main group of cases with 'problematic' data in our sample results from those VCs that, according to VE, invest more than once in the same round (in the same venture). Specifically, on the investment level, we find 1,261 cases where the same VCs invest more than once in the same round.[98] In most of these cases a VC invests twice in the same round, but there are also cases where a VC invests more than twice. Whilst the first two of the above-described groups of 'undisclosed' and 'unknown' VCs are mutually exclusive, this is different with respect to those VCs that invest more than once in a given round in a given venture. Specifically, the later group might comprise 'undisclosed', 'unknown' and 'disclosed/known' VCs, as well as cases of 'unknown round

[98] It should be emphasized that this is different from the common cases, in which the same VCs invest more than once in the same *venture, but in different rounds*. In fact, we have 7,241 cases of investments made by the same VC in the same venture, of which 'only' 1,261 cases occur in the same round – leaving us with 5,980 cases in which the same VC invested in the same venture but not in the same round.

amount'. In most cases (in more than 1,000 or 83% of the 1,261 cases) we have all relevant background information on those VCs that invest more than once in the same round to conduct our analysis. Nevertheless, we reckon that it would be inappropriate to treat them as 'normal' investments and include them in our analysis for two reasons. First, it seems likely that the double-listing of VCs in a given round is simply a mistake by VE. This assumption also finds some support by Lerner (1994) who finds that – particularly in the early years of VE there was a tendency to record separate disbursements of funds by the same VC in the same round as different rounds. Second, since we are interested in the experience of VCs (approximated by their previous number of investments), it would seem problematic if we included the same VC twice in a given round - since this would 'inflate' his experience. For instance, it would seem unreasonable to a argue that a VC with an initial experience score of, say, 1 (before investing in a given venture in a given round) would gain an experience score of 3 if he invested twice in this round within a very short period of time.[99] Therefore, in our analysis, we treat several investments by the same VC in the same round as a single investment by this VC. This deletion of investments leads to 'missing' data in the sense that it reduces the number of observations/units of analysis on the investment level.[100]

E.I.4.b.ii. Analyses of cases with missing data

The above four main groups of cases with missing data could present a threat to our analysis if they were not randomly distributed. To find out whether any patterns exist in the distribution of those cases we broadly use three different approaches.

Firstly, we look at the *interrelations between the cases with missing data* themselves. This is because it might be that certain cases with missing data

[99] In this context, it should be referred to our discussion of the proxies for VCs' knowledge used in our research (see Chapter D). There we argued that a suitable proxy for VCs' knowledge should be their number of investments in different ventures. In this context, we further argue that a venture develops and changes over time (i.e. from one round to the next). So, if the same VC invests in subsequent round in the 'same ' venture he is still likely to gain additional experience from these investments. If however, the VC makes several investments in the same round (i.e. in very short intervals), this venture is unlikely to have developed much between those investments – making it unlikely for the VC to gain much additional knowledge from those investments.

[100] Specifically, instead of the 14,730 observations on the investment level we now 'only' have 13,469 (14,730-1,261) observations on this level.

coincide with one or more of the other groups. For instance, cases with 'undisclosed VCs' might simultaneously be cases with 'unknown round amount'.

Secondly, we look at the *distribution/frequencies of the cases* in the above-described four groups *over time*. This is because it might be that certain cases with missing data are particularly frequent in certain years, for instance, because - as mentioned above - the way in which VE has gathered its information has changed over time.

Thirdly, we conduct a *comparison of groups of cases with and without missing data on the basis of other variables*, for which we have information in both groups. Specifically, we use chi-square tests to compare the expected and observed frequency of unknown VCs in different countries.

We begin our analysis of cases with missing data with an overview over the interrelation between the different groups of cases. Here, Table E-3 illustrates the relation between the four main groups of cases with missing data.

Table E-3: Relation between main groups cases with missing data

[number in brackets: % of cases within main group]

Main group of cases:	Total in main group	Only in main group	Additionally in group/s:						
			1	2	3	4	1+4	2+4	3+4
(1) Undis-closed VC	1,681	1,369 (81.4)	-	-	104 (6.2)	208 (12.4)	-	-	1 (0.1)
(2) Un-known VC	758	684 (90.2)	-	-	37 (4.9)	9 (1.2)	-	-	0 (0.0)
(3) Un-known $	994	804 (81.0)	104 (10.5)	37 3.7)	-	48 (4.8)	1 (0.1)	0 (0.0)	-
(4) 'Double -VC'	1,261	996 (79.0)	208 (16.5)	9 (0.7)	48 (3.8)	-	-	-	-

From Table E-3 it is evident that no two groups of cases with missing data fall closely together. In fact, the greatest mutual inclusion exists between cases of group 4 (VCs that invest more than once in the same round) and cases of group 1 (undisclosed VCs). 16.5% of the cases of group 1 also fall into group 4 - and 12.4% vice versa. But this has to be interpreted with some caution since, per definition, we don't know the identity of the undisclosed VCs. So it might be the same (undisclosed) VCs are investing more than once in a given round or it might be a different (undisclosed) VC.

Overall, therefore, there seems no clear pattern indicating that cases with missing data would coincide in two or more of the groups.

The next step in our analysis of cases with missing data consist in a graphical examination of the development in the proportion of those cases relative to the total number of investments in a given year. This is depicted in Figure E-2.[101]

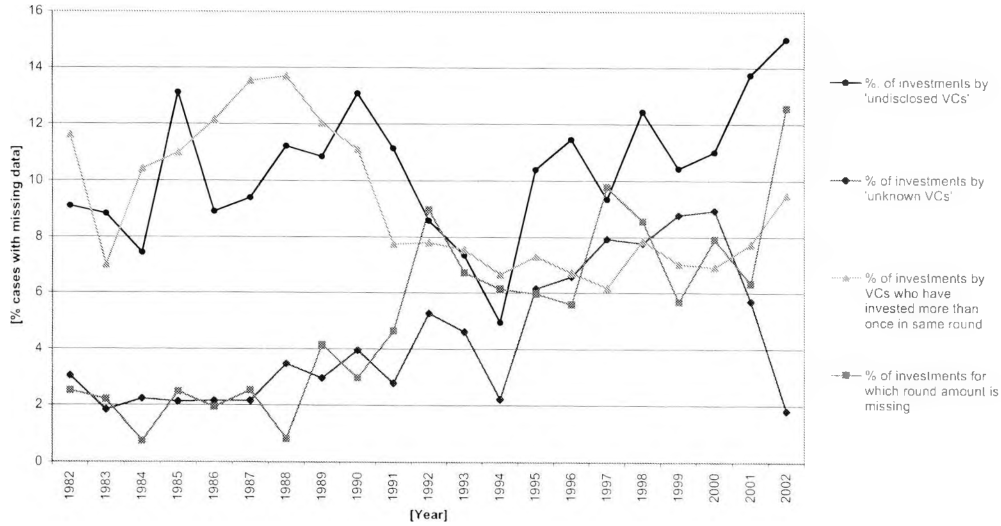

***Figure E-2: Proportion of cases with missing data** (**1982-2002**)*

As is evident from Figure E-2, from 1982 onwards, for each of the four main groups of cases with missing cases there is considerable variance in their relative proportion to the total investments in a given year. In fact, the variance over the sampling period is as stark that it seems very difficult to determine whether there is any clear development in the frequency of the number of cases in any of the groups over time. However, if any, the most likely trends in Figure E-2 could be: the proportion of a) investments by 'VCs who invest more than once in the same round' rather decreases, b) investments by 'undisclosed VCs' rather increases slightly, c) investments by 'unknown VCs' rather increases, and d) investments with 'unknown round amount' increases strongest.

With view to Figure E-2, it should be mentioned (and will be shown in the 'exploratory overview over the data' further below) that the vast majority of investments in our sample was made after the mid 1990s, when the biotech/-venture capital boom started. At the same also many new (mainly non-US) VCs entered the arena. As a consequence it is likely that, by the end of our sampling period, VE has not had enough time to update the information on those new VCs, particularly if they were not from the US.

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[101] In the early years (i.e. pre 1980s) of our sampling period, the overall number of investments is very low and there are hardly any cases with missing data. For reasons of illustrative clarity Figure E-2, therefore refers only to the years 1982-2002.

Our final approach to examining possible patterns in the four main groups of cases with missing data consists in looking at the frequency of those cases in different countries (i.e. US vs. non-US) to identify potential geographic biases in our data (as suggested by Kaplan et al., 2002). For this purpose, we examine - with a chi-square test - whether cases of missing data occur more frequently in the US than outside the US.[102]

'Undisclosed VCs': there is a significant (p<.000) relation between cases of investments by undisclosed VCs and the country of origin of the venture in which the investment was made; all 1,681 cases of investments by undisclosed VCs involve non-US ventures (this is despite US investments, with about 80%, clearly dominate our sample).

'Unknown VCs': there is a significant (p<.000) relation between cases of investments by unknown VCs and the country of origin of the venture in which the investment is made; cases of investments by unknown VCs are more frequent than expected in non-US ventures and less frequent than expected in US ventures.

'Unknown round-amount': there is a significant (p<.000) relation between cases of investments with missing round amount and the country of origin of the venture in which the investment is made; cases of investments by unknown VCs are more frequent than expected in non-US ventures and less frequent than expected in US ventures.

'VCs investing more than once in same round': there is a significant (p<.000) relation between cases of investments where the same VCs invested more than once in the same round and the country of origin of the venture in which the investment is made; cases of investments where the same VCs invested more than once in the same round are less frequent than expected in non-US ventures and more frequent than expected in US ventures.

From the above it is evident that the frequency of cases with missing data seems to be related to geographic aspects. Specifically, cases of missing data (undisclosed VC, unknown VC, and unknown round amount) are more frequent for investments outside the US than for investments inside the US. Cases of

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[102] A possible argument for differences in this context could be, for instance, that VE – as a U.S. company – puts a stronger focus on collecting accurate/complete information about U.S. investments; or it might just be easier to collect such information in the more mature/developed U.S. market than in non-U.S. markets (Kaplan et al., 2002, for instance, indicate that VE over-samples 'Californian' rounds).

problematic data (VC invested more than once in same round of same venture), in contrast, are less frequent for investments outside the US than for investments inside the US. One plausible explanation for this might be that VE has a stronger focus on the US VC market – which might result in more accurate information about the activity inside the US market than outside the US market.

In sum, from our analyses of cases with missing data, it seems that there is no consistent pattern that could simultaneously explain all four main groups of cases with missing data. However, there are clear indications that cases with missing data are not completely random. Specifically, as already indicated by previous research, we find some variation in the proportion of cases with missing data over time; and we find evidence for a better coverage of the VE data in the US than outside the US.

This raises the question of how to deal with the cases of missing data. In this context, several options are suggested in the literature (e.g. Tabachnick & Fidell, 2002). For example, one might consider estimating and replacing the values of missing variables using imputation procedures such as mean substitution, regression, expectation maximisation, and/or multiple imputations. However, all these procedures have associated problems (cf. Hair et al., 1998) and they would involve a 'guesstimate' of a fairly large proportion of variables. An alternative approach, therefore, is to drop the cases with missing information on key variables altogether. However, this would clearly mean a great loss of information. Furthermore, not all missing variables are relevant for all analyses; and most cases with missing values for one key variable have information available for other key variables. Thus, as explained before, we can often use certain available information on the cases with missing data to adjust other variables (on other levels of analysis).

As a consequence, we consider it most appropriate to exclude cases with missing values on a case-wise basis, depending on the particular level of analysis. For instance, we exclude cases of 'undisclosed' VCs for our analysis on the investment level (because we don't have information for these cases, for instance, on the VCs' knowledge); but we use the information on the undisclosed VCs to decide whether a deal is syndicated for our analysis on the round level.

Nevertheless, for all our subsequent analyses (with the exception of the case studies) and discussions, it should be kept in mind that there is a certain bias in our sample, particularly with view to an over-representation of US data.

E.I.4.b.iii. Outlier and influential cases

Another important data issue that needs to be addressed regarding the generalizability of our findings based on the samples obtained from VE concerns outliers and influential cases. Those cases could potentially affect the results from all three regression procedures (Logistic-, Multiple-, or Cox-Regression) we use for examining our hypotheses. 'Outliers' are cases that differ substantially from the main trend of the data. They can cause the model to be biased because they affect the values of the estimated regression coefficients.[103] 'Influential cases' are cases that exert undue influence over the parameters of the model – even if not identified as an 'outlier'.

Since our procedure for analysing those cases, as well as our method to deal with them, are essentially the same in all our analyses, we describe them at this point, and refer back to this section in the chapters that describe the analytical approaches for each individual hypothesis.

As Hair et al. (1998: 64) point out 'outliers cannot be categorically characterized as either beneficial or problematic but instead must be viewed within the context of the analysis and should be evaluated by the types of information they may provide. When beneficial, outliers – although different from the majority of the sample – may be indicative of characteristics of the population that would not be discovered in the normal course of analysis. In contrast, problematic outliers are not representative of the population, are counter to the objectives of the analysis and can seriously distort statistical tests. Owing to the variability in the impact of outliers, it is imperative that the researcher examine the data for the presence of outliers to ascertain their type of influence'.[104]

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[103] As Tabachnick and Fidell (2001: 66-67) point out, 'an outlier is a case with such an extreme value on one variable (a univariate outlier) or such a strange combination of scores on two or more variables (multivariate outlier) that they distort statistics ... and they lead to results that do not generalize except to another sample with the same kind of outlier'; and Gujarati (2003: 390) further explains, 'an outlier is an observation that is much different (either very small or very large) in relation to the observations in the sample. More precisely, an outlier is an observation from a different population to that generating the remaining sample observations. The inclusion or exclusion of such an observation, especially if the sample size is small, can substantially alter the results...'

[104] Similarly, with view to influential cases, the authors point out that although there is no single procedure for identifying influential cases and then deciding on the course of action, the basic premise is quite simple. In the absence of data entry error or other correctable reasons, influential cases that are substantially different from the remaining data on one or more variables should be closely examined. If it is ascertained that a case is unrepresentative of the general population, it should be laminated' (Hair et al., 1998: 234).

Therefore, following the procedures outlined by Hair et al. (1998) and Tabachnick and Fidell (2001), for each of our analyses, we take a two-step approach towards identifying those cases. Firstly, in the pre-analytical/screening stage, we examine the original variables for potential uni-/multivariate outliers. Secondly, in the analytical stage, we search for outliers and influential cases in the solution.

For this purpose, the residuals are the most fundamental diagnostic tool - since those cases not predicted well by the regression equation will have large residuals. We analyse the residuals in several ways. Specifically, we begin with partial regression plots for pairs of theoretical/independent and dependent variables. But because the identification of outlying/influential observations is said to be more a process of convergence by multiple methods than a reliance on a single measure - we also use a variety of diagnostics provided by SPSS (the statistical package we use for all our analyses) such as standardized/studentized residuals, leverage points, DFBeta, Mahalanobis distance and Cook's distance.

Based on this, we identify a number of cases that might potentially present outliers or influential cases. This is mainly due to extreme values of individual variables. But a closer examination of those cases across different variables suggests that none seems implausible in light of other variables, and there is no reason to believe that those cases should not be part of the overall population.

As such, we follow Hair et al. (1998), who argue that, whilst there are many philosophies as to how to deal with outliers, they should be retained unless there is demonstrable proof that they are truly aberrant and not representative of any observations in the population. But if they do represent a segment of the population, they should be retained to ensure generalizability to the entire population - because there are always outliers in any population, and one must be careful not to trim the data set.

We therefore decide to retain 'outliers' for our main analyses. Nevertheless, we run our main models both with and without those cases included, and we find that the results don't differ qualitatively.

Two exceptions to the above outlined procedure, however, concern those cases (rounds), for which VE states that the round-amount is below $100.000 and/or the round-length is below 90 days. With view to those cases, we believe it is more likely that the low variable values are due to sampling or data-entry errors on VE's part, which – as described in the previous section – sometimes tend to list individual investments as separate rounds. Therefore, we combine those 'rounds' with a deal size of less than $100.000 and/or 'rounds' shorter than 90 days with the previous round (and adjust all other variables, on all relevant levels of analysis, correspondingly).

In the following section we provide an exploratory overview over our units of analysis and the key data examined in our three research hypotheses that will be dealt with in the subsequent chapters.

E.II. Exploratory overview over the data

This section aims to facilitate understanding of the general structure as well as important developments over time regarding both units of analysis (i.e. investments, rounds, and ventures) and key variables used.

In this context, the following two sub-sections provide an overview over our data from two different perspectives: firstly, a cross-sectional perspective on the units of analysis, and, secondly, a time-series perspective on both the units of analysis and key variables. Both sections are based on our *raw data* and a sampling period from 1972 to 2002/3.[105]

The last sub-section summarizes and highlights the most important observations from this overview.

E.II.1. Cross-sectional perspective on units of analysis

As Figure E-1 further above indicates, different units of analysis coincide with different numbers of observations. Specifically, the number of observations decreases from the VC/investment level, to the round level, and on to the venture level. This is because many VCs make more than one investment in one or several rounds of the same venture or different ventures, and many ventures receive several rounds, often comprising several investments by several VCs.

Accordingly, in our *raw data*, we have the following numbers of observations for our units of analysis:[106]

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[105] Here, the cross-sectional perspective includes observations from January 1972 through to April 2003 (with about 250 investments made between January and April 2003). However, since we have no complete information for the year 2003, the subsequent time-series perspective, only includes observations for the period from January 1972 to December 2002.

[106] As explained in the previous section, because our sample contains cases with missing data, the number of observations in the raw data is higher than the number of observations actually available for our various analyses described in the subsequent three chapters.

1. *VC/investment level*: 14,730 individual investments (1,995 different VCs)
2. *Round level*: 5,012 separate rounds (5,012 lead VCs and 2,883 syndicates)
3. *Venture level*: 1,712 ventures (5,012 lead VCs and 2,883 syndicates)

Figures E-3 a)-c) take a cross-sectional perspective on our units of analysis. For this purpose, they relate the number of investments to the number of a) VCs, b) rounds, and c) ventures in our samples.

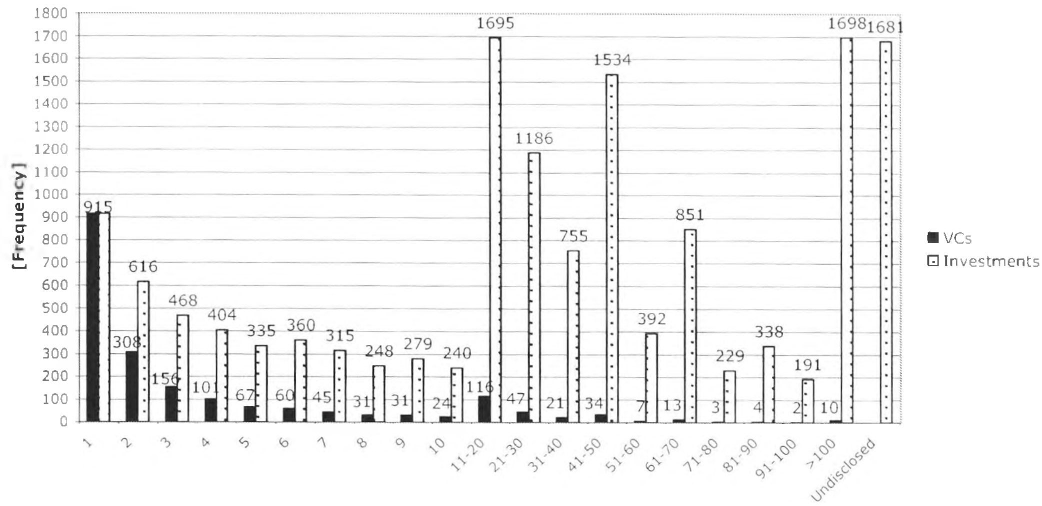

Figure E-3 a): Relation VCs-Investments
(Groups formed by total number of investments per VC)

Figure E-3 a) shows, for VC groups defined by the total number of investments per VC, the relation between investments and VCs. For example, starting with the left-most group '1', one can see that 915 VCs (ca. 46%) have made just one biotech investment during our sampling period, and are therefore responsible for a total of 915 investments (ca. 6%) in our sample. Moving to group '2', one can see that 308 VCs in our sample have made exactly two investments each and a total of 616 (2 x 308) investments between them. But summarizing the right half of Figure E-3 a) (i.e. VC groups '11-20' to '>100'), it is also noteworthy that most investments in our sample (ca. 72%) come from VCs that have made more than ten biotech investments each - although this VC group represents only a small proportion of all VCs in our sample (ca. 13%). Overall, this means that the distribution of investments per VC is highly skewed with a large number of small contributors and a small number of large contributors.

Another perspective on our data can be gained by looking at the frequency of investments in groups defined by the round numbers in which these investments have occurred (in our data, all ventures have at least received one, the first, round, but only one venture has received a total of 20 rounds). This is shown in Figure E-3 b).

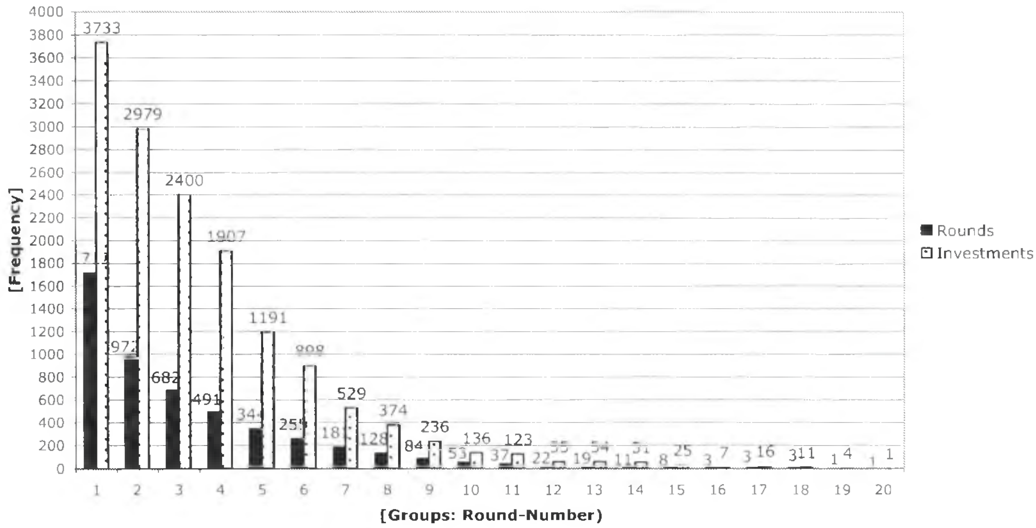

Figure E-3 b): Frequencies of rounds and investments (Round groups defined by the round-number)

From Figure E-3 b) it is evident that - with a few minor exceptions in later rounds - the frequency of both rounds and investments in our sample decreases rapidly from the first group ('round number 1') to the last group ('round number 20'). First rounds alone account for more than one third of all rounds and more than one quarter of all investments in the sample. Furthermore, although not shown explicitly in Figure E-3 b), the number of investments per round (i.e. the number of different VCs participating in a round) is fairly stable at around 3.2 investments across round-numbers. However, with an average of only about 2.2 investments (VCs), first rounds seem to be somewhat different from later rounds.

For the last cross-sectional perspective on our data we look at the relation between investments and ventures. This is depicted in Figure E-3 c) below. There, we categorize ventures according to the maximum number of rounds they have received during our sampling period. This is different from the previous Figure E-3 b) that looked at the round number without differentiating between ventures on the basis of how many rounds they have received in total.[107]

[107] To clarify this point with an example, group '8' in Figure E-3 b) above refers to the *group of all the 8th rounds* in our sample, independent of whether those 8th rounds were the last round a venture has received or not; group '8' in Figure E-3 c), in contrast, refers to the *group of ventures that have received a total of 8 rounds* during the sampling period.

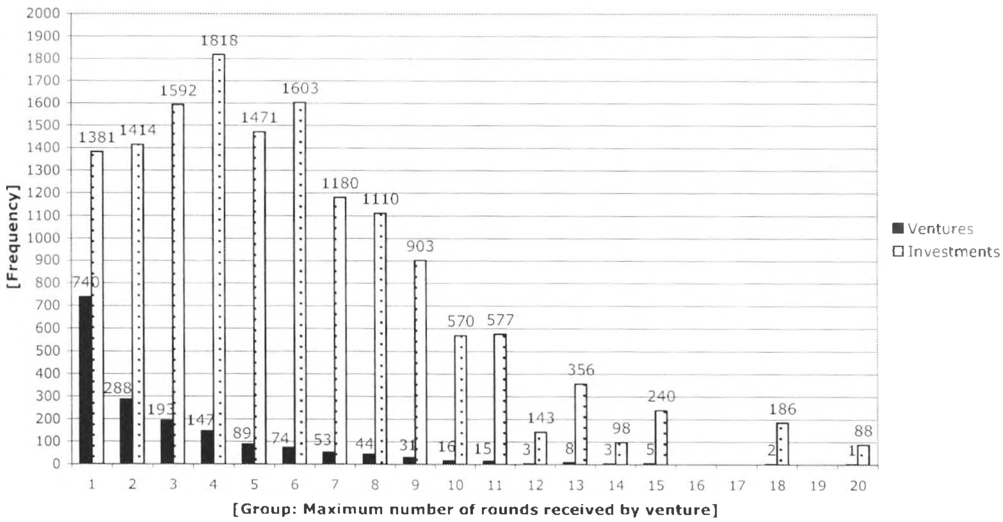

Figure E-3 c): Frequencies of ventures and investments (venture groups defined by the maximum number of rounds received)

From Figure E-3 c) it is evident that most ventures in our sample (730, or ca. 43%) have received only one round of funding (namely their first round); and a decreasing proportion of ventures have received more than one round. However, from Figure E-3 c) it is also evident that the largest group of ventures doesn't account for most investments in our sample. Instead, most investments in our sample fall into the group of ventures that has received four rounds of funding. Again, also from this perspective the number of investments per round - with an average of 3.3 - is relatively similar across the groups; but those ventures that received only one (the first) round, on average, only attracted 1.8 investments (VCs) in that round.

E.II.2. Time-series perspective on units of analysis and key variables

The above cross-sectional perspective on our raw data obscures the fact that the number of observations in our data varies substantially over time.

For instance, the above-mentioned Figure of 1,995 VCs in our sample represents the total number of different VCs that have *ever* made an investment in a biotech venture during our sampling period. However, the actual number of VCs that are active (i.e. make an investment) in a given year can, and does, vary. Similarly, also the numbers of investments, of rounds, and of ventures receiving funding vary substantially over the years.

In this context, Figure E-4 below provides an overview over the developments in the number of VCs, investments, rounds, and ventures during our sampling period from 1972 to 2002.

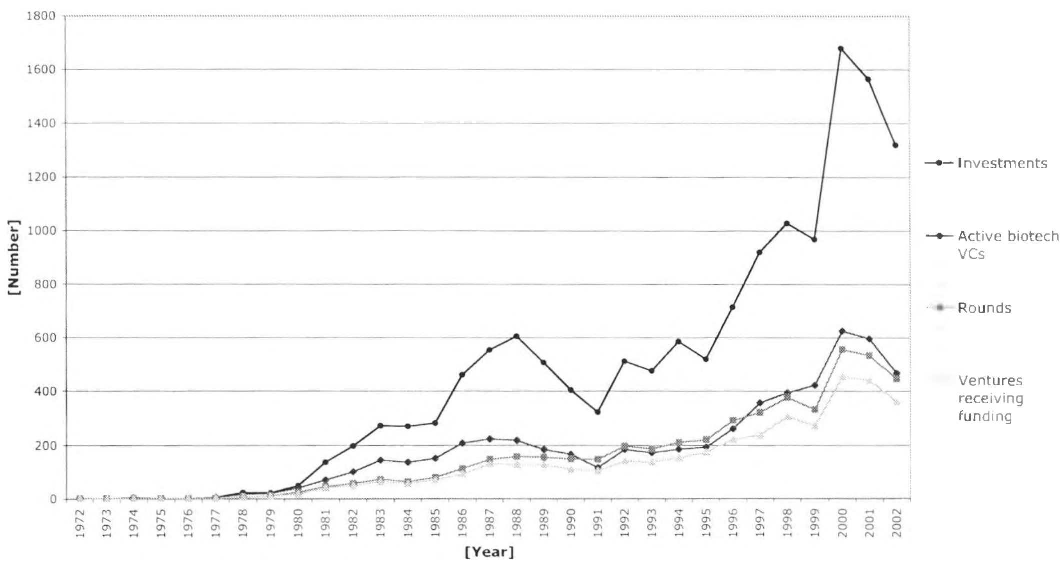

Figure E-4: Annual numbers of VCs investing in biotech, investments, rounds, and ventures receiving funding (1972-2002)

A number of points are particularly worth noting from this Figure E-4.

For instance, it is evident that before 1980 there was hardly any venture capital investment activity in the biotech sector. However, from the early 1980s onwards the activity picked up to reach a first peak in late 1980s. After some 'shaky' years, in 1996 the investment activity in the biotech sector picked up again and - apart from a minor 'plunge' in 1999 - experienced a dramatic increase that led to an extraordinary peak in 2000. After that year, however, there was to be observed a decrease in activity for the final two years of our sampling period (and, although not shown in Figure E-4, this general downward trend continued further, albeit to a lesser extent, until today).

Whilst this general pattern is particularly evident with view to the number of investments made in biotech ventures, similar trends are also to be observed regarding the number of VCs actively investing in biotech ventures, the number of rounds in biotech ventures, and the number of biotech ventures receiving funding in a given year. In fact, these last three variables show a remarkably parallel development over the sample period. At the same time though, the number of active VCs always outweighs that of ventures receiving financing in a given year. This indicates that in many cases VCs don't invest alone but in syndicates.

Based on the forgoing, in the following sections we take a closer look at the developments of several key variables in the trend analyses below.

Since, as mentioned above, we conduct our analyses on three different units representing different levels of aggregation in our data, we illustrate the development of relevant key variables separately for each level of aggregation – the investment level, the round level, and the venture level. This facilitates an understanding of the development of the key variables used for the examination of our different hypotheses in the subsequent Chapters.

However, before we do this, a couple of facts need highlighting.

To begin with, it is self-evident that the venture capital activity in the biotech sector does not occur in a vacuum. Therefore, we begin our discussion with a brief section that illustrates the wider context in which the biotech venture capital activity takes place.

Furthermore, as mentioned above, investment levels are closely correlated with VC levels. Although the latter doesn't present a separate unit of analysis for our study, an understanding of the developments on the VC level seems crucial for an understanding of the developments on the investment level. We therefore include a discussion on the developments on the VC level in the section dealing with the investment level of analysis.

Finally, it should be noted that, in following sections and illustrations, we only refer to the period from 1982 to 2002 (instead of 1972-2002 as before). This is because a) before 1982 the overall number of observations on all levels of aggregation is almost negligible (see Figure E-4 above) and b) the focus on a shorter period with more observations allows for a more comprehensible illustration of the relevant trends, less distorted by a few outliers/extreme cases.

E.II.2.a) Context

To begin with, when taking a time-series perspective on our sample data, we need to examine what is happening in aggregate in the stock- and private equity markets over the sampling period. This is depicted in Figure E-5 below.

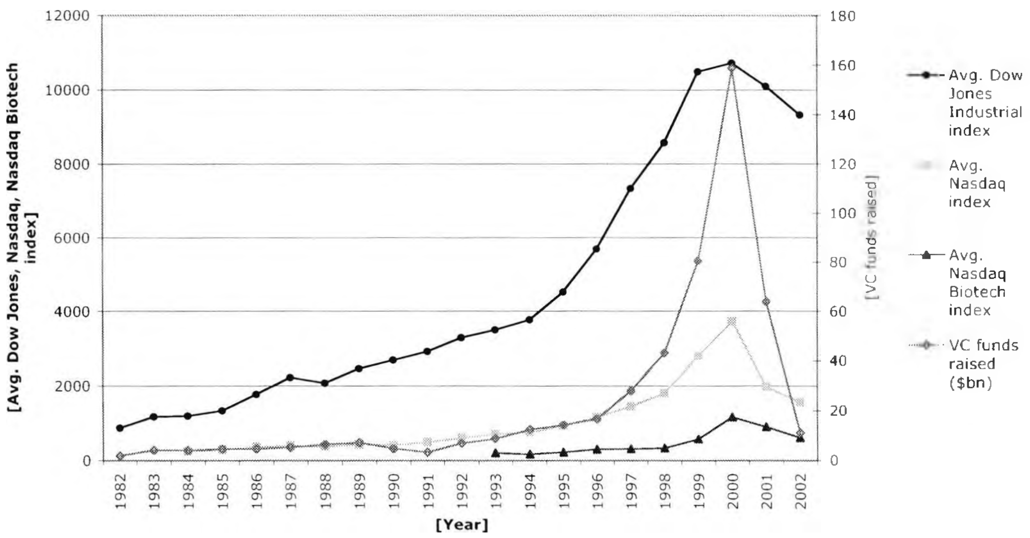

Figure E-5: Stock-/private equity market context during the sampling period (1982-2002)

Comparing Figures E-4 and E-5 above, we can see that the investment activity in the biotech sector follows broadly the same trends as the activity in the general stock- and private equity markets – all of which experienced a substantial boom from the mid 1990s culminating in the collapse of the year 2000, the aftermath of which lasted until at least 2002. This is true of all the indicators but is particularly evident with respect to aggregate venture capital (biotech and non-biotech) funds raised, which – with $160bn - show the most extreme peak in 2000.

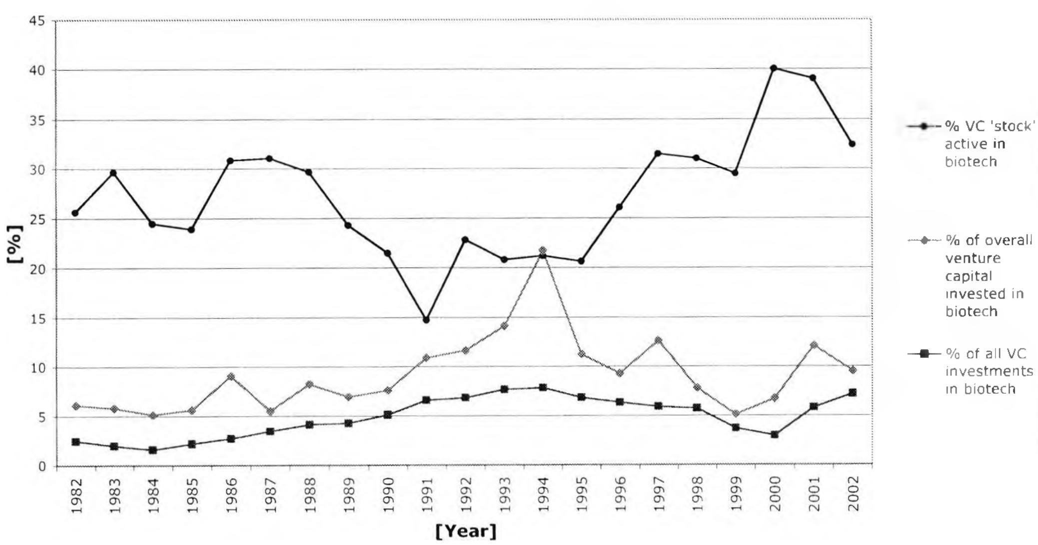

Figure E-6: Venture capital activity in the biotech sector relative to the venture capital activity overall (1982-2002)

Figure E-6 above shows that the level of the VC activity in the biotech sector - relative to that of the VC activity overall – also varies significantly over the sample period. For instance, the relative proportion of the 'stock' of 'biotech VCs' that is actively investing in biotech in a given year varies widely, but never exceeds about 40%.[108] Also, the proportion of their funds invested in the biotech sector only once (in 1994) shows a significant peak exceeding 20%, but lies generally in the region of 5-10% of their overall funds invested. Similarly, the number of investments by the 'biotech VCs' in the biotech sector never exceeds 8% of their total number of investments. Finally, it should also be mentioned that the proportion of the VC stock that is actively investing in the biotech sector does not vary in line with the number of investments and the funds invested in the sector. For instance, it seems that in the early to mid 1990s a relatively small proportion of the biotech VC stock is responsible for a relatively (i.e. compared to other sectors) large proportion of the number of investments and funds invested in the sector.

In sum, whilst the VC activity in the biotech sector appears to follow the overall trends in the stock- and private equity markets, a closer look reveals a significant variance in the relative attractiveness of this sector to investors.

Based on this general overview, in the following three sections, we look in some more detail at the development and some of the key-characteristics of our three main levels of analysis - investments, rounds, and ventures.

E.II.2.b) Investments

As mentioned before, although VCs don't represent a separate unit of analysis for the examination of any of our hypotheses, a understanding of the development on the VC level seems important for an understanding of the developments on the investment level - since those investments are made by VCs.

Therefore, we begin our overview over the developments on the investment level with an overview over the development on the VC level.

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[108] In this context, it must be emphasized though that Figure E-6 only refers to the 'biotech VCs' that invest at least once in biotech (and therefore show up in our data). However, it is obvious, many VCs don't invest in biotech at all. Therefore, the overall population of VCs is much larger. Yet, even the limited sample of 'biotech VCs' (i.e. those that invest also, but not exclusively, in biotech ventures) shows a varying preference for the biotech sector. We refer to the 'stock of biotech VCs' in a given year as the number of VCs that have been founded in or before this year and that have made at least one investment (overall or in biotech) in the three years prior to the focal year. If they haven't made such an investment, we assume that they are 'out of business' and therefore subtract them from the stock of biotech VCs

Here, Figure E-7 below illustrates the development in the number of new and active VCs, their average number of investments in biotech, and the average sizes of those investments in biotech over the sampling period.

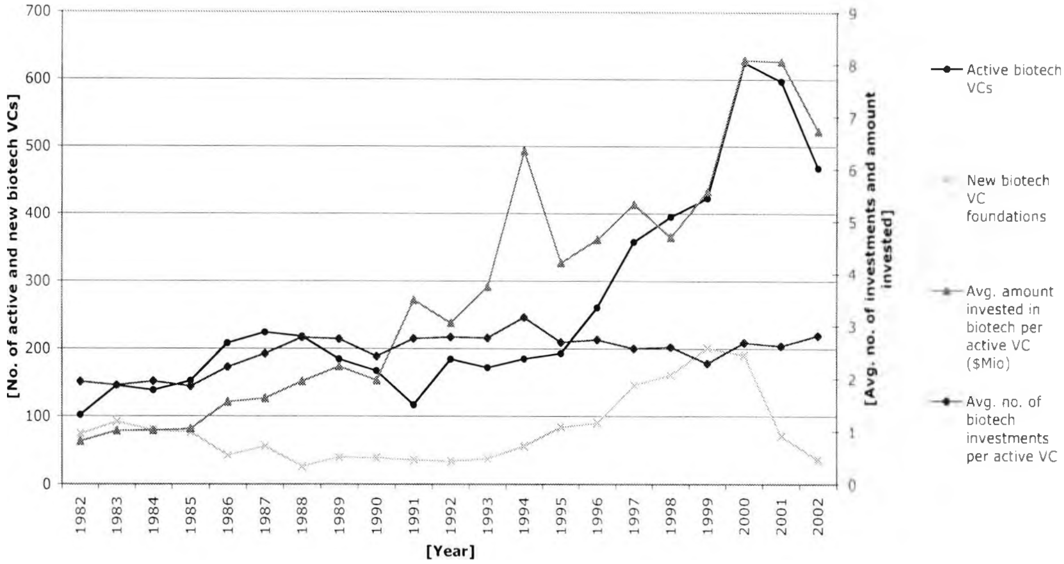

Figure E-7: Number of newly founded and active VCs, avg. amount invested and avg. number of investments per active VC (1982-2002)

As can be seen from Figure E-7 above, between 1982 and 1995 the number of VCs that are actively investing in biotech ventures in any given year varies between 100 and 200. However, in the second half of the 1990s, there is a dramatic increase in the number of active biotech VCs, which culminates at about 600 VCs in 2000 falling again to about 470 in 2002.

As Figure E-7 suggests, this dramatic increase in the number of active biotech VCs is partly due to the arrival/foundation of new VCs. However, it also arises from non-biotech VCs starting to invest in biotech. From 1995 to 2000 the number of active VCs increases by more than 400, but the number of new VCs 'only rises' by slightly more than 100. Part of the increase in the number of active biotech VCs thus is due to the increasing proportion of the 'stock' of VCs that becomes attracted by the biotech sector during the boom period in the second half of the 1990s (see also Figure E-6 on the relative VC activity in the biotech sector above). An important issue therefore is whether this process resulted in lower quality investment selection over the Bubble period.

We note that the average amount invested in biotech per VC follows a similar pattern. There is however a noteworthy peak in 1994, when the average amount invested in biotech ventures per active VC suddenly jumps from less than $4Mio in 1993 to more than $6.5Mio in 1994 - to fall again to ca. $4Mio in 1995. This peak seems to mirror the trends in the relative VC activity in the biotech sector depicted in Figure E-6 above: in 1994, a comparatively small proportion of VCs made considerable investments in the biotech sector, both in relative and absolute terms.

Nonetheless, it is clear that the 1994 peak in the average amount invested per VC was significantly surpassed by the peaks in 2000 and 2001, when those VCs that actively invested in biotech (about 40% of the biotech VC stock, see Figure E-6 above) spent on average about $8Mio in the sector.

Finally, Figure E-7 also shows that the number of investments per VC remains relatively stable over the period from 1982 to 2002, with an average of about 2.6. Thus whilst numbers per VC remain constant, the average investment size increases.

Figure E-8 below looks at another interesting aspect of the VCs in our sample. This is the country of origin of the active VCs. Here the focus is only on those three countries with the largest number of active VCs, the US, the UK and Germany (together the later two account for more VCs than all other countries combined in Europe, the Americas, or the Asia-Pacific Area).[109]

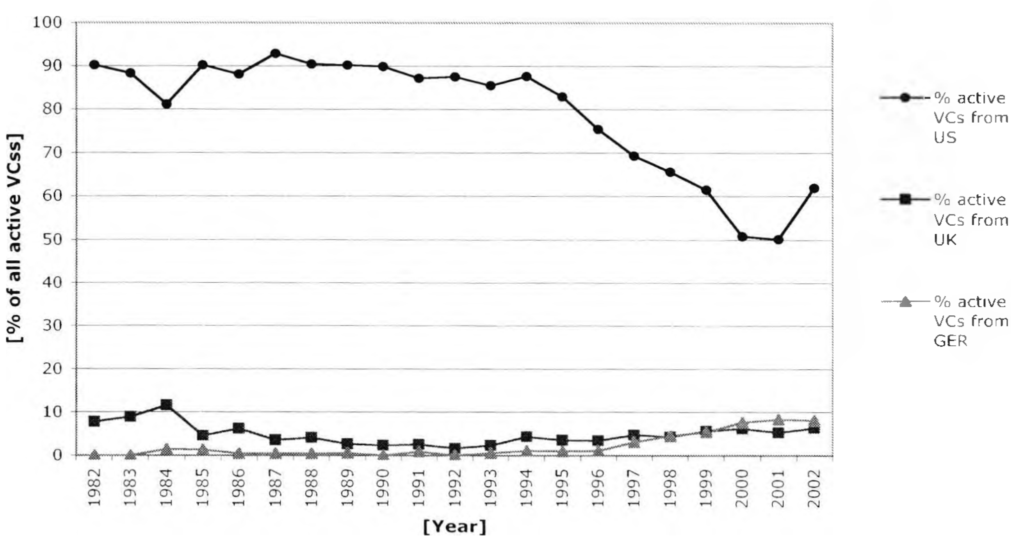

Figure E-8: % of origin of active VCs from US, UK, and Germany (1982-2002)

[109] In this context, it should also be mentioned that the picture would look relatively similar when plotting the country of the investment destination instead of the investment origin. This saying, for most of the sampling period there seems comparatively little cross-boarder investment activity in the (biotech) venture capital markets.

From Figure E-8 above, it is evident that US VCs clearly dominate our data throughout the sampling period. However, it is also evident that this dominance becomes (relatively) weaker after 1994, when a larger proportion of the active VCs comes from countries such as the UK and Germany (note that the small increases in the proportion of UK and German VCs towards the end of the sampling period coincide with a dramatically increasing total number of active VCs during that period). With view to Figure E-8 above it should be mentioned that VE is an US organisation. As such, there might be some bias in the database towards US VCs (as already discussed in the first main section of this chapter that also deals with the quality of our data). However, several other sources and conversations with industry experts confirm the overall picture which is an overwhelming dominance of US VCs at least until the mid 1990s.

Turning now to what is in the focus of our research interest, Figure E-9 below illustrates the development in the average 'knowledge' of the active VCs. In this context, it should be referred to our discussion on proxies for VCs' knowledge in Chapter D above. There, we have suggested that the number of previous investments in ventures overall, in biotech ventures, and/or in certain types (stages/sectors) of biotech ventures should be a suitable proxy for VCs knowledge. However, we have also noted that some previous research has used the VCs' age for this purpose. Therefore, Figure E-9 depicts the evolution of all these proxies in the sample period.

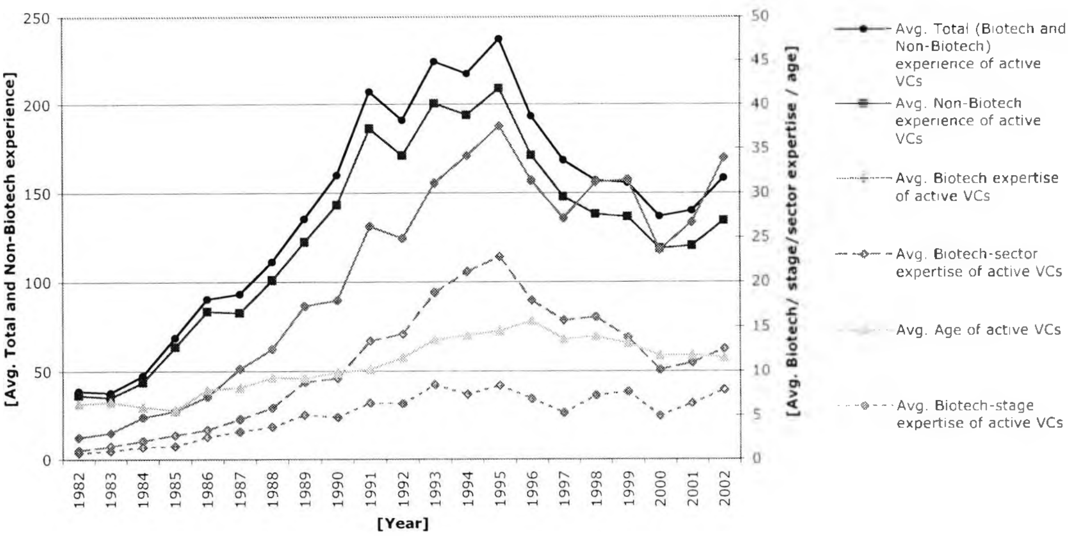

Figure E-9: Average investment experience of active VCs (1982-2002)

A couple of interesting observations can be made in Figure E-9 above.

To begin with, with view to Figure E-9, it seems worth mentioning that the biotech/-stage/-sector expertise (left-hand scale) of the 'biotech VCs' is much smaller than their general and non-biotech experience (right-hand scale). On average, the biotech expertise accounts for less than one fifth of the VCs total experience.[110]

Another and particularly noteworthy aspect of Figure E-9 seems the general trend in the average 'knowledge' of the active VCs' over the years. Here, most of our proxies for VCs' investment experience rise substantially until 1991, reach a peak in 1995, fall again to reach a temporary low in 2000, but then begin to rise again in 2001. This overall pattern is particularly visible with respect to the VCs total and non-biotech experience. However, the VCs' biotech and biotech-sector expertise also follow a very similar trend, with arguably the main exception of an additional small peak in 1998/99. For both the VCs' biotech-stage expertise and age, in contrast, this trend is less visible; and the average age of active VCs reaches a peak in 1996, a year after the other knowledge proxies.

Finally it is worth examining Figure E-9 in light of the lessons learned from the three previous Figures E-6 to E-8. Figure E-6 indicates a relatively high level of activity by relatively few biotech VCs in the biotech sector from the early to the mid 1990s. Figure E-7 furthermore indicates a high number of investments and a high average investment size by those VCs during the early to mid 1990s. Figure E-8 moreover shows that the relative proportion of US VCs – undoubtedly the most experienced, falls dramatically from more than 80% in 1994 to about 50% in 2000. Figure E-9 now indicates that the early 1990 is also the period of the highest average investment experience by the VCs.

Although it is clearly dangerous to draw conclusions from those figures based on average values, one possible explanation for this pattern might be that during the early to mid 1990s only or predominantly the more or most knowledgeable of all biotech VCs were actively and frequently investing in the sector. However, the decrease in the average investment experience of active biotech VCs in the period from 1995 to 2000 is more difficult to explain. Reasons might include that the more knowledgeable VCs withdrew from the sector, more (but less knowledgeable) VCs from the stock of biotech VCs became active in the sector, and/or more new (inexperienced) biotech VCs – e.g. from the UK and/or Germany - entered the sector.

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[110] It is clear however that the average values disguise the fact that the actual level of biotech-specialisation varies widely between VCs.

Whatever the reasons, intriguingly, the decrease in the average investment experience of the active VCs during that period coincides with a dramatic increase in both the number and size of investments in the sector - as shown and discussed in the following section.

Here, Figure E-10 below illustrates the development in the total number of investments, the total amount invested, and the average size of an investment over the sampling period.

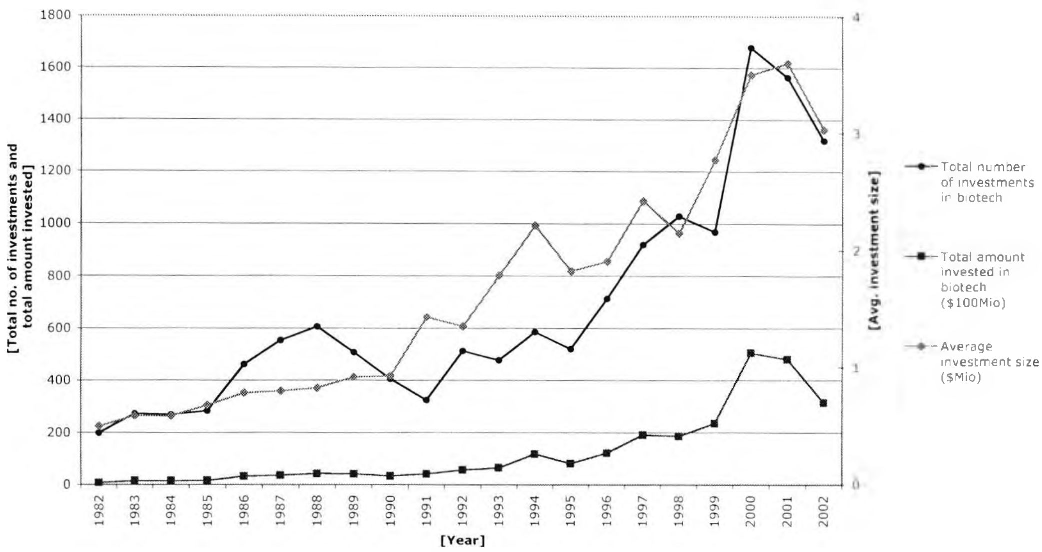

Figure E-10: Total number and average size of investments (1982-2002)

As Figure E-10 above shows, after an early smaller peak in the late 1980s and a subsequent downturn until the early 1990s, the total number of investments rises again from the early 1990s, and significantly so from the mid 1990s until 2000. Also, the total amount invested in biotech rises visibly from the early 1990s, but particularly in the late 1990s, to reach a sudden peak of more than $5Bn in 2000. After that boom year, the total amount invested decreases, first slowly (slightly less than $5Bn in 2001) and than substantially. Finally, also the average size of the investments rises significantly (although with some 'ups and downs') from the early 1900s to 2000/2001. For instance, whilst the average investment size in 1990 was about $1Mio, in 2000 it was about $3.5Mio.

Together with Figure E-7 above, which showed that the average number biotech investments per VC remained relatively stable over the years, this suggests that in the second half of the 1990s, and particularly in 2000, (more) VCs were willing to spend more money per venture, arguably incurring a greater financial risk per investment.

The existing academic literature suggests that syndication between VCs also might serve to reduce the risk of an investment. It is thus interesting to examine the trend in syndication throughout the same period. Figure E-11 below depicts the development in the proportion of syndicated investments and the size [$Mio] of un-/syndicated investments.[111]

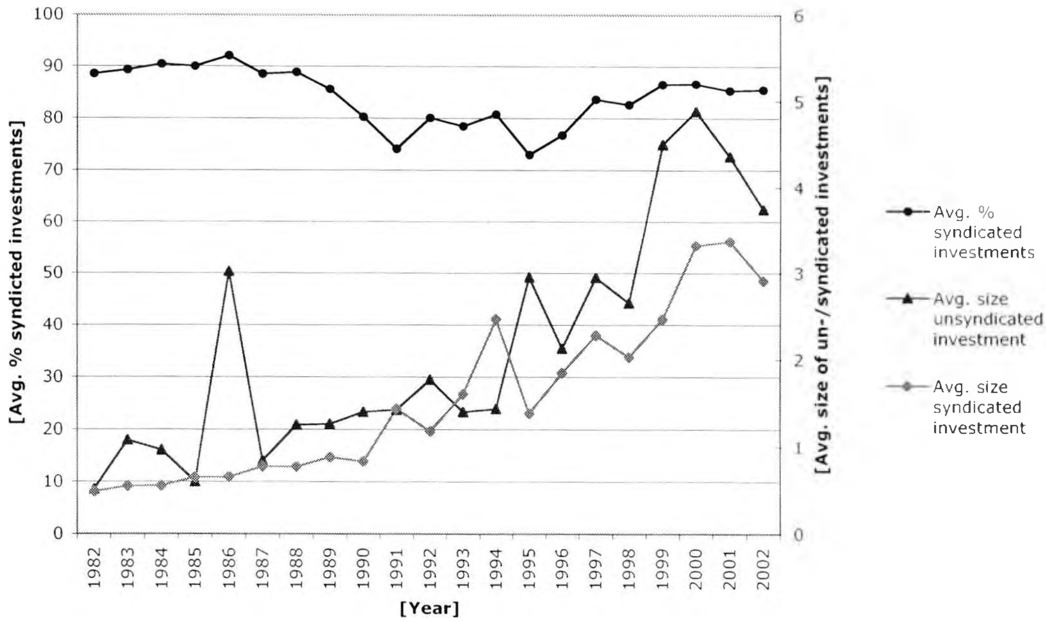

Figure E-11: Avg. % syndicated investments and avg. size [$Mio] of un-/syndicated investments (1982-2002)

As Figure E-11 above shows, the proportion of syndicated investments remains fairly stable, between ca. 70% and 90%, during the sampling period. At the same time, Figure E-11 also shows that the average size of both unsyndicated and syndicated investments rises considerably, particularly since the mid 1990s – with the average size of unsyndicated investments in all but two years (1993/4) being larger than the average size of syndicated investments. Interestingly, this is also the period for which the previous Figures E-9 and E-11 have exhibited a peak in the overall amount invested in biotech by a relatively small proportion of active biotech VCs as well as in the average investment size.

So, whilst in principle syndication could assist the VCs during this period in time by reducing the financial risk associated with their investments (the investment size for the syndicate member is smaller than that of the lone VC), since *both* the syndicated *and* unsyndicated investments are *increasing* in scale over the period, (and notably also during the period when the average investment

[111] We will deal with the issue of syndication in more detail below in Chapter F.

experience of the VCs is *decreasing*), the problem of rising financial risk over time remains part of the developing Bubble. At the same time, however, it is not clear whether the overall increase in the number and size of investments during the 1990s means that (more) VCs invest more funds in the existing ventures or in more *new* ventures. We shall defer consideration of this issue until the subsequent sections on 'rounds' and 'ventures'.

E.II.2.c) Rounds

Figure E-12 below illustrates the development in the total number of rounds, the average amount invested per round, the average number of VCs per round, and the average length of a round (time to the next round or IPO or acquisition).

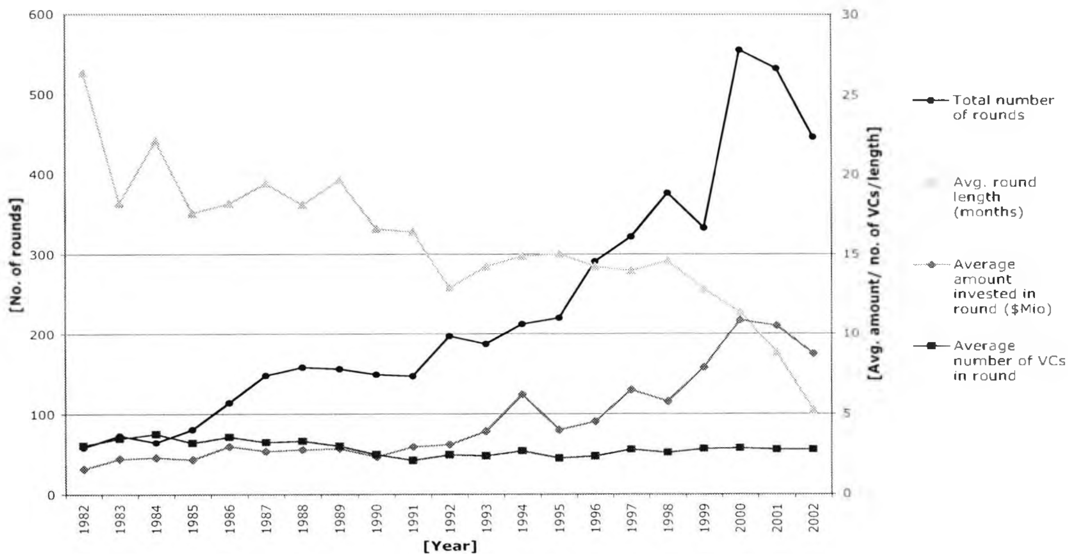

Figure E-12: Rounds, avg. amount, avg. no of VCs, and avg. round length (1982-2002)

Figure E-12 confirms the impression gained from the previous figures. Whilst the total number of rounds doubled from the mid 1990s to 2000 – from about 225 to more than 550 - the average amount invested per round almost tripled – from about \$4Mio in 1995 to about \$11Mio in 2000. Since the average number of VCs per round (i.e. the number of investments per round) remained fairly constant, at about 2.6, this suggests that individual VCs were willing to incur substantially greater financial risks in their deals since the mid 1990s.

Another interesting development observable in Figure E-12 concerns the average round length, defined as the time in months between one round and the next round (or a 'final' event such as an IPO or acquisition). With the exception of the early-mid 1990s, the round-length decreases over most of the sampling period, and particularly during the boom period of 2000 and its aftermath. However, this finding has to be interpreted cautiously because of the way the round length is calculated, namely as the difference between the date of one round and the next. Thus, towards the end of our sampling period, the average round length shown in Figure E-12 is likely to be biased towards (the observable) shorter rounds. Several ventures might yet receive another round of funding after our sampling ends, thus probably increasing the average round length.

Building upon the two previous Figures E-11 and E10, Figure E-13 below looks at the syndication of VCs, but by contrast with Figure E-12 above, now does so at the round level.

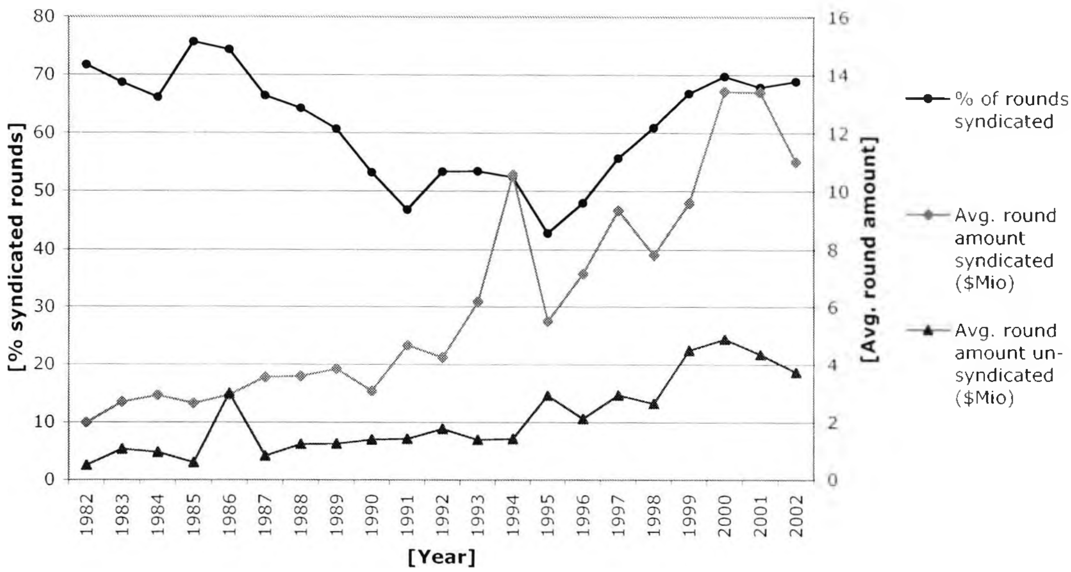

Figure E-13: % syndicated rounds, avg. round amount in un-/syndicated rounds

From Figure E-13 above, we note that (i) the average round amount in syndicated rounds is larger than that in unsyndicated rounds, and (ii) the divergence between the two increases steadily during the period to the year 2000. This suggests that syndication is associated with larger round amounts and is consistent with the hypothesis (to be examined in detail and tested extensively later) that syndication may help solve capital rationing and risk reduction problems facing venture capitalists. By syndicating the average investment is smaller, allowing smaller funds to invest and a given fund to be spread more widely amongst available opportunities. However, although the syndicate member's investment is smaller than the lone investor's, we emphasise again that the average absolute size of investment for both types is increasing during the period to the millennium.

Figure E-14 below illustrates another aspect of likely relevance for our analyses. This is the proportion of rounds that might be classified as 'high-risk'. In this context, it seems plausible to argue that certain types of investments might be considered to be more risky than others. For instance, investments may be more risky because they concern a) ventures of a particular stage (e.g. start-up-, seed-, or early-stage ventures), b) ventures of a particular type (e.g. ventures engaged in the notoriously risky development of human drugs - i.e. those in the subsector 41, according to the VE classification), or c) first round (which suffer from extreme asymmetries of information compared to later round investments).

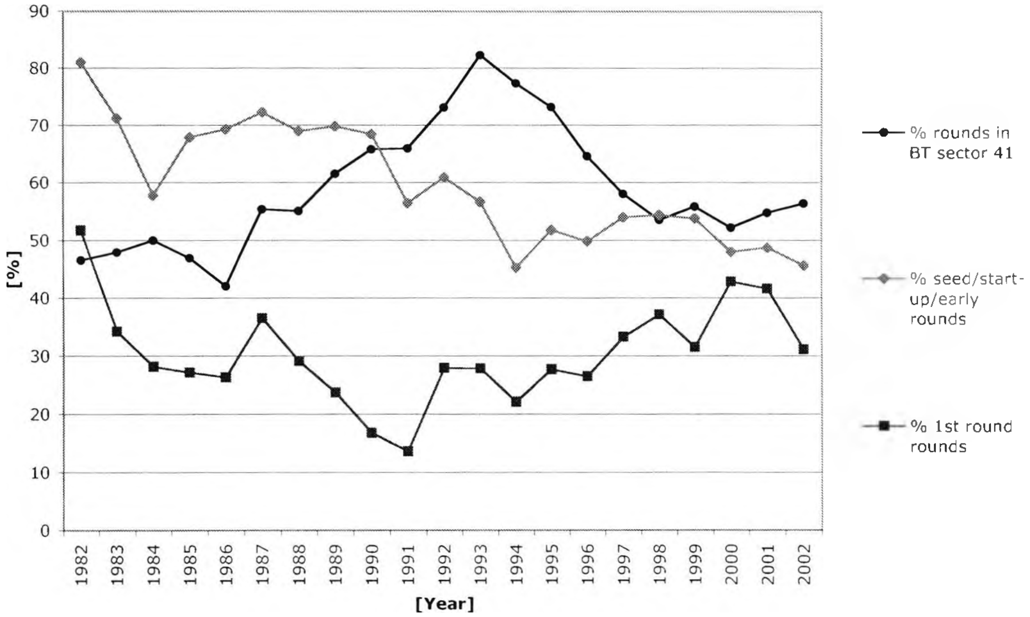

Figure E-14: % of 'high-risk' rounds (1982-2002)

As Figure E-14 above shows, the relative proportions of the different types of 'high-risk' rounds evolve differently over time. For example, the proportion of seed, start-up and early stage rounds decreases at least until the mid 1990s, whilst the proportion of late stage rounds (not shown in Figure E-14), increases. This could be due to the fact that those ventures that received first round funding in their 'infancy' during the early part of the sampling period received second or subsequent rounds that might be classified 'later-stage' in the latter part of the sampling period. This assumption finds some support in the fact that the proportion of first rounds decreases- at least until the early 1990s.

However, the situation changes from the mid 1990s onwards, when the proportion of seed-, start-up-, and early-stage rounds remains relatively stable (or decreases only slightly), whilst the proportion of first rounds increases by about 50% (from about 28% to about 42%). In this context, we must refer back to Figure E-12 above where it was shown that the total number of rounds increased by about 100% from the mid 1990s to 2000 – from about 225 to more than 550. Combining these figures, one can argue that increasing number of rounds in the second half of the 1990s mainly went into later rounds of existing ventures and/or in first rounds of later stage ventures. Indeed, as we will see in the next section ('Ventures'), this is consistent with the fact that the average age of the ventures receiving funding increased from slightly over 2 years in the early 1980s to 4-5 years in the late 1990s.

Finally, with view to Figure E-14 it should be noted that whilst the proportion of rounds going into the sub-sector 41 dominates our data throughout the whole sampling period this tendency is particularly pronounced during the mid 1990s culminating in a peak of more than 80% in 1993.

Turning now again to what is in the focus of our research, i.e. the 'knowledge' of VCs, the following three Figure E-15 a)-c) look at three different yearly 'averages' of the investment experience of the VCs in rounds/syndicate: the yearly averages of a) the cumulative experience of all VCs in a round/syndicate, b) the average investment experience of all VCs in a round/syndicate, and c) the investment experience of the most knowledgeable 'lead' VC in a round/syndicate.

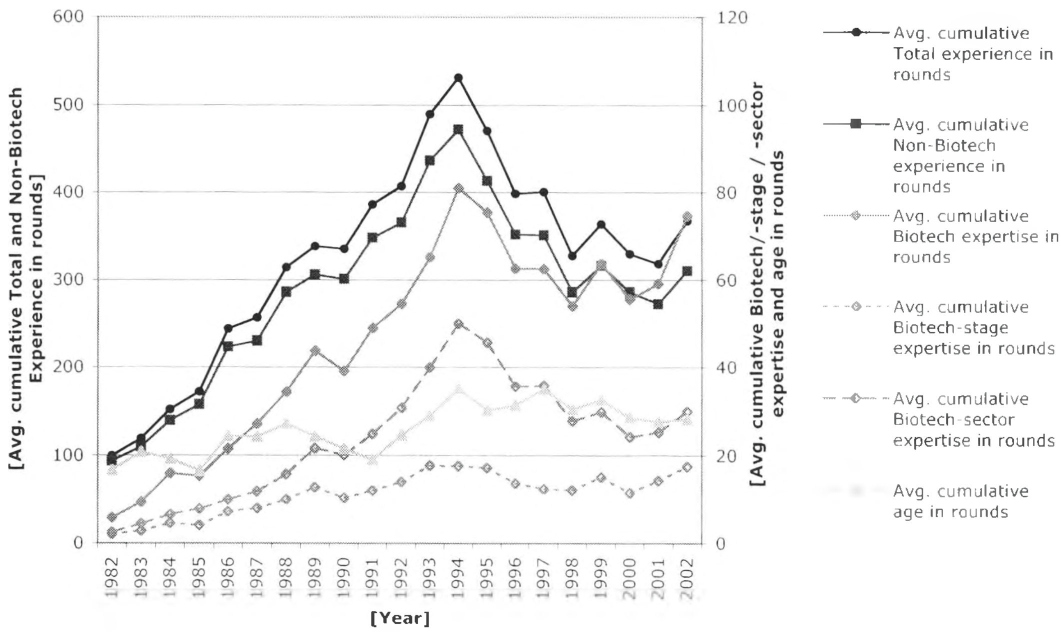

Figure E-15 a): Average cumulative investment experience of all VCs in rounds (1982-2002)

Figure E-15 a) above is *important for the discussion of the role of VCs' experience on their investment approach and the performance of their investments that form a major part of this thesis*. It shows the development of the experience of all VCs in a round/syndicate over the entire 21-year sampling period. The pattern for all measures of experience is that of rising steeply to a peak in the mid 1990s and falling quite dramatically to the millennium, after which point the upward trend is resumed but generally at a slower pace. The development of the average experience of the VCs in rounds/syndicates resembles that of the average experience of VCs depicted in Figure E-9 above. However, apart from the obvious differences in the overall level of experience, one noteworthy difference concerns the year when the average experience reaches its peak. With view to the lone VCs this was in 1995 (see Figure E-9). With a view to the investment experience in the rounds/syndicates, Figure E-15 a) now shows a similar peak, but occurring one year earlier, in 1994.

At the same time, we have argued above (see Chapter D) that the cumulative investment experience of the VCs in a round/syndicate not necessarily is the most relevant proxy for the actual VC investment experience. This is, for instance, because, several VCs in the current round/syndicate might have already invested together in the same ventures before. As such, it is questionable whether the investment experience they have gained from those investments is in fact 'cumulative' since experiences may be duplicated within the group. An arguably more appropriate way to assess the investment experience in rounds/syndicates therefore might be to look at the average experience of the VCs in the round/syndicate.[112]

Therefore, Figure E-15 b) below illustrates the development of the average experience of the active VCs at the round level. Here, it should be noted that average experience of active VCs is not necessarily the same as depicted in Figure E-9 above with view to the average investment experience of the active VCs in a given year. In contrast to Figure E-9 above, which was based on the yearly averages of investment experience of all VCs, Figure E-15 b) below is based on the yearly averages of the investment experience in rounds (i.e. the yearly averages of the average investment experience of VC syndicates). Therefore, the Figures are in general not identical.[113]

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[112] Another, and arguably even better, approach obviously would be to approximate the knowledge of the VCs in the round/syndicate by adding together only the experience of the VCs that is 'not shared' in form of previous joint investments. However, the necessary computational effort associated with this approach has prevented us from following this line further.

[113] To illustrate this point: if there are, say, just three VCs investing only once in a given year with a knowledge score of, 1, 2, and 6 respectively, the average knowledge of the individual VCs in this year would be (1+2+6)/3=3. If all three VCs invested alone in the given year, the average knowledge of the rounds in this year would be identical to the average knowledge of the individual VCs (3). If, however, the first two VCs syndicated in one round whilst the third VC invested alone in another round/venture, the average knowledge in the rounds/syndicates in that year would be

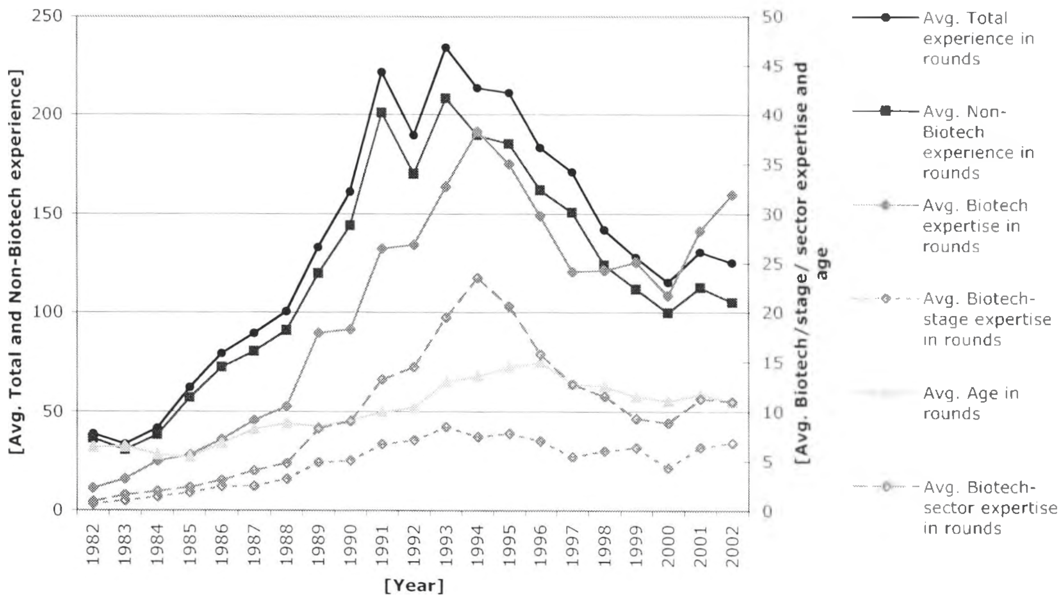

Figure E-15 b): Average 'investment experience' of all active VCs in rounds (1982-2002)

When looking at Figure E-15 b) above and comparing it with Figure E-9 above, it seems that, overall, the average investment experience of the rounds/syndicates is in fact similar to that of the all VCs.[114] This holds with emphasis for the maximum levels (peaks) and, importantly, it seems to be more or less independent of the investment experience proxy used.

In addition, the overall trends seem very similar. Broadly speaking, the average investment experience in the rounds increases - as did the average investment experience of individual active VCs - from the beginning of the sampling period to reach a peak in the mid 1990s. Thereafter it falls again to reach a low in 2000 - after when another rise occurs for the last two years of the sampling period.

However, when comparing Figures E-15 b) and E-9 in more detail, one finds that there are in fact differences between the average investment experience of the lone VCs active in a given year and the average investment experience of the rounds/syndicates in that year. For instance, it is noteworthy that the average total and non-biotech investment experience in the rounds reaches its peak a

[(1+2)/2+(6/1)]/2=3.75. Similarly, if the first VC invests alone but the second and the third VC join forces in a syndicate in a different round/venture, the average knowledge of the rounds/syndicates in that year would be [(1/1)+(2+6)/2]/2=2.50. So, it should be evident that the knowledge of the individual VCs in a given year (depicted in Figure E-9 above) might or might not be identical to the average knowledge of the rounds/syndicates in the same year (depicted in Figure E-15 b) below).

[114] It should be noted here that in the present context terms 'syndicate' and 'rounds' is used interchangeably. So a 'syndicate' might comprise just one or several VCs.

year earlier (in 1993) than that of the lone VCs (in 1994) – although the biotech investment experience in both groups reaches its main peak 1994.

Another observation concerns the fact that the small peak in the average biotech investment experience in the years 1998/9 is more visible in case of the lone VCs (avg. score: over 150) than case of the rounds/syndicates (avg. score: about 125). Overall, after 1995, the average investment experience of rounds/syndicates seems somewhat lower than that of lone VCs.

Here, it is clearly impossible to draw any final conclusions from figures based on average values only. But one possible explanation for this might be that the more knowledgeable of the active VCs tend syndicate relatively more often with the more ignorant VCs in the period from 1995 to 2000 than in the prior years - thus 'watering' down the average investment experience of the lone VCs.

From our discussion above it is evident that the average investment experience of the rounds/syndicates in a given year is critically determined by the compositions of the rounds/syndicates. For instance, if highly knowledgeable VCs always syndicate with ignorant VCs this pushes the overall average of the investment experience in the rounds/syndicates down as compared the other extreme where the more knowledgeable VCs never syndicate.

At the same time, it seems plausible to argue that if the investment experience of the VCs in the round/syndicate is of any relevance at all (e.g. in that it determines the initial investment decision or subsequent decisions regarding the best management of the investment), then it might well be that the investment experience of the most knowledgeable VC in the syndicate (what we shall now refer to as the 'lead VC') is more influential than the average investment experience of the whole syndicate. There is some reason to suppose this is in fact the case.

Therefore, Figure E-15 c) below depicts the development of the average investment experience of the most knowledgeable 'lead' VCs in the rounds/syndicates only (in case of sole investments this is the investment experience of the sole VC in the round).

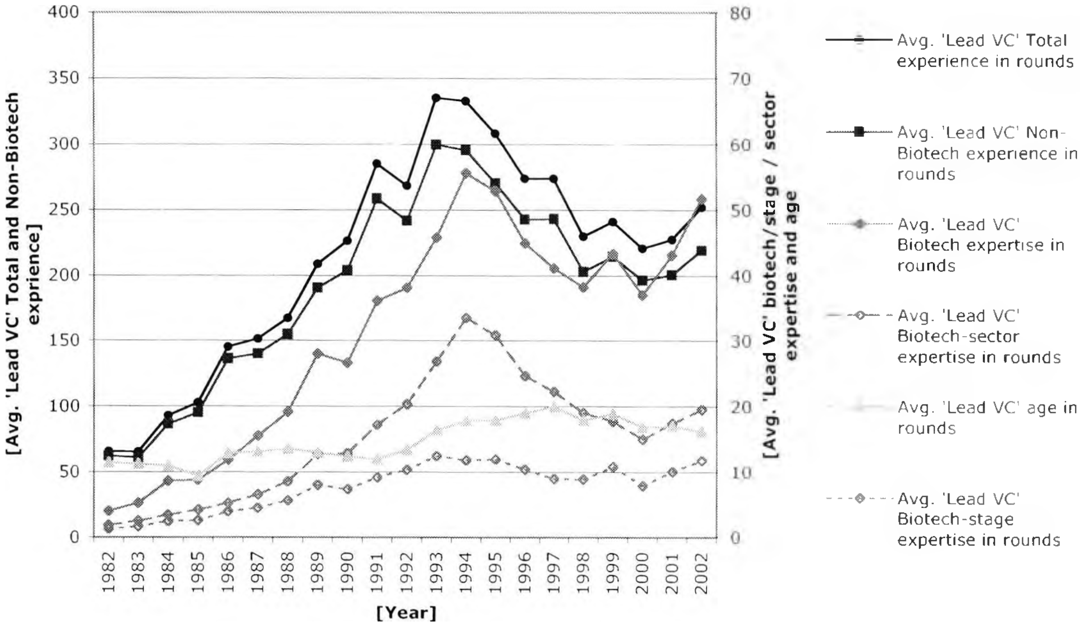

Figure E-15 c): Average 'investment experience' of 'lead' VCs' in rounds (1982-2002)

As Figure E-15 c) above shows, the development in the average investment experience of the 'lead VCs' in the rounds closely resembles that of all VCs in the rounds (and that of the VCs in a given year, see Figure E-9 above).

However, Figure E-15 c) also shows that the average investment experience of the lead VCs in the rounds is considerably higher than that of all VCs in the rounds. For instance, in the peak-years 1993/4 the average total experience of the lead VCs is more than 330 whilst the average investment experience of all VCs in the rounds is only about 200. Similarly also holds for the biotech-expertise which in the peak years is, on average, about 280 for the lead VCs but only about 190 for all VCs in the rounds. In this context, it should also be kept in mind that the average investment experience of all VCs in the rounds, as depicted in Figure E-15 b) above, comprises the investment experience of the lead VC. Thus, it is evident that the average investment experience of the non-lead VCs in the rounds is considerably lower than that shown in Figure E-15 c).

In the following section, we finally turn to the last, and highest, level of aggregation. This is the venture level.

E.II.2.d) Ventures

Figure E-16 below illustrates the development in the total number of ventures receiving financing, the average age of those ventures receiving financing, and the number of new venture foundations in a given year.

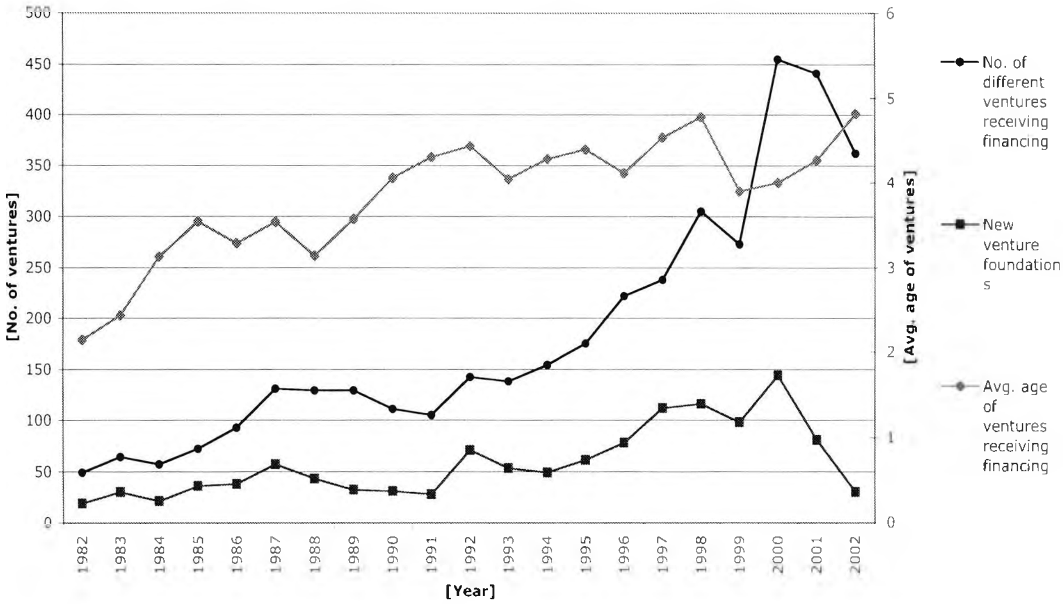

Figure E-16: Number of biotech ventures receiving funding, average age of ventures receiving financing, and number of new venture foundation (1982-2002)

Figure E-16 above also supports, now on the venture level, the trends that were already to be observed in the previous sections on the VC, investment, and round levels. Whilst the number of ventures that receive funding in a given year rises almost throughout the sampling period, this trend is particularly marked after the mid 1990s, when the total number of ventures receiving funding rises dramatically from about 175 in 1995 to more than 450 in 2000. Thus it would seem that the accelerating amount invested during the second half of the 1990s feeds into an increasing number of different ventures, and not just into a growing number of rounds in the same ventures. However, as Figure E-16 also shows, the number of new ventures per year also rises considerably, and particularly in the second half of the 1990s - but less than the overall number of ventures receiving funding. Thus, taken alone, new ventures cannot account for the substantial increase in the overall number of ventures receiving funding. Instead, most of the financing events in the second half of the 1990s seem to involve existing ventures and therefore consists of follow-on funding. This assumption seems also supported by the relatively high average age of ventures receiving funding, and by the fact that the average age of ventures receiving funding rises despite the increase in the number of new ventures.

Figure E-17 below takes a closer look at those ventures receiving funding in a given year. This is similar but not identical to what has already been shown in Figure E-12 above for the round level - because, as Figure E-12 shows, on average, ventures receive slightly more than one round of financing per year.

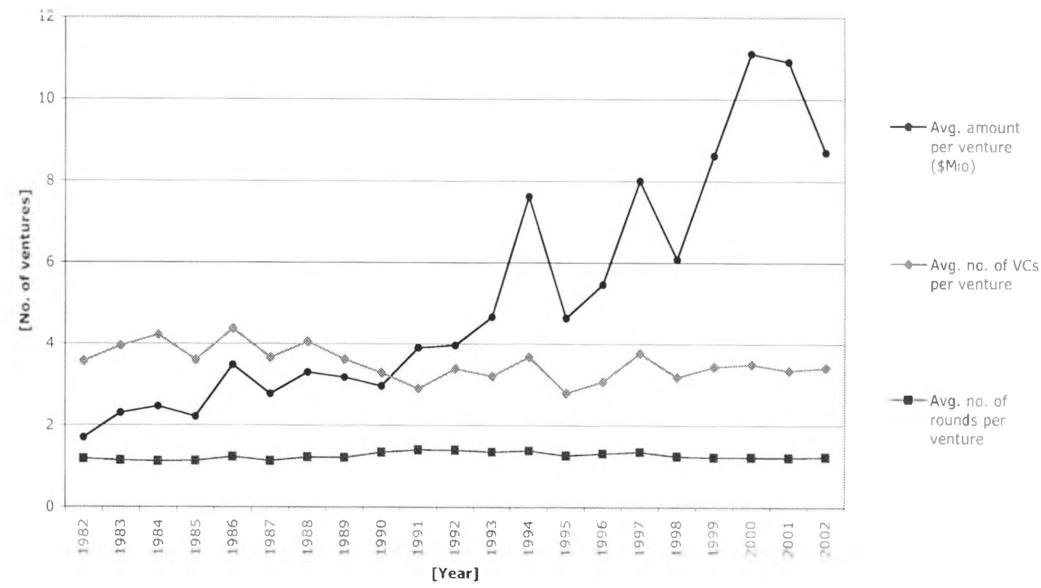

Figure E-17: Avg. amount received, avg. no. of VCs, and avg. no. of rounds per venture that received financing (1982-2002)

As is evident from Figure E-17 above, the average amount invested per venture increases – with some ups and downs – substantially between 1994 and 2000. Since the average number of both VCs and rounds remains fairly constant throughout the whole sampling period, this again suggests that the VCs are willing to incur a greater financial risk in the second half of the 1990s.

Turning now to the ultimate outcomes of the ventures in our sample, Figure E-18 below provides an overview over the number of biotech ventures that went public per year, and the average age of those ventures at their IPO.

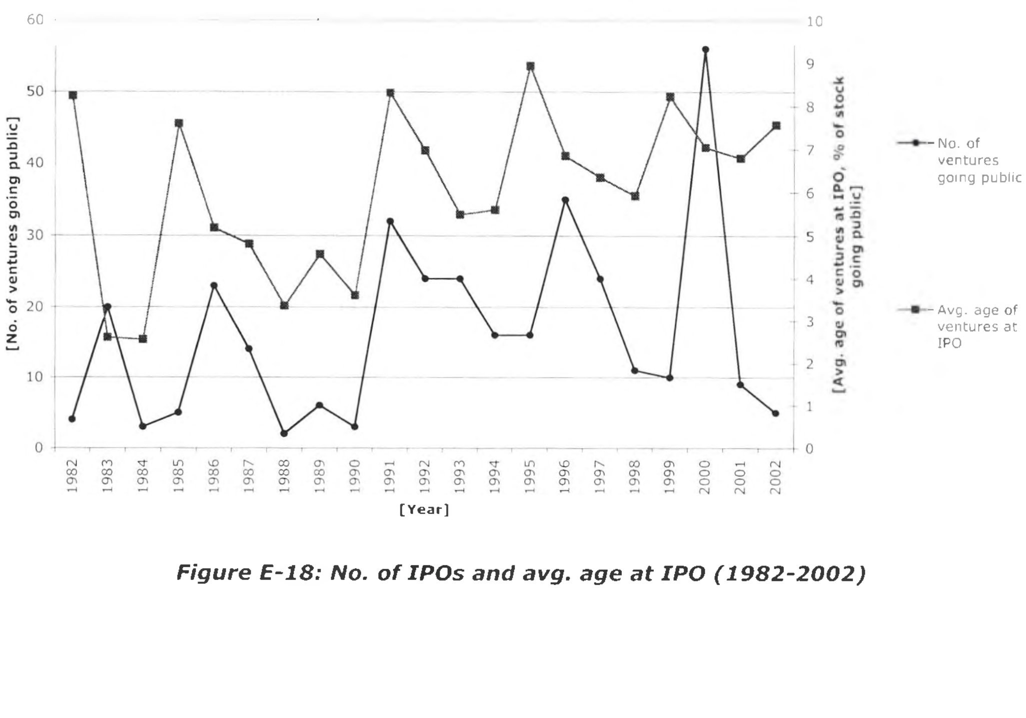

Figure E-18: No. of IPOs and avg. age at IPO (1982-2002)

What is immediately evident from Figure E-18 above is the fact that the IPO market for biotech ventures is extremely cyclical. Short periods, in which the 'window of opportunity' opens widely for biotech IPOs, are followed by periods, in which much fewer IPOs are to be observed. At the same time, Figure E-18 also indicates some variation in the age of the ventures that make it to an IPO. The variation in the venture age at IPO is sometimes, but not always, in line with the variation in the windows of opportunity. Overall, however, the average age of ventures that make it to an IPO seems to rise during the sampling period.

To conclude our overview, Figure E-19 below finally shows the status of our sample ventures by the end of 2002.

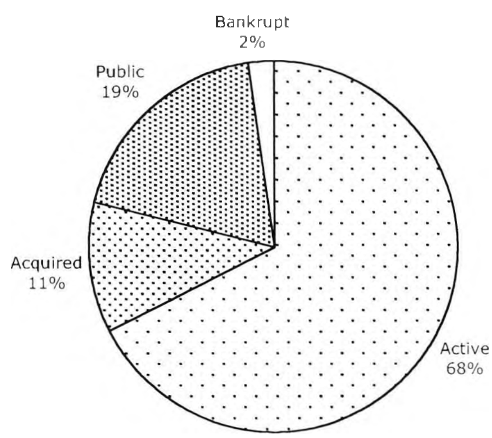

Figure E-19: Status of sample ventures by the end of 2002 (N=1712)

Several aspects are noteworthy with view to Figure E-19. Most obvious, more than two thirds of our sample ventures are still active by the end of our sampling period. This is understandable from the previous figures, which had shown that most ventures in our sample were founded in the second half of the 1990s. As such, they are too young for their ultimate success to be determined.

However, although not shown in Figure E-19, it should be mentioned that many of those 'active' ventures are likely to be in fact inactive or 'living dead'. In unreported analyses we find that about 15% of the active ventures (about 10% of all ventures in our sample) have not received a new round of funding five years after their last round of funding (this corresponds to the average round-length plus 2.5 standard deviations in our sample). Thus, whilst some of those active ventures might not have needed a new round of founding - because they might have turned profitable - many are likely to have ceased their activity but remain on the VCs' books. This might also explain the unlikely low proportion of officially bankrupt ventures in our sample.

Finally, with view to the acquired and public ventures in our sample it should be mentioned that, according to Venture Economics, a few ventures first went public but then were acquired. As such the actual proportion of ventures that went public (that we will use for subsequent analyses) is slightly higher than shown in Figure E-1, namely about 25% of all ventures in our sample.

E.II.3. Summary and conclusion

This Chapter has been an exploration of the evolution of aggregate measures of venture capital activity during the period 1982-2002. It has provided a context for the detailed large-sample analyses as well as for the case studies to follow in the next chapters.

Summarizing our observations on the *raw data* are, most noteworthy are:[115]

1. Of the total venture capital funds ($500bn) raised until 2002, 77% ($386bn) were raised after 1996, and 31% ($159bn) in the year 2000 alone
2. In total VCs invested $26.5bn in biotech until 2002, but about 80% ($21bn) of this were invested after 1995, and more than 33% ($9.9bn) in the years 2000 and 2001
3. Between 1972 and 2002 almost 2000 different VCs make a total of 14,730 investments in about 5,000 rounds of about different 1,700 biotech ventures
4. Most VCs (ca. 46%) only make one single biotech investment, and a few VCs (ca. 13%) are responsible for the vast majority of the investments (ca. 72%)
5. The average number of different VCs investing in biotech per year is below 200 until 1995, but increases thereafter to over 600 in 2000
6. The average proportion of active biotech VCs from the US in a given year is about 80% until 1995, but it falls to about 50% in 2000
7. About 55% of all biotech investments occur after 1995, and almost 12% of all investments in the boom year 2000 alone
8. About 60% of all rounds (and 80% of all investments) in biotech are syndicated, and the average round involves 3.2 VCs

[115] It must be emphasized again that, because of many cases with missing data on certain variables, the number of observations available for our subsequent analyses is substantially lower than the number of observations in our raw data.

9. The average deal size of syndicated (unsyndicated) rounds increases from about $2Mio ($1Mio) in the early 1980s to almost $14Mio ($4Mio) in 2000
10. The average round length decreases from about 400 days in the 1980s to about 300 days in the mid 1990s, and to about 200 days in the late 1990s
11. The average knowledge of active biotech VCs in a given year increases dramatically until the mid 1990s, but it falls thereafter until 2001 (to the level of the late 1980s)
12. About 25% of all biotech ventures ultimately make it to an IPO, during several 'windows' of opportunity in an extremely cyclical market.

Concluding, from our above overview it is obvious that the venture capital activity in the biotech sector has experienced a dramatic development over the past three decades, but especially so during the 'boom' period in the second half of the 1990s.

Here - from the perspective of our project - it is particularly interesting to observe that the pattern for all measures of VC experience is that of rising steeply to a peak in the mid 1990s and falling quite dramatically to the millennium.

This decrease in VCs' 'knowledge – or: increase in VCs' 'ignorance' - coincides with dramatic increases in both the number and the average size of biotech investments.

Together these trends clearly spell greater (financial) risk for both biotech VCs and their investors, in a period arguably characterized by increasing 'irrational exuberance'.

CHAPTER F: VCS' KNOWLEDGE & SYNDICATION OF INVESTMENTS

F.I. Introduction

In this chapter our interest is on the relation between VCs' knowledge and VCs' investment approach

As we described in the general literature review, chapter C, the VC's investment approach comprises several features that are said to be distinct from those of more traditional investors. All these features could be affected by the VCs' knowledge. However, within the scope of our project, it is clearly impossible to examine all the features of the VCs' investment approach and their relation to VCs' knowledge; we have to focus on a selection only.

In this chapter, we focus on one particular aspect of the VC's investment approach, namely, syndication. Syndication is one form of collaboration between firms, temporary in nature and designed for the purposes of a specific investment. A central feature of a VC syndicate is that it involves two or more VCs simultaneously taking an equity stake at an investment round of a venture. Syndicate partners in fact make a series of joint decisions under uncertainty that result in a payoff, which, under the syndicate agreement, will be shared jointly among them (Lockett & Wright, 1999; Wilson, 1968).[116]

With respect to our project, syndication is of interest for several reasons.

To begin with, syndication of investments by VCs is a very common phenomenon (Brander et al., 2002; Gompers & Lerner, 2001). Sorenson and Stuart (2001), for instance, find in a study of 7,590 US VC-backed ventures, in the period 1986-1998, that syndicates financed slightly more than two thirds of the ventures, and the average venture received investments from 5.3 VCs. Wright and Lockett (2003) find that in the period 1989-2001, 44-64% of US deals were syndicated, whereas in Europe the corresponding proportion was lower at 23-56%. Similarly, Hochberg et al. (2004) find that of the 47,000 investment rounds by US VCs 44.7% involved syndicated funding; and Manigart et al.

[116] It should be mentioned that, in the extant literature, the term 'syndication' sometimes is used in a more general way to refer to investments by VCs in the same venture – independent of whether those investments take place in the same round (Brander et al., 2002). However, for the purpose of our study, we use the term 'syndication' exclusively to refer to joint investments by VCs in the same round (i.e. at the same time) of a venture.

(2004), based on a survey of 317 European VCs find that more than 90% of the VCs syndicated at least some of their investments. Overall, therefore, syndication is clearly a very common characteristic of the VC's investment approach.

However, despite the fact that syndication is commonplace in the VC industry, it has received disproportionately little attention in both the theoretical and empirical academic literature; and in particular the motivation of this practice is neither well researched nor well understood (Brander et al., 2002; Lockett & Wright, 1999; Wright & Lockett, 2003). As Lerner (1994) suggests, this may be because of the difficulty of analysing syndication patterns empirically and the complexity of the motives behind it. However, another contributory factor may be that the VC industry is rather secretive, and it is difficult to obtain the relevant breadth and depth of information to conduct a study.

Thus, surprisingly little is known on the motives for syndication (Manigart et al., 2004). For instance, it is not obvious why syndication should exist in the presence of alternatives that are available and the management difficulties associated with it. As Lockett and Wright (1999: 304) note 'the problem remains, why do venture capitalists syndicate private equity when there exists the possibility of re-insurance and when the practice of syndication may create ex post managerial problems?' Similarly, Sorenson and Stuart (2001) observe that syndication frequently occurs even when the capitalization requirements of the venture are modest compared to the financial resources of any one venture capitalist. This, furthermore, is despite the obvious disadvantages of syndication, such as the reduction in the share of expected profits to the potential syndicate member as compared with the go-it-alone approach. Thus, Manigart et al. (2004: 1) ask why 'do VC firms give up potential return by not investing the whole amount needed by the portfolio company, but rather seek another VC firm to co-invest and thereby share in the potential gains (or losses)?'.

Whilst the above considerations make syndication an interesting area for further theoretical and empirical research, with view to our project, it is particularly worthy of investigation because most of the limited empirical research on syndication has explicitly referred to VCs' (lack of) knowledge as one possible motive for syndication.

We will look at this literature in more detail below. But at this stage it should already be mentioned that the existing literature is ambiguous regarding the role of VCs' knowledge for syndication as compared, for instance, to financial aspects.

At the same time, as mentioned before (chapter C), most of this literature on venture capital has used arguably inadequate proxies/methods to measure VCs' knowledge; and this proposition also holds for the literature on syndication. Since we believe to have developed better and more fine-grained proxies to measure VCs' knowledge, it therefore appears interesting to use these proxies and compare our results to those of previous studies.

Finally, syndication is an interesting subject of study for this project because of the fact that the decision to syndicate an investment is made at the *beginning* of the investment process and the decision to participate or not is made individually by each VC. This allows us to study the impact of VCs' knowledge at the level of the individual VC; and thus a study of the determinants of syndication can provide the 'clearest' or 'purest' picture of the relation between VCs' knowledge and (certain aspects of) VCs' investment behaviour. This is clearly in contrast to subsequent aspects of VCs' investment behaviour (advice, monitoring etc.), which are likely to be related not simply to the knowledge of an individual VC but to the knowledge of the *group*, i.e. the syndicate.

The guiding question for our review of the literature on syndication and the subsequent development of our research hypothesis is therefore:

What role does VCs' knowledge play as a motive for syndication?

F.II. Literature review

Whilst there is considerable anecdotal evidence for the significance of syndication in the venture capital industry, the academic literature on this issue, as mentioned above, is very limited (Brander et al., 2002; Lerner, 1994; Lockett & Wright, 1999; Wright & Lockett, 2003).

Before turning subsequently to the venture capital-specific literature on syndication, it should be noted once more that syndication is not a process unique to venture capital. Rather, it is just one of several forms of inter-organizational collaboration (Lockett & Wright, 1999). Other such forms include for example, joint ventures, mergers and acquisitions between firms.

Whilst it is impossible, within the scope of our project, to review the rapidly growing body of literature on inter-organizational collaboration in detail, it is worth pointing out that this literature suggests a variety of rationales for competitors – as VCs certainly are - to work together in a situation also referred to as 'co-opetition' (Brandenburger & Nalebuff, 1997).

For instance, collaboration might serve to improve a firm's strategic position (e.g. Porter & Fuller, 1986), or it might allow the partners to attain economies of scale (e.g. Gomes-Casseres, 1994). At the same time collaboration might also result from environmental uncertainty (e.g. DiMaggio & Powell, 1983; Hannan & Freeman, 1989; Pfeffer & Salancik, 1978), and/or in response to changes in the competitive environment (e.g. Das & Teng, 1996; Mowrey et al., 1995). This aspect of collaboration might also explain why collaboration is increasingly used in high technology areas, when firms lack the know-how to compete individually (e.g. Eisenhardt & Schoonhoven, 1996; Hagedorn, 1993; 1995; Hamel et al., 1989). Here, collaboration might serve - as a vehicle for organizational learning - to gain access to complementary skills and assets and to embark on new technological innovations and developments (e.g. Kogut, 1988b; Kogut et al., 1995; Mitchell & Singh, 1992; Dodgson, 1993; Dyer, 2000; Gulati, 1998; Hagedoorn, 1993;Hamel, 1991; Hamel & Prahalad, 1990; Teece, 1988). Thus, many possible reasons exist for firms to collaborate, but access to missing and/or complementary knowledge and skills is amongst them.

These benefits not withstanding, the literature also points out the costs and risks of collaborating. Most obvious, in this context, is the fact that potential pay-offs from joint projects have to be shared between the partners. Furthermore, in any alliance, there is a need for coordination and cooperation between the parties if the collaboration is to achieve shared objectives and joint pay-offs (Doz, 1996). Collaborations might however suffer from conflicting objectives (Porter, 1990) and collaborating firms are also vulnerable to partners' opportunistic behaviour (Gulati et al., 1994; Kugut, 1989). However, the most serious risk of collaboration may be that it deters the business' own efforts at upgrading its skills (Porter, 1990). This may occur because of over-reliance on the partner or because the collaboration has eliminated a threatening competitor. Hsu (2003), suggests in fact four main categories of costs of collaboration: 1) transaction and search costs of locating the right partner, 2) costs of guarding against the threat of partner of expropriation, 3) costs of complacency in developing in-house skills and capabilities, and 4) costs from revenue sharing.

In sum, whilst potentially beneficial in many instances, collaboration also entails likely costs in financial and in knowledge terms. This leads to a trade-off that has to be carefully balanced when a decision over collaboration is to be made.

Based on the above insights from general literature on inter-organizational collaboration, in the following section we turn to the specific literature on syndication in the venture capital context, first the theoretical oriented and then the empirical literature.

F.II.1. Theoretical literature

In the venture capital literature, several theoretical models have been suggested to explain syndication between VCs, although none of these models has been developed specifically with view to VCs.

Bygrave (1987, 1988), for instance, derives the arguably most encompassing theoretical perspective on syndication from the *resource-exchange model* developed by Pfeffer and Salancik (1978).[117]

Building upon the ideas outlined in Granovetter's (1973) seminal article on 'the strength of weak ties', this model strives to explain how and when collaboration between firms might help them to control their environment. When the environment is uncertain there are four primary reasons for linkages between organisations (Pfeffer & Salancik, 1978): gathering information, transmitting information, obtaining commitments and support, and legitimating the organisation. Together, these reasons should serve to stabilize outcomes for the firm and to reduce the uncertainty it faces. Consequently, the resource-exchange model predicts that the interconnectedness of a firm is a function of concentration, uncertainty, and munificence.[118]

As Bygrave (1987, 1988) argues, this model is also useful to explain syndication between VCs. VCs are both competitors and suppliers to each other because they compete for investment deals and they also share deals – in form of mutual referrals and/or syndication. All industries in which VCs invest of course have a degree of uncertainty (unpredictability of outcomes) but some VC-favoured industries (e.g. genetic engineering) face more uncertainty than the average (e.g. candy manufacturing). As regards 'munificence', Bygrave points out that the main resources that a VC needs are money (including the opportunity of spreading of financial risk), deal flow (good investment prospects are always scarce), and people able to manage the investments. At various times, each of these resources may be abundant or in short supply. For instance, the funds

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[117] It should be noted that we have already come across the resource-dependence model further above in our general literature review (Chapter C). There, we looked at this model in the context of the VC-venture relationship. In the current chapter, by contrast, the model only deals with the VC-VC relationship.

[118] Interconnectedness = f(concentration, munificence, uncertainty); where: 'interconnectedness' = number and pattern of linkages among organizations, 'concentration' = degree to which power is concentrated or dispersed in the environment, 'munificence' = availability or scarcity of resources a firm can gather from its environment, 'uncertainty' = unpredictability/dispersion of outcomes.

flowing into the industry may vary over time, as do the ventures seeking venture capital. Based on this Bygrave (1987, 1988) notes that the resource-exchange model predicts that VCs' interconnectedness should be highest in industries with intermediate levels of concentration. Furthermore, the interconnectedness between firms should be greater in more uncertain and in less munificent industries. By exchanging information of prospective investments VCs strive to reduce this uncertainty, and by sharing investments with one another VCs strive to cope with the scarcity of deals in which to invest. In this situation, there are two principal flows between venture capital firms: economic exchange (money and goods/services) and information exchange (which may or may not be accompanied by economic exchange).

The rationales for syndication outlined in the resource-exchange model are also reflected in much of the more recent literature in this field, although with different emphasis. Broadly speaking, there are two competing views as to why venture capitalists syndicate equity investments (Lockett & Wright, 1999: 304). These are the finance-perspective and the resource/knowledge-perspective. In the following, we briefly review these two strands of the literature that seem particularly relevant because they might principally explain syndication in all rounds.[119]

From the traditional *finance perspective*, VCs may syndicate, broadly speaking for two (related) reasons – to surmount capital constraints and/or to diversify their portfolio risk. VCs are typically much smaller than institutional investors, often operating with scarce financial resources. These *capital constraints* due to the comparatively small size of a VC firm or fund might often present an obstacle for many VCs to invest alone (Sahlman, 1990). Simply put, if a VC firm's funds are insufficient to invest in a particular project, syndication of the deal may be

[119] However, it should also be mentioned that there are at least two additional theoretical arguments referred to in the literature that might help explain syndication, but primarily with view to later rounds. First, according to the '*window dressing' motive* VCs might syndicate to 'window dress' their performance in the eyes of their investors (Lakonishok et al., 1991). From this perspective, Lerner (1994) explains, VCs may syndicate into later stage rounds of – less risky but also less profitable – ventures, allowing them to report that they funded star companies when they attempt to raise future pools of capital from their investors. Second, according to the '*constant-share'* motive, syndication of later round investments may further be a result of informational asymmetries between previous-round (inside) VCs and potential new (outside) VCs (Admati & Pfleiderer, 1994). In this context, Lerner (1994) explains, because inside VCs may exploit their informational advantage and overstate the proper price for the securities in the next financing round, new outside VCs might only be willing to invest if the previous VCs maintain a constant share of the venture's equity.

the solution. Likewise, from the *portfolio diversification* perspective, syndication of investments by VCs constitutes a means of reducing risk by spreading capital across a greater number of investments (Bygrave, 1987, 1988; Wilson, 1968).[120] It is worth noting here that the VC market is much less liquid than the stock market. Minimum investment periods make private equity un-saleable in the short to medium term (Lockett & Wright, 2001). In summary, Barry et al. (1990) note, from the 'traditional finance' perspective, the relative commonness of syndication between VCs might be seen as a result of their relative disadvantages compared to more traditional investors, who invest in listed stock. Multiple participations in different ventures may enable a VC to achieve an efficient scale of operations (overcoming capital constraints) whilst at the same time reducing risk by spreading it over a larger number of investments.

In addition to the finance-related motives for syndication, several authors also point out the potential relevance of a number of *knowledge-related motives* for syndication. Lockett and Wright (1999: 306), for instance, argue that in case of venture capital 'the key (non-financial) resources are considered to be informational in nature' and relevant with view to the deal flow, the pre-investment decision-making and/or the post-investment management of investments.[121]

To begin with, from a knowledge-perspective, syndication may be a means of securing the vitally important current *deal flow*, by increasing the likelihood of

[120] As Manigart et al. (2004: 4) explain, the '*traditional finance perspective*' shows that by constructing a well-diversified portfolio, risk can be reduced without reducing expected return. The risk of any investment can be subdivided into a firm specific component (unsystematic risk) and a market component (systematic/market risk). The firm specific component can be eliminated by holding a well-diversified portfolio of investments. By spreading investments across a greater number of investments that do not co-vary, syndication has the potential to reduce risk considerably (Markowitz, 1952). This means that the variation in returns is reduced without reducing the expected return of the portfolio. Systematic or market risk, however, cannot be eliminated and this risk remains for a well-balanced portfolio.

[121] At the same time, Lockett and Wright (1999) correctly point out that existing research has primarily concentrated on the question as to why firms syndicate out investment opportunities to other firms. However it is also important to consider why VCs syndicate into a deal. Here, the authors further note that, from a resource-based perspective, there are two possible scenarios. Either the firm wants to join the syndicate because it feels it has expertise that it can offer, or the firm may be looking to learn from the lead investor and thus be looking to develop its resource base for the future. We acknowledge the relevance of this aspect. However, in our data, we have no information about which VC syndicates a deal in or out. Therefore, in the following, we do not deal with this aspect in more detail.

learning about good investment opportunities in the future. It is important for venture capitalists to be in a position to compete for as many deals as is possible so that they can make their investment selections from as wide a supply of deals as is possible. Thus, by syndicating VCs can participate in a larger number of deals. By syndicating, VC firms may expect other partner VC firms to reciprocate in future, thereby securing improved access to more and/or better quality future deals (see also: Seppa & Jaaskelainen, 2002; Sorenson & Stuart, 2001). With respect to the latter, the expectation of reciprocity may also reduce the incentives of VCs to behave opportunistically enhancing trust between syndication partners (Zucker, 1986).

Another, important knowledge-related motive for VCs to syndicate is their desire to improve the *pre-investment selection* process by improved screening, due diligence, and decision-making. Even after its own evaluation of an investment proposition, a VC might still be unsure about the venture's prospects and, therefore, might prefer to get a 'second opinion' (Brander et al., 2002; Lerner, 1994; Sah & Stiglitz, 1986; Sorenson & Stuart, 2001).[122] Related to this, Brander et al. (2002) further suggest that syndication may also lead to *collusion*, where investors, through cooperation, may be able to increase their negotiating power towards the entrepreneur and as a result get better financing terms (e.g. by having to pay a lower price for the firm's equity).

In addition, by syndicating, VCs may be able to share their specific knowledge and complementary skills and as a result potentially add more value to the portfolio company in the *post-investment management* (Barry et al., 1990; Brander et al., 2002; Bygrave, 1987; Sorenson & Stuart, 2001). Barry et al. (1990), for instance, propose that one explanation for the participation of multiple VCs is the benefit of additional monitoring; the presence of multiple VCs allows the originating VCs to obtain independent assessment about the likely success of the venture in the post-investment phase. More generally, Lockett and Wright (1999: 307) explain, 'the need of specialist expertise in the management of investee companies may be met by the resource base of the

[122] Sah and Stiglitz (1986), for instance, show that hierarchical organizations in which investments are made only if several independent observers agree, may be superior to ones where projects are funded after one affirmative decision. In the VC context Lerner (1994) notes that upon receiving an investment proposal, a VC commonly doesn't make a decision himself. Instead, he forwards the proposal to some other VCs to get a second opinion. Those other VCs might, or might not, become, syndicate partners for the investment; but another VC's willingness to invest in a potentially promising venture may be an important factor for a VC's investment decision.

company or by industry experts from outside the firm. However, if this is not possible [...] the venture capital firm may wish to enlist the help of a syndicate partner to assist in the management of the investment'. Pointing into the same direction, Brander et al. (2002), furthermore, note that different VCs might have different skills and information. Some might be helpful in organizing production, others might line up customers, others might contribute in human resource management etc. As such syndication between VCs might enhance their 'valued added'. Finally, Kaplan et al. (2004: 26) suggest that it *might* be 'beneficial for less experienced investors to syndicate with and learn from more experienced multinational investors'

From the above it is evident that there are a number of different possible motives for VCs to syndicate, of which finance- and/or knowledge-related factors are arguably the most relevant. Such motives presuppose a net benefit to syndication for the participating partners. We have discussed above mainly the benefits.

However, as we have seen from the general literature on inter-organizational collaboration at the beginning of this section, there are likely to be costs and risks involved in syndicating.

It is worth noting that in the venture capital context, the potential costs of syndication have been almost completely neglected. Only a few authors mention those costs. Kaplan and Strömberg (2003), for instance, point out that there is a threat of some partners behaving as 'free-riders'. Syndicate partners who don't own relevant resources might benefit from syndicate partners who own those resources without 'paying' (returning other resources) for it. Pointing into the same direction, Wright and Lockett (2002: 4) argue that '... syndication imposes a management cost that is reflected in terms of coordination and timing difficulties regarding decision making'. Brander et al. (2002), furthermore, note that the primary cost of syndication is that some share of the potentially profitable investment must be given up to secondary VCs; the authors therefore assume that syndication will be sought in cases where the expected benefits exceed the expected costs of syndication. This idea is also picked up by Hopp and Rieder (2004: 13) who take an real-options perspective and propose that 'due to the presence of more than one option holder the overall costs of undertaking a syndicated venture capital deal will be higher than under [...] a VC deal with a single investor'. In this context, the same authors further suggest that 'established and experienced investment firms are acquainted with the needed skills and expertise to survive in their niche or industry and therefore do not have to rely on syndication in order to make better investment decisions in the ex-ante and ex-post investment stage' the authors propose that 'specialists VCs should be less inclined to syndicate, as the additional (informational) benefit is limited' and 'only special circumstances would urge a VC specialist to make a joint investment (Hopp & Rieder, 2004: 25).

F.II.2. Empirical literature

Overall, the empirical literature on syndication is scarce; but, as we will show in the following, the few studies that exist in this context provide support for several of the theoretical motives for syndication discussed above, although with a different emphasis (Table F-1 in Appendix II summarizes the empirical key studies on the motives for syndication).

Bygrave (1987, 1988), for instance, uses data from the Venture Economics database on first-round investments by 464 US VCs in 1,501 US portfolio ventures for the period 1966-1982 to identify possible motives for syndication.[123] From this sample he finds that VCs primarily investing in high-innovation ventures (HIVCs) have a (highly significant) higher proportion of co-investments than VCs primarily investing in low-innovation ventures (LIVCs). Similarly, he also finds that high-innovation ventures receive a much higher proportion of syndicated investments than low-innovation ventures - although the former received much smaller investments. This, Bygrave argues, is because of the higher risk associated with high-innovative investments, making sharing of information with other co-investors more important. Also Bygrave's (1987) other findings point in the same direction: the ratio of syndicated to sole investments was much higher in case of early- than in case of later-stage ventures (although the average amount invested in the former was much lower). Furthermore, this ratio also was much higher for ventures from the computer industry than for

[123] In this context, Bygrave (1987, 1988) classifies the portfolio ventures in his sample by a) innovativeness (high vs. low), b) development stage (early vs. late), and c) industry (various). He then classifies the VC firms in his sample by a) their investment preference (proportion of high- and low-innovation technology ventures), b) the absolute number of those ventures they had invested in this sample, and c) their size (funds under management). Based on this he identifies and examines a group of 61 VCs that fall into one of the following three categories: 21 HIVCs (firms that had the highest proportion of high- to low-innovation portfolio ventures and the highest number of high-innovation portfolio ventures), 19 MICVs (firms that were among the 61 firms with the highest number of portfolio ventures but that did not specialize primarily in low- or high-innovation investments), and 21 LIVCs (firms that had the highest proportion of low- to high-innovation portfolio ventures and the highest number of low-innovation portfolio ventures).

ventures from the consumer industry (although there was almost no difference in the average amount invested in the two types of companies). Finally, Bygrave (1987) finds no difference in the degree of coinvesting of large VC firms ('those with deep pockets') and small firms. Overall, Bygrave (1987, 1988) therefore concludes that, in accordance with the above outlined resource-exchange model by Pfeffer and Salancik (1978), there is evidence that *the primary reason for coinvesting is sharing of knowledge rather than spreading of financial risk.* VC firms might gain access to networks by having knowledge that other firms need. This, furthermore, might be particularly important in case of investments in high-innovation ventures.

Lerner (1994) comes to similar conclusions. With a focus on the VCs' choice of syndicate partners, he examines VCs' syndication behaviour based on 651 investment rounds in 271 private biotechnology ventures between 1978 and 1989, also from the Venture Economics database.[124] He finds that VCs primarily syndicate with similarly established VCs in first rounds. Specifically, in first rounds, VCs from the smallest size quintile syndicate significantly more often with each other, whilst VCs from other size quintiles do not show any significant preference for the size of syndication partners (although VCs from the largest quintile appear to have some preference for syndications with VCs from the second largest quintile).[125] In later rounds, however, VCs are found to syndicate investments to both similarly and less 'established' VCs. Without reporting his findings in detail though, Lerner (1994), further notes that similar patterns are found when using VCs' age instead of size. Furthermore, Lerner finds indications - without statistical significance though - that older and/or bigger VCs might invest alone more often, and that VCs specialising in startups ventures - traditionally considered the most risky investments - might have less syndicate partners than other VCs. In addition, Lerner (1994) finds that - in later rounds - the VCs' experience (approximated by the VCs' age, size, and number of

[124] In this context, and with view to first round investments, Lerner (1994) distinguishes between non-/established VCs' based on their *age* and *funds under management* (relative to all VCs' funds under management in a given year; divided in quintiles). Additionally, with view to later round investments, he also categorizes VCs based on the *number of the* their *previous biotech investments*.

[125] Here it must be mentioned though that Lerner's (1994) article seems ambiguous. In the body-text, he mainly states that, in first rounds, *more* established VCs tend to syndicate more often with each other. This would support his hypothesis, and it is often referred to in studies by other authors. However, Lerner (1994) also reports that *less* established VCs tend to syndicate more often with each other. This seems also supported by the charts presented in his paper - although it contradicts Lerner's hypothesis and part of his discussion.

previous biotech investments) is smaller than in first round investments. Overall, Lerner (1994) therefore concludes that *gathering additional information for the ex-ante decision-making and selection of investments might be a particularly relevant motive* for syndication.[126]

To a similar conclusion come Hopp and Rieder (2004), in a working paper that examines the relation between VCs' experience and their 'syndication ratio' (proportion of syndicated to unsyndicated investments).[127] They use a database sample of 812 VCs who had made 3,230 investments in 1,962 German portfolio companies. Whilst the authors themselves point out that the results of their study have to be taken with some caution, it is nevertheless interesting that they find some indications for a negative relation between the VCs' size and the VCs' syndication ratio.[128] Furthermore, the authors also find that more 'specialized' VCs have lower syndication ratios than their less specialized peers.[129] Hopp and Rieder (2004) interpret their findings as suggesting that less experienced VCs are more inclined to syndicate as they might not have the necessary expertise; and they further take this as support for the *resource-driven motive for syndication that intends to overcome informational asymmetries.*

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[126] At the same time, Lerner (1994) also finds some support for the 'constant share' (Admati & Pfleiderer, 1994) and the 'window dressing' (Lakonishok et al., 1991) motives of syndication in *later* rounds.

[127] Hopp and Rieder (2004) classify the VCs' experience according to their number of investments in groups of 'one time investor' (1 investment), 'very small VC' (2-3 inv.), 'small VC' (4-6 inv.), 'lower middle field VC' (7-10 inv.), 'upper middle field VC' (11-20 inv.), 'large VC' (21-50 inv.), and 'very large VC' (> 50 inv.).

[128] With respect to the problems of their study, Hopp and Rieder (2004) acknowledge that the 'syndication ratio' is likely to be biased in that those VCs with only one single investment (with 512 VCs, the vast majority in their sample) can only have a syndication ratio of either 0 (if the investment was not syndicated) or 1 (if the investment was syndicated). As a consequence, the authors mainly conduct their analysis on a sample of VCs with at least two investments. Moreover, the authors also acknowledge that, in their data, they have no information about how many rounds of funding their sample ventures have received. Therefore, they have to adopt a broad definition of syndication by 'pooling' all VCs ever invested in a venture. As a consequence, if a venture has received two rounds, each by one different VC, it would still be considered as a venture that had received funding from a syndicate of VCs. This also affects (i.e. likely inflates) the syndication ratios of the VCs used by the authors. Finally, the authors don't control for any other variables but the ventures' industry sector and the 'type' VC (level of specialization).

[129] It is not quite clear how Hopp and Rieder (2004) define VCs' 'specialization'; but it seems like this is the categorization used by the provider of the database the authors employ for their study.

Lockett and Wright (1999, 2001) come to a somewhat different conclusion. They use a questionnaire-based survey of ca. 60 UK VCs to examine their motives for syndication.[130] Based on this, they find that knowledge-related aspects don't present such a strong motive for VCs to syndicate, as do finance/-portfolio-related aspects. Specifically, they find the following motives for syndication significant ($p<0.01$): the 'large size of the deal in proportion to the size of funds available', the 'requirement for additional financing' and the 'large size of the deal in proportion to the firm's average deal size'. However, Lockett and Wright (1999) also find some weaker evidence for knowledge/experience related motives to syndicate a deal out, particularly for the ex-post management of investments (e.g. expertise regarding industry and/or stage of an investment; all with $p<0.1$). With respect to the VCs' motives to syndicate in to a deal, Lockett and Wright find similar results. Overall, therefore, the authors conclude that *syndication is more a response to the need to spread the financial risk* (*i.e. portfolio diversification*) *and to gain additional financial resources than to share information and manage investments.*

At the same time, Lockett and Wright (1999) also find that both the finance- and the knowledge-related motives are more important for VCs with a smaller preferred investment sizes (i.e. arguably for those VCs who are smaller and/or prefer to invest in early-stage ventures) than for those with a larger preferred investment size. In addition, Lockett and Wright (1999) find that for selecting a syndicate partner neither the financial characteristics nor the resource base of the firm are important factors. Instead, partner selection seems far more influenced by past interaction, reputation and investment style. As the authors suggest, this could indicate that VCs indeed are wary regarding the possible costs/risks associated with syndication, and that they see a trade-off associated with syndicating.[131] Finally, Lockett and Wright (1999) find that competition in the VC market (e.g. low level of funds available to VCs) is negatively related to VCs' syndication.

[130] Lockett and Wright (1999, 2001) categorize VCs by their self-stated industry and financing-stage expertise (Likert scale) and/or minimum investment size preferences.

[131] The later argument finds further support by a subsequent study by Wright & Lockett (2003). Based on two surveys of (58/56) UK VCs, the authors examine the structure and the management of syndicate partnerships. Doing so, they find that trust is a critical element in the syndicate contracts. The syndicate contracts enshrine the control rights of the members rather than specifying duties of behaviour; and non-legal sanctions are more important than legal sanctions in ensuring cooperation by the syndicate partners.

Sorenson and Stuart (2001) examine several factors with likely impact on VC's spatial (i.e. geographic or industry) 'investment reach'. Amongst those factors are *VCs' general and industry experience* and various measurements characterizing a *VC's network position*.[132]/[133] Using a sample of 1,025 VCs investing in 7,590 ventures (from various industries) between 1986 and 1998, which was collected from the Venture Economics database, Sorenson and Stuart (2001) find that, on the one hand, the likelihood of VCs to invest in a venture decreases sharply with the venture's geographical and/or industry distance. At the same time, the authors also find that VCs' general experience, when interacted with either geographic or industry distance, indeed are significantly and positively related to the VC's propensity to invest in a 'distant' venture (i.e. a VC's general experience extends his investment reach). However, contrary to the authors' expectations, this is not the case for the VC's industry experience. Furthermore, when also interactions between a VC's network characteristics are included in the models, the relation between the interacted effect of VCs' general knowledge and distance and the VCs' propensity to invest in a distant venture, only remains significant with view to ventures that are 'distant' to the VC by their industry, but becomes insignificant with view to geographically distant ventures. Overall, Sorenson and Stuart (2001) therefore conclude that a *VC's experience primarily influences the geographic scope of his investment reach*

[132] Sorenson and Stuart (2001) approximate VCs' 'general experience' by their number of previous investments overall, and 'industry experience' by their number of previous investments in the same industry as a particular venture under consideration; and they approximate the VCs' 'network position' by their mean affiliation (previous syndications with syndicate partner in current investment), affiliate distance ('closeness' of syndicate partner to investment venture) and centrality (focal VC's overall network position).

[133] However, Sorenson and Stuart (2001) don't examine the role of VCs' experience as a motive for syndication. Instead, they consider both factors as independent variables in their analysis of VCs' investment behaviour. Here, the authors argue that VCs, overall, tend to invest 'locally' (in terms of geography and industry), but they also note that there are considerable differences in the 'spatial reach' between VCs - where 'spatial distance' refers to a) geographical distance, defined as the distance in miles between VC and venture, and/or b) industry distance, defined as the dissimilarity between the industry of a particular venture under consideration and the industries a VC has previously invested in. In this context, Sorenson and Stuart (2001) assume that VCs' experience could be related to VCs' propensity to syndicate 'distant' ventures because increasing experience should a) reduce the costs of monitoring at a distance, b) make VCs more confident in their ability to evaluate investment opportunities, and/or c) enhance VCs' networks with experts and entrepreneurs in the industries in which they repeatedly invest, providing privileged access to information about promising investment opportunities. As a consequence, the authors further assume that more experienced VCs are more likely to invest in distant ventures.

through the development of networks through syndication – where general experience proxies well for the development of a VC's network but has no net effect when network-related variables are included directly. In other words, the positive effect of previous (general) experience on a VC's propensity to invest in distant ventures seems moderated by the network a VC builds over time. The development of syndication networks helps diffuse information across spatial boundaries and therefore allows a VC to invest more frequently also in spatially distant ventures.

Brander et al. (2002) examine and compare two possible motives for syndication: the pre-investment 'selection motive' and the post-investment 'value adding' motive.[134] In this context, Brander et al. (2002) take a unique approach in that they examine the relation between syndication and investment performance (a topic we will come to in Chapter H, further below). Specifically, the authors hypothesize that if the 'selection' motive was central for VCs to syndicate, then the performance of syndicated investments should, on average, be inferior to that of stand-alone investments. This is because only an ambiguous investment proposition would call for a 'second opinion, whilst unambiguous (good) propositions would not be syndicated and unambiguously bad propositions would be rejected. If, in contrast, the 'value-adding' motive was central for VCs to syndicate, then, the authors further hypothesise, the performance of syndicated investments should on average be superior to that of stand-alone investments. This is because different VCs in the syndicate should contribute different/complementary skills and contacts that should be valuable for the post-investment management, resulting in better investment performance. Based on data on 114 Canadian VCs that invested between 1992 and 1997 in 2,889 ventures from various industries Brander et al. (2002) find that the annual return for VCs is significantly higher for syndicated than for unsyndicated investments (35-39% vs. 15-20%). The *authors interpret this as support for the hypothesis that the post-investment 'value-adding' motive is much more important for syndication than the pre-investment 'selection' motive.* At the same time, the authors also acknowledge that both the 'selection' and the 'value adding' motive could be operating simultaneously.[135]

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[134] Brander et al. (2002) do not actually differentiate explicitly between VCs on the basis of their knowledge.

[135] In addition, Brander et al. (2002) also acknowledge that other motives might play a role for VCs' syndication such as collusion, risk sharing and portfolio management, which cannot be ruled out on the basis of their analysis.

Manigart et al. (2004), in a similar vein as Lockett and Wright (1999, 2001), use a questionnaire-based survey to examine the motives for syndication of 317 VCs in six European countries.[136]/[137] Based on this approach, the authors find that (in contrast to previous US studies but in line with previous European studies) finance-related portfolio management motives are most important for European VCs - both for later and for early stage VCs, but more important for smaller than for larger VCs. The deal flow motive, furthermore, is more important for larger, early-stage than for smaller and/or later-stage VCs. Overall, Manigart et al. (2004) therefore conclude, *risk sharing, portfolio diversification, and access to larger deals are more important motives for VCs to syndicate than selection and monitoring of deals*. This holds for both later- and early-stage VCs. Value adding is not a significantly important motive for any VC firm, but it is more important for early-stage investors than for later-stage investors.[138] At the same time, while the deal flow, selection and value adding motives are equally important for early stage VC firm, there seems to be a hierarchy of motives for later stage firms: for these firms the finance motive is followed in importance by the deal flow motive, which, in turn, is significantly more important than the selection motive. Furthermore, with respect to a VC's available knowledge, the authors find that the VCs' industry specialization has *no* influence on the importance of any of the motives to syndicate except for the selection motive: non-specialized, early stage VCs syndicate more for improved deal selection purposes than specialized, early stage VCs. However, improved deal flow or value adding capabilities appear not to be important for more specialized VCs.[139]

[136] The six countries were: Belgium, France, Germany, The Netherlands, Sweden, and the UK.

[137] Manigart et al. (2004) categorize VCs primarily according to their self-stated development-stage preference (defined by whether the average age of their previous investments was above or below the average age of the overall sample) and additionally according to their self-stated industry-specialization (5-point Likert scale: high-low); and the authors ask VCs to indicate (on 5-point Likert scales) the relevance of several aspects linked to two 'portfolio-management-related' motives - i.e. 'spreading risk' ('financial motive') and 'increasing the deal flow' - and two 'individual-investment-related' motives - i.e. 'pre-investment deal selection' and 'post-investment monitoring and value adding'.

[138] Here, Manigart et al. (2004) further note that whilst this could suggest that European VCs underestimate the role that syndication may play in access to information, knowledge, value adding skills and deal flow, in preliminary interviews, VC managers expressed the view that they were unlikely to invest in a deal if they did not have confidence in their own knowledge/abilities with respect to a particular deal and its sector.

[139] In this context, Manigart et al. (2004) however acknowledge that their findings have to be taken cautiously because of their very imprecise measure of VCs' specialisation.

Finally, economies of scale can play an important role in choosing to syndicate. Having to perform due diligence on an investment is rather like having to perform a survey when buying a house. Each buyer acting independently will incur the same survey costs. If they were able to act together (buying in a consortium) only one survey cost would be incurred and the (equal) amount each would pay would tend to zero with the size of the consortium. The same logic applies to the due diligence costs in a venture capital syndicate.

A study by Valliere and Peterson (2004) based on a series of informal interviews with 57 US and Canadian VCs who were actively investing in early-stage, high-tech ventures during the period from 1998 to 2001 found that *sharing of due diligence efforts* was a significant benefit of syndication; and many of them syndicate their deals and shared due diligence on an informal rotation basis with other investors. In the Valliere and Petersen study a sizeable minority (16%) of participants found such economies of scale highly important and occasionally even reported investing without any significant due diligence efforts beyond the reliance on the due diligence or reputation of other investors - arguably giving evidence that they had sufficient trust in the knowledge of their syndicate partners. At the same time, there is also some indication that syndication might be more strongly applied among earlier-stage investors, where deal sizes are typically smaller and therefore provide a smaller base upon which to amortise the fixed costs of due diligence (Valliere & Peterson, 2004). Overall, therefore, the study by Valliere and Peterson (2004) also *suggests that gaining additional experience might be an important motive for VCs to syndicate, although this might be more to reduce cost than to make better decisions or provide better monitoring/support to the investment.*

As mentioned before, collaboration in general and syndication in particular are likely to offer not only benefits to the partners but also involve potential risks and costs which have to be weighed carefully. This is quite well documented in the empirical literature on collaboration in general (e.g. Dollinger et al., 1997; Gulati, 1995; Kogut & Zander, 1992; Kogut, 1989;Kotabe & Swan, 1995; Mitchell & Singh, 1996a; Perlmutter & Heenan, 1986; Powell et al., 1996; Robertson & Catignon, 1998; Stuart, 1998; Walker et al., 1997).

In the empirical literature on venture capital, however, the risks and costs of syndication have been almost completely neglected. This is despite some authors acknowledge that these are issues that might be relevant.

Steier and Greenwood (1995), for instance, in an indepth case study of one venture and its syndicate of VCs, shows that syndication can be associated with substantial costs for both the venture and its investors. Specifically, the case shows that the formal coordination between partners can lead to substantial delays on critical decisions, such as when it comes to further funding. In the particular case these delays even resulted in the venture going into receivership although it seemed fundamentally sound, and although at least one of the investors would have liked to continue financing it.[140] Similarly, also Wright and Lockett's (2003) above mentioned survey of UK VCs reveals that VCs perceive coordinated action and decision-making to take longer in syndicated than in un-syndicated investments; and particular difficulties regarding coordination and decision-timing are posed by larger syndicates. But, overall, Hopp and Rieder (2004) conclude that 'it is rather striking that there exists no study revealing the reasons why venture capitalists refrain from syndicating in or -out an investment and under which circumstances this is the case'.

F.II.3. Preliminary summary and conclusion

Table F-1 summarizes the above-reviewed empirical studies on VCs' motives to syndicate.

*** INSERT TABLE F-1 HERE ***

A partial synthesis of the literature on the motives for syndication discussed above is as follows. If we consider finance and knowledge as resources, a generalised resource-constraints model argues that lack of any one of these elements may be remedied by participating in a short-term investment relationship namely a syndicate. Additional motives include risk-reduction (financial and technical risk reduction) and a desire for control (buying in early at a low price per share). Finally, if syndication pays off we should expect to find a habit forming amongst successful syndicators so that syndication activity persists through time. The reason that syndicates are temporary rather than permanent associations arises from the fact that different kinds of expertise and levels of finance may be required for different investments. It is not worthwhile to invest in permanent resources (merger) if the resources required may be needed only for a short time.

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[140] In the related case of loan covenants between banks and MBOs, Citron et al. (1997) show that syndication complicates and slows decision-making. The origins of the agency (management) cost imposed by the syndicate may be created by the diverse objectives of members, which may become more apparent with larger number of partners.

Thus, several preliminary conclusions can be drawn with respect to our research question.

To begin with, neither theoretical nor empirical research does indicate whether there is any dominant motive for VCs to syndicate. Furthermore, to some degree, extant empirical research even shows contradicting findings particularly with view to the role of finance vs. knowledge related motives for syndication.

At the same time, although the existing literature on venture capital has hardly dealt with this issue explicitly, it seems reasonable to assume (also from the literature on inter-organizational collaboration in general) that a VC's decision to syndicate results also from his assessment of the trade-off between the benefits and the risk/costs of syndication. This assessment, in turn, might be influenced by (a combination of) several factors, such as factors related to the VC himself, to the financial aspects of a deal, and to the particular investment opportunity, such as a venture's industry or development stage.

Thus, with view to our research question, it seems reasonable to assume that knowledge-related issues are likely to be amongst those factors with likely impact on VCs' syndication decision. Simply put, if a VC was absolutely certain to make a profit from his investment, there would be little need for him to syndicate. But absolute certainty (or absolute knowledge) does not exist, and there always remains a risk associated with an investment.

Indeed, most available studies indicate the potential relevance of knowledge-related issues as a motive for syndication, although with varying emphasis. However, as we have already argued further above (see Chapter C), extant literature on venture capital overall has almost completely neglected the (differences in) VCs' knowledge and/or used VC characteristics to differentiate between VCs that do not really seem appropriate as proxies for VCs' knowledge. This also holds for the literature on syndication between VCs.[141]

Therefore, using our more adequate proxies/ways to measure VCs' knowledge, developed in Chapters D, we can hopefully obtain a clearer picture about the actual role VCs' knowledge plays for syndication.

[141] To avoid too much repetition, at this stage, it should be referred to our discussions of the VC characteristics used in the extant literature to differentiate between VCs, and of the suitability of those characteristics as proxies for VCs' knowledge (see: preliminary conclusion from the review of empirical literature, chapter C, and to our discussion on more appropriate proxies for VCs' knowledge, i.e. the number of VCs' previous investments overall and/or in a particular type of venture, in chapter D.

Based on the above, in the following, we develop our research hypothesis regarding the impact of knowledge on an individual VC's likelihood to syndicate an investment.

F.III. Hypothesis

To begin with, it should be emphasized that our approach is different from some extant research in that we investigate the relative importance of different motives for syndication only as a bi-product of our analysis that primarily focuses on the role of VCs' knowledge in this context.

With view to the latter, we suggest an examination of the impact of knowledge on syndication along two dimensions: the *level of knowledge* and the *type of knowledge*. As outlined above (see Chapter D, 'Propositions'), the two dimensions can be approximated by the number of a VC's previous investments overall and in a particular type/stage of venture respectively.

If, as it seems likely from the above literature review, syndication is also a result of the VC's perception of the trade-off between the expected benefits and costs, and if VCs' knowledge furthermore influences the perception of this trade-off, then it seems reasonable to argue that a higher *level of knowledge* should make a VC less inclined to syndicate. This is because, all other things equal, VCs with different levels/types of knowledge will have a different perception of the up- and downside potential of an investment opportunity - and, correspondingly, of the syndication trade-off.

For instance, a more knowledgeable VC should be more confident in his capabilities to make good pre-investment decisions and/or to provide relevant post-investment monitoring and support to ensure a successful outcome of his investment. Therefore, given a certain investment opportunity (and all other things equal), this is likely to reduce the expected benefits from syndication for the knowledgeable VC vs. the ignorant VC – presumably making the former less appreciative of other VCs' capabilities for these tasks.

At the same time, also the relative costs/risks of syndication should be higher for a knowledgeable VC compared to an ignorant VC. The later risks 'only' loosing his money in a bad investment, but the former risks loosing his money, his reputation, and his knowledge - in that he provides access to this knowledge (e.g. in form of his particular evaluation criteria/processes and/or contacts to important industry players) to his less knowledgeable syndicate partner. Thus, a knowledgeable VC might be assumed to be less inclined to bear the additional costs/risk associated with syndication, e.g. to share the expected success of the investment or to risk free-riding behaviour by syndicate partners.[142]

This will lead the more knowledgeable to either accept or reject a project more quickly and 'expertly' and to act independently of others. Our database is only of investments that were accepted. We therefore expect that expertise will show itself in a reduced tendency to syndication. This is because the more certain a VC is of the outcome of the investment the more likely he will be to go-it-alone to avoid sharing profits.[143]

So far we have only been concerned with the VC's general level (amount) of knowledge. However, as we have argued further above (see our Propositions P1 and P2, Chapter D), it seems also relevant to differentiate between different *types of knowledge* such as, on the one hand, knowledge related to investing/managing startup ventures in general ('general experience'), and, on the other hand, knowledge related to investing/managing startups of a particular type, i.e. sector and/or stage ('specific expertise').

In this context we have further argued that specific expertise might be more valuable than general experience - although the latter should be valuable nevertheless. As a consequence, it now seems reasonable to assume that if - as proposed above - a negative relation exists between a VC's level of knowledge and his propensity to syndicate, this should also be influenced by the VC's type of knowledge. Specifically, it should be more pronounced with view to his specific expertise than with respect to his general experience.

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[142] Here, it must be mentioned that if one considers - as we do - syndication a trade-off between the risks associated with an investment and the risk associated with syndication, both factors should have an impact on the decision to syndicate. It seems reasonable to assume that the perceived risk associated with syndication, in turn is a function of the partners' potential previous syndication experience: the perceived risk of syndication between two partners should be the smaller/greater the more/less experience they have with co-investing with each other. However, on the basis of our data, we cannot test for previous co-investment experience between two syndicate partners. Therefore, in the following we focus exclusively on those factors with likely impact on the perceived risk associated with the investment (but not on the perceived risk associated with the syndication).

[143] In this context, Sorenson and Stuart (2001) also note that the decision-making literature counsels that a change in the willingness to rely on one's own judgment does not necessarily constitute a rational shift in behaviour. Research shows that individuals become more comfortable engaging in an activity simply by doing it, especially when the feedback regarding success lies chronologically distant from the activity. Thus, VCs might judge themselves to be better investors regardless of any real improvement in their selection ability.

The VC's *general experience* might be less related to a VC's syndication behaviour because general experience should not enhance a VC's confidence in his pre-investment decision and his post-investment value-adding capabilities to the same degree as his specific expertise. Thus, a VC's general experience will not reduce his perception of the risk associated with an investment to the same degree as his specific expertise with respect to this type of investment. At the same time, if general experience is less important for the perception of risk associated with an investment, a VC might perceive less risk in exposing his general experience to the risk of syndication.

In contrast, *specific expertise* regarding a particular sector/stage of an investment opportunity should make a VC particularly confident in his capabilities to realistically asses this opportunity, to make the appropriate pre-investment decisions and to provide the adequate post-investment monitoring/support services. As a consequence, all other things equal, a VC with plenty of specific expertise might perceive less risk in a given investment opportunity. At the same time, this should also impact his perception of the syndication trade-off. If a VC perceives less benefit in getting access to additional expertise, the possible risks associated with syndication (e.g. opportunistic behaviour by syndicate partners) might be perceived to be larger. Therefore, we expect the negative relation between a VC's knowledge and his likelihood to syndicate to be particularly pronounced for the VC's specific expertise. As a consequence, all other things equal, a VC's general experience shouldn't have the same impact on his assessment of the syndication trade-off as his specific expertise.

Also this assertion finds some support form other researchers – although, as we have argued above, they have used either no or only inappropriate measures for VCs' knowledge in their own empirical studies. Lerner (1994), for instance, argues that if certain VCs develop special expertise in a complex industry such as biotechnology, it is not obvious that such specialists will be particularly likely to co-invest. Similarly, Wright and Lockett (2003), note that skilled VCs may be less reliant on others for specialist information. Finally, Manigart et al. (2004) hypothesize that the 'deal flow', the pre-investment 'selection', and the post-investment 'value-adding' motives for syndication will be less important for specialized VC firms: 'VC firms specialized in a specific industry sector will have a deeper understanding of that sector and therefore experience less informational asymmetries to evaluate opportunities. Given greater in-house knowledge on their target sectors, VC firms that are specialized in a specific sector will have lower need to rely on syndicate partners for selection purposes' (Manigart et al., 2004: 8).

In sum, one might expect the above-suggested negative relation between knowledge and syndication to be more pronounced the better matched a VC's expertise is to the investment under consideration. General experience may be useful but cannot provide the indepth knowledge relative to a specific investment opportunity. Thus we expect a much weaker relation between a VCs' general experience and the tendency to syndicate, though still predict a negative one.

Our hypothesis follows directly from our above discussions. Specifically, we have argued that, all other things equal, more knowledgeable VCs should be less likely to syndicate; and that the negative relation between knowledge and syndication should be more pronounced the better the 'match' between past experience and current opportunity.[144]

Formally stated this leads to our **Hypothesis 1**:

Other things equal, a) the more knowledgeable a VC, the less likely he is to syndicate; and, b) the better matched a VC's experience is to his current investment opportunity the more pronounced is his tendency to go-it-alone.

So far, our main focus was on the role of VCs' knowledge - approximated by us as the number of VC's previous investments - as a motive for VCs to syndicate, and our arguments regarding the negative relation between VC knowledge and syndication were based on the assumption of 'all other things being equal'. This, however, neglects the fact that not only are VCs likely to differ with respect to their knowledge, but also other factors with possible impact on VCs' propensity

[144] In this context, it should be emphasized though that there is only very limited research available to solidly justify these arguments; and we acknowledge that there are also some arguments that might support a different direction in the relation between VC knowledge and VC syndication (for example, more knowledgeable VCs might be more aware of the unpredictable uncertainty, that is likely to be associated particularly with high-risk/high-tech investments - potentially making them even more inclined to syndicate those investments than ignorant VCs). Lockett and Wright (2001: 389), for instance, point out that 'there are competing views about the effects of these characteristics on the willingness to syndicate. Venture capital firms with greater experience and reputation may, on the one hand be less motivated to syndicate a transaction because they believe that by investing in sole investments they have the expertise to generate superior returns to their competitors. Alternatively, they may still be motivated to syndicate transactions because they place importance on the variance of their returns and/or gaining access to deal flow'. However, based on our discussions above, we believe a negative relation between the two variables to be more plausible.

to syndicate are likely to differ. Those factors - which might be context-, VC-, finance, and/or venture-related – are likely to affect VCs' perception of the risk associated with an investment opportunity, and therefore also the VCs' assessment of the syndication trade-off (assuming VCs' knowledge to be constant). These factors therefore should be controlled for when examining the relationship between VCs' knowledge and syndication. We will discuss those factors below in the section outlining our methodology.

F.IV. Methodology

This section describes our methodology for examining our hypothesis, including the variables and their operationalization, the statistical methods, and the analytical approaches.

F.IV.1. Variables and their operationalization

F.IV.1.a) Dependent variable

The dependent variable in our analysis is the VC's decision to syndicate an investment, or not. We operationalise this variable by a dichotomous dummy variable that takes the value of 1 if the investment is syndicated, and the value of 0 if it is not syndicated.

F.IV.1.b) Theoretical variables

The theoretical variables in our analysis are *five different proxies for VCs' knowledge*: the VCs' 1) *age*, 2) *non-biotech experience*, 3) *total experience*, 4) *biotech expertise*, 5) *biotech-stage expertise*.[145]

The above variables and their operationalization have already been described in detail further above, and we therefore refer to our propositions in Chapter D for more details. In short, however, we operationalise our main proxies for VCs' knowledge (2-5) as the cumulative number of a VC's investments until the year prior to the investment under consideration in non-biotech ventures (non-biotech experience), in all types of ventures (total experience), in biotech ventures (biotech expertise), and in biotech ventures of the same stage as the venture under consideration (biotech-stage expertise). However, to compare our findings with extant literature, which sometimes used the VC's age as a knowledge proxy

[145] We don't include the sixth proxy discussed in Chapter D, the VCs' biotech-sub-sector expertise, in our final analysis because preliminary analyses have shown that the results for this proxy are qualitatively the same as for the VCs' biotech-stage expertise.

- and also because the VCs' age might pick up some 'residual effects' of learning (Stuart et al., 2001) as well as his 'reputation', which might make him particularly attractive syndicate partner - we also include this proxy in our analysis. We operationalise the VCs' age by the time (in years) between the VCs' foundation and the date of the particular investment under consideration (and in those cases where we don't know a VCs' foundation date, we use the date of the VCs' first investment noted in the Venture Economics database).[146]

Based on this, we expect the negative relation between VCs' knowledge and his likelihood to syndicate to be increasingly pronounced from the VC's age, over his non-biotech and total experience, to his biotech and biotech-stage expertise.

Since we are interested in potential differences in the relation between the above outlined knowledge proxies and the VC's decision to syndicate an investment, we will test these proxies individually in separate models using the same units of analysis, i.e. only cases for which we have information on all five knowledge proxies. This allows us to contrast and compare not only the coefficients for the individual proxies but also the overall predictive power of the models comprising the different proxies.

F.IV.1.c) Control variables

Although our main focus is on the relation between the VC's level and type of knowledge and his likelihood to syndicate an investment, we acknowledge that several other factors are likely to be of relevance, too. We therefore control for those other factors in our baseline model to find out about the impact of our theoretical over and above the other factors, which can broadly be categorized into context-, VC-, finance-, and venture-related factors.[147]

Context-related control variables

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[146] It might be mentioned here, that another, arguably very important factor with likely impact on the VCs' perception of the risk associated with an investment is the experience internally available to the venture, approximated, for instance, by the academic background and/or the professional track record of its management. However, whilst it would be clearly desirable to include those variables in the current analysis (as planned initially), the available data provide no information to enable us to do so

[147] With view to those control variables, it should be mentioned, that we include them into our baseline model because there are some reasons to believe that they might impact VCs' propensity to syndicate. However, without much extant research to build upon, in many cases, it seems too speculative to develop specific hypotheses about the direction of the relation between those control variables and syndication.

As Lockett and Wright (1999: 311) point out, 'the decision to syndicate an investment is not taken in a vacuum, rather it is anticipated that there may be a number of contextual factors that may influence the extent of syndication in the market'. With respect to the contextual environment, therefore, a factor with likely impact on VCs' syndication behaviour might be the situation on the stock- and/or private equity markets at the time an investment opportunity occurs (Lockett & Wright, 1999, 2000). Therefore, we include several context-related factors in the baseline model, which might impact VCs' propensity to syndicate.[148]

Annual change in number of VCs investing venture capital: The VCs' propensity to syndicate is likely to be influenced by the total number of VCs actively investing in a given year. For instance, assuming the number of investment opportunities to remain constant, a larger number of VCs should increase the opportunity to syndicate. In this context, it seems recommended to consider all VCs, independent of whether they have already invested in the focal industry (biotechnology) or not, because even if a VC hasn't previously invested in biotech, he might decide to do so, and by this become a 'biotech VC'. Furthermore, because of the cyclicality in the markets - that might make it difficult for the (number of) VCs to adjust to the number of investment opportunities – and because the absolute number of VCs dramatically increases towards the end of our sampling period, we feel it is more appropriate to consider the change in the number of VCs rather than the absolute number of VCs in this context. Therefore, we control for the *percentage change in the number of VCs investing venture capital in the year of the investment under consideration compared to the previous year.*

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[148] In preliminary analyses, we also tested some additional context-related factors with a possible relation to syndication such as the time (individual years or periods of 2-5 years) when the investment took place, or the Dow Jones Industrial, the Nasdaq, and the Nasdaq Biotech indices (and their % change in the year of the investment compared to the previous year). Here, the time (year or periods) showed some relation to syndication (generally, the more recent investments showed a stronger negative relation to syndication than those investments that took place at the beginning of our sampling period); and the examined indices showed no consistent relation to syndication. Overall, however, the inclusion of those factors did not increase the explanatory power of the models, but – in some cases – it caused problems of multicollinearity with other context-related factors that were included in the models. As a consequence, we opted to leave out those factors from the analysis and to keep only those factors, which did not cause problems of multicollinearity and for the inclusion of which we had plausible theoretical arguments.

Annual change in number of biotech ventures receiving venture capital: Related to the above arguments, it seems also likely that the number of biotech ventures receiving venture capital influences the propensity to syndicate of those VCs whishing to invest in biotechnology. For instance, assuming the number of VCs to remain constant, a larger number of investment opportunities should reduce the competition between VCs, and their need to syndicate (cf. Bygrave, 1987; Lockett & Wright, 1999). Again, we feel it is more appropriate to use the percentage change rather than the absolute number because the later increases towards the end of our sampling period. Therefore, we control for the percentage *change in number of biotech ventures receiving venture capital in the year of the investment under consideration compared to the previous year.*

Annual change in venture capital raised: If, as some previous literature indicates, syndication is (also) influenced by financial motives, then it seems plausible to assume that the overall liquidity of the venture capital markets might also be related to VCs' general propensity to syndicate. For instance, if more funds are available for investments overall, this might reduce the VCs need to syndicate investments because of financial constraints. In this context, we again suggest that it is more appropriate to consider the change in venture capital raised than the absolute amount of venture capital raised, because the latter increases dramatically towards the end of our sampling period. Furthermore, and identical to our arguments further above, we feel it is more appropriate to use the total amount raised, and not just the biotech amount raised, because biotech investments represent a sub-sample of all investments by VCs. Although VCs often raise funds from their investors for investments in particular types/industries of ventures, many VCs also have considerable discretion about their investment decisions. As such, if there are good investment opportunities perceived to exist in biotechnology, more funds should go into this sector. Therefore, we control for the *percentage change in the total venture capital amount raised by all VCs in the year of the investment under consideration compared to the previous year.*

High-/biotech-boom years (1996-2000): With view to context-related aspects, a factor with likely impact on VCs' general investment approach, including the VCs' syndication behaviour, concerns the dramatic developments in the financial markets during the high-tech Bubble from about 1996 to 2000. We control for these boom years because much has been written about the 'irrational exuberance' of investors during this period of hype. As such it seems possible that during this period the 'normal laws' – if there are any – determining VCs syndication decision have been set out of power (Valliere & Peterson, 2004).

Therefore, we control for the 'high-/biotech-boom years (1996-2000)' by a *dummy variable that takes the value of '1' if the investment takes place in the years 1996-2000 and the value of '0' otherwise.*

VC-related control variables

The next set of control variables concerns features of the VCs, other than their knowledge, which might be assumed to impact the VCs' propensity to syndicate.

VC type 'private equity partnership': Whilst the majority (60%) of investments in our sample come from independent private equity partnerships (VCs in a narrow sense), a considerable proportion (24%) also come from VCs in a broader sense, such as bank-, insurance-, pension-fund-, university-, government-, incubator-, endowment-, or consultancy-related investors (and in ca. 16% of the investments, the investor type is unknown). Although, to our knowledge no prior research exists on whether there are differences in the syndication behaviour of different types of investors, it seems reasonable to assume that this is the case. For instance, 'true' VCs might be assumed to be more dependent on a constant deal flow, which might be enhanced by having a network of syndicate partners. Therefore, we control for the VC type 'private equity partnership' by a *dummy variable that takes the value of '1' if the investor under consideration is categorized by VE as a truly independent private equity partnerships (VC in a narrow sense), and the value of '0' otherwise.*

VC from US: To control for the VCs' country of origin seems relevant because there is growing attention to the differences between venture capital markets (cf. Kaplan et al., 2003; Manigart et al., 2002; Sapienza et al., 1996); and those differences between countries might also be reflected in VCs' propensity to syndicate, as well as in their motives for syndication (Manigart et al., 2004). Therefore, we control for whether a 'VC comes from the US' by a *dummy variable that takes the value of '1' if the investor under consideration stems from the US, and the value of '0' otherwise.*

VC 'syndication history' in biotechnology: To control for a VCs' previous syndication behaviour seems important because, as outlined before, literature on collaboration in general suggests that experience with collaboration in the past impacts the propensity to collaborate in the future. At the same time, we have to caution about the interpretation of findings on this variable mainly because we only have information on a VC's history of syndication in the biotechnology context. As such, it might be possible that although a VC has no track record of syndication in biotechnology he has considerable experience with syndication outside the biotech context.[149] Nevertheless, we include this variable because it might provide at least some idea of whether a VC has any prior experience with syndicating at all. Therefore, we control for the 'VC's syndication history' in biotechnology' measured by the *proportion of the VC's previous investments that were syndicated.*[150]

Finance-related control variables

The next set of variables we control for in our baseline model concerns finance-related aspects. We include those aspects in a separate step in our model for two reasons. Firstly, it seems reasonable to assume that the investment- and/or deal size is not exclusively determined by the VC's (willingness to invest his) financial resources. Instead, it is also likely to be a function of the financial requirements of the venture under consideration. Secondly, most literature on syndication suggests an important role of financial aspects as motives for syndication. Therefore, to single out the relevance of those aspects - and to relate our findings to extant research - we include them in a separate step in our models.

We control for two finance-related control variables.

Round amount ('deal size'): Several prior studies suggest that the size of the particular investment under consideration could be a very important factor for a VC's propensity to syndicate (cf. Lockett & Wright, 1999, 2000; Manigart et al., 2004). From this extant literature it seems reasonable to assume that there is a positive relation between the round amount and the VC's likelihood to syndicate an investment. This could be because the VC wishes to spread his financial risk by investing only a limited amount in a single investment and/or because of financial constraints on the part of the individual VC - both increasing his likelihood to syndicate if the venture under consideration requires an amount

[149] Obviously, one ideally would want to have information on prior collaborations between two particular VCs, and on the success of those collaborations - as determinants for their propensity to syndicate again in the future (cf. Lockett & Wright, 1999; Sorenson & Stuart, 2001; Valliere & Peterson, 2004). Unfortunately though, in our data we do not have information on this issue.

[150] It should be mentioned that this control variable might be biased in that a considerable proportion of VCs in our sample (ca. 46%) only have made one single investment. Consequently those VCs can have only values of '1' or '0' for this control variable, depending of whether their first investment was syndicated or not. To check for the robustness of our findings, we therefore run additional - unreported analyses - that include only those VCs that have made more than one investment; but we obtain qualitatively similar results.

larger than the VC's threshold. Therefore, we control for the 'round amount' as the *total amount invested by all VCs participating in a deal* (*i.e. by the sole VC in case of an unsyndicated deal, and by all syndicate partners in case of a syndicated deal*).

Relative deal size: As discussed in the previous paragraph, it seems likely that the total round amount has an impact on VCs' likelihood to syndicate an investment. However, as also mentioned above, it seems further likely that the impact of the round amount also depends on the individual VC under consideration, as a larger round amount should not have the same impact on the syndication decision in case of a VC who previously made larger investments than in case of a VC who previously made smaller investments relative to the current round amount (cf. Lockett & Wright, 1999; Manigart et al., 2004).[151] Therefore, we control for the 'relative deal size', measured as the *ratio between the current round amount* (*see above*) *and the average previous investment size of the VC under consideration*.

Venture-related control variables

The next set of control variables for our baseline models comprises venture-related aspects. In this context, most extant literature suggests that VCs' propensity to syndicate is the greater the greater the perceived risk associated with an investment opportunity (e.g. Bygrave, 1987, 1988). Whilst the perceived risk certainly is also influenced by the above-discussed financial aspects, several venture-related aspects are also likely to be of relevance in this context.[152]

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[151] One might also assume that the size of the current investment relative to a VC's available funds should be a relevant variable for an analysis of VCs' syndication behaviour. In our data, though, we have no information on the funds available to a VC at a certain point in time. But we have information on the VCs' average previous deal size at a certain point in time. This might also serve as an indication for the VC's size (funds under management), because larger VCs are said to prefer economies of scale in their investments, i.e. make larger investments.

[152] In preliminary, unreported analyses we tested several other venture-related variables. Most noteworthy of those was the number of patents held by a venture at the time of the investment. As expected, this variable was negatively related to syndication. One plausible explanation for this might be that ventures with more patents present less risky investment opportunities, because they might certify some quality of the venture and/or because VCs might hope to recoup some of their investments by selling the patents in case the venture fails. However, we do not include this variable in our main analysis because we have information on patents only for about one-third of our sample ventures. Furthermore, even where information about patents is available for ventures in our sample, this information only spans the period from 1970 to 1999. Together this would result in a reduction of about 50% in the number of observation on the investment level.

Venture first round of funding: Whilst most extant research on the motives for syndication has neglected the fact that many ventures receive funding in several rounds from the same or different syndicates, it seems plausible to assume that a given VC firm may syndicate for different reasons at different rounds of an investment (cf. Lerner, 1994).[153]/[154] This is particularly obvious with view to first rounds. There, a VC has hardly any information about the internal risks and uncertainties associated with the particular investment. Therefore, in first rounds, the information asymmetries between investors and ventures are likely to be higher than in later rounds – when a VC may have already invested in (and thus gathered information about) and when the venture will have a longer track record. As such, one might expect a higher propensity to syndicate first round investments than later round investments. However, if financial motives dominate the syndication decision, one might also expect a lower propensity to syndicate first round investments, because they are often said to involve smaller deal sizes than later rounds. Furthermore, another important motive for VCs in this context is likely to be their desire to gain First-mover advantage by way of cheaper shares and more control. This is most likely to be achieved when being the only investor in the first round of a venture. Either way, we need to control for whether an investment is done at first or later round, and we do so by controlling for the 'first rounds' of funding by a *dummy variable that takes the value of '1' if the investment under consideration involves the first round, and the value of '0' otherwise*.

Venture early development stage: Several prior studies on the VCs' motives for syndication have pointed towards the stage and/or age of a venture as an important factor to control for (cf. Bygrave, 1987, 1988; Lerner, 1994; Lockett &

[153] Lerner (1994), in one of the few round-based studies, argues that if opinions of other VCs are an important motivation for syndication, VCs should be careful in their choice of first round syndication partners, but this choice should be less critical in later rounds. Having decided to provide capital to a firm, venture capitalists should be much less concerned about confirming their judgement. In his empirical work Lerner finds in fact that, on average, VCs in first rounds are significantly *more* experienced than VCs' in later rounds. It should be noted though that Lerner's measure of experience is VC age. We have pointed out the deficiencies in this measure and will explore the role of age versus our set of proxies in syndication later.

[154] This view is also supported by industry experts such as Robert J. Kunze of Hambrecht and Quist, who argues that syndication of startup rounds circumvents capital constraints and complements expertise, but ' these benefits pertain only to startup financing requiring the venture capitalist's first investment decision. There are different strategies and motivations for syndication in follow-on financing' (cited in: Lerner, 1994).

Wright, 1999, 2000; Valliere & Peterson, 2004).[155] This is particularly evident with respect to early stage investments (e.g. start-up/seed and/or early stage). Because of their 'liability of newness/smallness' ventures in those stages are more prone to fail and more difficult to evaluate (Hannan & Freeman, 1984; Stinchcombe 1965). Thus, they should present riskier investment opportunities for VCs, making them more inclined to syndicate (cf. Barry, 1994; Berger & Udell, 1998; Sorenson & Stuart, 2001). This is particularly so in the biotech industry, because of the highly risky scientific nature of most R&D projects, together with the significant administrative hurdles in the approval process of biotech products (e.g. drugs), early-stage biotech ventures arguably present especially high-risk investment opportunities. On the other hand, as already mentioned in the previous section, another important motive for VCs in this context is likely to be their desire to gain First-mover advantage by way of cheaper shares and more control. It is important to get in early to achieve this. Consistent with this idea, Lerner (1994) finds indications that VCs specialising in startups ventures – traditionally considered the most risky of investments - have *less* syndicate partners than other VCs. Furthermore, as was mentioned above in the context of first round investments, it is also likely that early-stage investments involve smaller deal sizes. Thus, if capital rationing motives dominate the syndication decision, one might also expect VCs to be less likely to syndicate early-stage investments. Therefore, we control for 'early-stage investments' by a *dummy variable that takes the value of '1' if the investment under consideration involves a venture that is in the start-up, seed, or early stage of its development (according to the Venture Economics categorisation), and the value of '0' otherwise.*

First investment by VC in a venture: Whether or not a VC has already previously invested in a particular venture is likely to be an important factor to control for when exploring syndication, because it indicates the newness of the venture to the VC rather than the newness of venture capital to the venture captured by the 'first round' variable discussed in the previous section. Thus, the present variable captures similar, but not identical, aspects to those discussed in the previous paragraph on first round investments. Many ventures in our sample

[155] In the following discussion we only refer to the development stage of a venture, but similar arguments could also be made with respect to the age of an investment opportunity. In fact, unreported analyses result in qualitatively similar findings for the ventures' stage and age. However, problems of multicollinearity prevent us from analysing both variables simultaneously, and, given the choice, we feel the development stage is more informative than the age.

have gone through several rounds of VC funding. Those rounds might or might not involve the same VCs. In first rounds all VCs investing in the venture obviously invest for the first time in the venture. In later rounds, however, the VC might or might not have already had invested in the venture, and as such might or might not have had an opportunity to learn about the focal venture. This clearly could reduce the risk perceived by the VC to be associated with the investment opportunity, and accordingly also his propensity to syndicate. Therefore, we control for a 'first investment by the VC in a focal venture' by a *dummy variable that takes the value of '1' if the VC invests for the first time in a venture, and the value of '0' otherwise.*

Venture and VC from different countries: Finally, it seems also relevant to control for whether or not a VC comes from a different country than the venture because, as shown above, considerable literature presents VCs as relationship investors that take an active role in the management and/or control of their investments. Clearly, it is more difficult for VCs to fulfil this role if they are geographically and/or culturally distant from their investment venture (cf. Sorenson & Stuart, 2001). As such, it seems further reasonable to assume that if VC and venture are very distant, but the VC nevertheless wants to invest in the venture, his likelihood to syndicate the investment – for instance with a VC who is closer to the venture – should increase. Therefore, we control for whether or not 'VC and venture stem from the different country' by a *dummy variable that takes the value of '1' if venture and VC come from different countries, and the value of '0' otherwise.*[156]

F.IV.2. Statistical method and analytical approach

F.IV.2.a) Statistical method

Since our dependent variable (a VC's syndication decision) is dichotomous, our theoretical variables (the proxies for VCs' knowledge) are continuous, and our control variables are both continuous and dichotomous, the most suitable method of analysis is *logistic regression* (Field, 2000; Menard, 2002; Tabachnick & Fidell, 2001).

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[156] We are aware that this proxy is rather crude since it differentiates between, say, a German venture and a French VC, but not between a Californian venture and a New York VC – although the former are more distant to each other from a geographically perspective. However, we reckon, because the later pair is more distant than the former from a cultural, language, political, and legal perspective, it nevertheless makes sense to control for this by the variable suggested.

Logistic regression serves to predict a discrete outcome dependent variable (DV, e.g. syndication yes/no) by estimating a probability for the event conditional on a set of independent variables or regressors (IVs).[157]

The DV, Y, is the probability of having one outcome or another based on a nonlinear function of the best linear combination of the IVs. In case of two outcomes categories this is:

$$\hat{Y}_i = e^u/(1+e^u)$$

where $\hat{Y}_i$ is the estimated probability that the *i*th case (i=1, ..., n) is in one of the categories and u is the usual linear regression model:

$$u = A + B_1 X_1 + B_2 X_2 + \ldots + B_k X_k$$

with constant A, coefficients B_j, and IVs X_j for k IVs (j=1,2, ..., k).

This linear regression equation generates the *logit* or *log of the odds*:

$$\ln[\hat{Y}_i/(1-\hat{Y}_i)] = A + \sum B_j X_{ij}$$

That is, the linear regression equation is the natural log of the probability of being in one group divided by the probability of being in the other group. Thus, the difference between multiple regression and logistic regression is that the linear portion of the equation above, the logit, is not the end in itself, but is used to find the odds of being in one of the categories of the DV given a particular combination of scores on the IVs.

Based on this, one can use logistic regression for two main purposes. On the one hand, one can estimate the coefficients of individual predictor variables in a given model. On the other hand, one can compare the predictive power of models including different predictor variables. We briefly describe both aspects in the following.

[157] Multiple regression is not applicable in this context since it assumes a linear relationship between the IVs and the DV. However, when the outcome variable is dichotomous, this assumption is usually violated. One way around this problem is to transform the data using the logarithmic transformation. This has the effect of making the form of the relationship linear whilst leaving the relationship itself non-linear. The logistic regression equation is based on this principle. It expresses the multiple linear regression equation in logarithmic terms and thus overcomes the problem of violating the assumption of linearity. Because the model produced by logistic regression is nonlinear, the equations used to describe the outcomes are slightly more complex than those for multiple regression.

In logistic regression, the procedure for *estimating coefficients* is *maximum likelihood*; and the goal is to find the best linear combination of IVs to maximise the likelihood of obtaining the observed outcome frequencies.[158] So, as with multiple regression (see Chapter G below), one tries to fit a model to the data that allows estimating values of the DV from known values of the IVs.

The output from SPSS (the program we use for our analysis) provides two *coefficients* β *and exp*β (exponentiated β; in the following 'exponentiated beta'), where the latter is considered more informative because it is an indicator of the change in odds ('odds ratio') resulting from a unit change in the IV (proportionate change in odds = (odds after unit change in IV)/original odds)). Thus the exponentiated beta gives the number by which one would multiply the odds of being in one group for each one-unit increase in the IV; and a value of exponentiated beta greater (less) than 1 indicates a positive (negative) relationship between the IV and the DV. For instance, if one is interested in the relation between 'articles published and promotion' and runs a logistic regression with the DV 'promotion' (yes/no), the IV 'number of articles published', and several control variables, and one obtains an exponentiated beta coefficient for the IV of, say, 1.08, one may say 'each additional article published increases the odds of promotion by about 8% if other variables are controlled for' (NB: this is *not* the same as saying that the probability of promotion increases by 8%).

There are several tests test available to evaluate the statistical significance of the coefficients, of which we will use two. The first is the *Wald, or z, statistic*: $W_j^2=(\beta_j/SE_{Bj})^2$ (where β is the coefficient and SE its standard error) that has a χ^2 distribution and tells whether the β is significantly different from 0 (in which case the IV makes a significant contribution to the prediction of the outcome). If several IVs are used, each is evaluated as if it entered the equation last (i.e. the contribution made by each IV is assessed over and above that of other IVs.[159]

[158] 'Maximum likelihood' estimation is an iterative procedure that starts with arbitrary values of coefficients and determines the direction and size of change in the coefficients that will maximise the likelihood of obtaining the observed frequencies. Then the residuals are tested and another determination of directions and size of change in coefficients is made, and so on, until the coefficients change very little, i.e. converge.

[159] Several sources express doubt about the use of the Wald statistic. For instance, Menard (2002) pints out that when the absolute value of the regression coefficient is large, the estimated standard error tends too become to large, resulting in increased Type II errors, and making the test too conservative.

The second is the *likelihood-ratio test*, considered superior to the Wald statistic. This compares models with and without each IV. Each IV is evaluated by testing the improvement in model fit when that IV is added to the model or conversely, the decrease in model fit when that IV is removed. A significant value for an IV indicates that it contributes significantly to the prediction of the outcome (or that the model is significantly degraded if the IV is removed). We report the significance levels based on this likelihood-ratio test.

Turning now to the *comparison of different logistic regression models*, one can differentiate two main types. The first type concerns models that include more predictor variables sequentially (resulting in a comparison between incomplete and full models). The second type concerns models that include different predictor variables (resulting in a comparison of two full models).

To begin with the first type of comparison, in our analyses, we use *sequential logistic regression*. Although we are mainly interested in the relation between knowledge-related IVs and the outcome variables, as outlined before, we acknowledge that several other variables are likely to have an impact on the outcome. We therefore control for those factors in our base-line model. At the same time, from the extant literature on venture capital, it is not clear which other factors might be relevant in this context. Therefore, to shed additional light on this question, we develop models in a stepwise manner, adding sequentially blocks of context-, VC-, finance-, and venture-related factors. The final models then include the constant, the full set of control variables and the theoretical variables (proxies for VCs' knowledge). In this context, the sequential logistic regression process asks if a (block of) variable(s) that enters the model later adds significantly to the explanatory power of the model beyond the variables already included. Thus we wish to establish what impact knowledge-related factors have on syndication *when other factors are held constant.*

For this purpose, there are several tests to evaluate the *goodness-of-fit* between models. A common first step in any analysis is to ask if the IVs, as a group, contribute to the prediction of the outcome. This involves, for instance, a comparison between the constant-only and the full model. If no improvement is found, when all IVs are added, the IVs are unrelated to the outcome. For a candidate model (block), a *log-likelihood* is calculated, based on summing the probabilities associated with the predicted ($\hat{Y}_i$) and actual (Y_i) outcomes for each case:

$$\log-likelihood = \sum_{i=1}^{N} Y_i \ln \hat{Y}_i + (1 - \hat{Y}_i)$$

The log-likelihood statistic is analogous to the error sum of squares in multiple regression and as such is an indicator of how much unexplained information there is after the model has been fitted. Therefore, large values of this statistic indicate poorly fitting models; and, in general, as IVs are added/deleted, the log-likelihood decreases/increases. Then, the question in comparing models is: does the log-likelihood decrease/increase significantly with the addition/deletion of IV(s)? Two nested models (or two subsequent steps in the same model) are compared by computing the difference in their log-likelihoods and using a χ^2 *statistic* (analogous to the F-test for the linear regression sum of squares). In SPSS, rather than reporting the log-likelihood itself, the value is multiplied by –2 (also referred to as -2LL), because -2LL has an approximately chi-square distribution and so makes it possible to compare values against those expected by chance alone.

$$\chi^2 = -2[(\text{log - likelihood for bigger model}) - (\text{log - likelihood for smaller model})]$$

This is often also presented as:

$$\chi^2 = -2[LL(B) - LL(0)]$$

Here, a significant decrease in the log-likelihood (i.e. a significant increase in the predictive power of the model/step) results in a *significant value* for χ^2, indicating that the IVs, individually or as a set, reliably contribute to the prediction of the outcome category. Ideally, therefore, one would like to see a *non*-significant -2LL (indicating that the amount of unexplained data is minimal) and a highly significant (model/step) χ^2 statistic (indicating that the model including IVs is significantly better than the model without the IVs).

Another goodness-of-fit test compares either an incomplete model (some IVs) or the full model (all IVs) against the perfect (hypothetical) model (that would provide an exact fit of the expected to the observed frequencies, if only the right IVs were used. There are several goodness-of-fit statistics available for this purpose. One goodness-of-fit test produced in SPSS is the *Hosmer and Lemeshow's goodness-of-fit test* (*HL-test*). This statistic tests the hypothesis that the observed data are significantly different from the predicted values from the model. With these statistics a *non-significant* difference value (χ^2) is desired, indicating that the full or incomplete model adequately duplicates the observed frequencies at the various levels of outcomes. If the HL-test statistic is greater than .05, as we want for well-fitting models, we fail to reject the null hypothesis that there is no difference, implying that the model's estimates fit the data at an acceptable level. This does not mean that the model necessarily explains much of the variance in the DV, but it means only that however much or little it does explain is significant. As with other tests, as the sample size gets larger, the HL-test's power to detect differences from the null hypothesis improves.

Finally, it is also possible to evaluate the *overall strength of association* in a logistic regression model. For this purpose, a number of measures have been proposed in logistic regression as an analog to R^2 in multiple regression. Whilst all approximate R^2, none of them has the same variance interpretation as R^2. SPSS provides two measures in this context. First this is the *Cox and Snell R^2* (R^2_{CS}), which is based on log-likelihoods and takes into account the sample size

$$R^2_{CS} = 1 - \exp[-(\frac{2}{n}(LL(B) - LL(0)]$$

However, the R^2_{CS} cannot achieve a maximum value of 1. The *Nagelkerke R^2* (R^2_N) measure adjusts the R^2_{CS} so that a value of 1 can be achieved

$$R^2_N = \frac{R^2_{CS}}{R^2_{Max}}$$

where R^2_{CS} = 1-exp[2(n^{-1})LL(0)]

Turning now to another important aspect of the statistical method used for our examination of Hypothesis 1, although logistic regression requires much less *assumptions* to be met regarding the distributions of the data used than parametric tests such as multiple regression, several aspects are important nevertheless and therefore should be tested for.

When a goodness-of-fit test is used that compares observed with *expected frequencies* in cells formed by combinations of discrete variables, there a limit to logistic regression in that logistic regression analysis may have little power if expected frequencies are too small (Tabachnick & Fidell, 2001). Specifically, the expected frequencies for all pairs of discrete IVs must meet the 'chi-square' requirements; and all expected frequencies should be greater than one, and no more than 20% should be less than five. To test for this assumption, we use cross-tabs to check the adequacy of expected frequencies for all pairs of discrete IVs. The expected frequencies are calculated as: [(row total)(column total)]/(grand total). Whilst we do not report the findings of these tests in detail, it should be mentioned that none of the results show any expected frequencies smaller than one, and no more than 20% are less than five - indicating that this assumption is met for our logistic analyses.

Whilst logistic regression makes no assumptions about *linear relationships* among the IVs themselves, it assumes a linear relationship between continuous IVs and the logit transform of the DV. Furthermore, in logistic regression, multivariate normality and linearity among IVs may enhance power, because a linear relationship of IVs is used to form the exponent in the logistic regression function (Tabachnick & Fidell, 2001). When the assumption of linearity in the logits is violated, then logistic regression will underestimate the degree of relationship of the independent to the dependent variables, lacking power due to Type II errors). There are several graphical tests and statistical methods for testing this assumption, such as the *Box-Tidwell* approach. We use these methods, in unreported analyses, to test our key variables for linearity in their logits and find that several variables cause violations of this assumption. As a consequence, we try transformations of those variables and find some of them to reduce the violation of the linearity assumption. However, when running our main analyses both with the original and the transformed variables, the results don't differ substantially. Therefore, we report the untransformed variables, which are easier to interpret, for the main analyses.

As other regression methods too, also logistic regression is sensitive towards *outliers* or *extreme/influential cases*.[160] One or more of the cases may be very poorly predicted by the solution; a case that actually is in one category of outcome may show a high probability for being in another category. If there are enough cases like this, the model has a poor fit. In this context we take a two-step approach. First, in the pre-analytical/screening stage, we examine the original data for potential uni-/multivariate outliers. Second, in the analytical stage, we examine the residuals of each analysis for influential cases in the solution. Here, in unreported analyses, we examine our data for outliers and influential cases in the solution using standardized (z) residuals, leverage points, DFBeta, Cook's distance, and Mahalanobis distance. We find a number of cases with extreme values in some variables, but none seems implausible in light of other variables, and there is no reason to believe that those cases should not be

[160] As Gujarati (2003: 390) explains, 'an outlier is an observation that is much different (either very small or very large) in relation to the observations in the sample. More precisely, an outlier is an observation from a different population to that generating the remaining sample observations. The inclusion or exclusion of such an observation, especially if the sample size is small, can substantially alter the results...' Similarly, also Tabachnick and Fidell (2001: 66-67) point out, 'an outlier is a case with such an extreme value on one variable (a univariate outlier) or such a strange combination of scores on two or more variables (multivariate outlier) that they distort statistics ... and they lead to results that do not generalize except to another sample with the same kind of outlier'.

part of the overall population. As such, we follow Hair et al. (1998), who argue that, whilst there are many philosophies as to how to deal with outliers, outliers should be retained unless there is demonstrable proof that they are truly aberrant and not representative of any observations in the population. But if they do represent a segment of the population, they should be retained to ensure generalizability to the entire population - because there are always outliers in any population, and one must be careful not to trim the data set. We therefore decide to retain all 'outliers' for our main analyses. Nevertheless, we run our main models both with and without those cases included. Since the results don't differ qualitatively, we only report the findings of those analyses that include all cases for which we have information on all variables.

Logistic regression, like all varieties of multiple regression, is also sensitive to extremely high *correlations* among the IVs (Tabachnick & Fidell, 2001). Their impact is to reduce any IV's predictive power by the extent to which it is associated with the other IVs. As collinearity increases, the unique variance explained by each IV decreases and the shared prediction percentage rises. This further reduces R (as a measure of the multiple correlation); and it often also results in unstable values for the regression coefficients. In the pre-analytical/screening stage, high bivariate correlations that might cause multicollinearity or singularity can be identified in correlation matrices in form of high correlation coefficients between the two variables. Here, values of 0.8-0.9 are said to be critical. However, from this it is not possible to uncover *multicollinearity*. Therefore, it is essential to test for multicollinearity following a logistic regression analysis. SPSS does not have an option for producing collinearity diagnostics in logistic regression. However, we obtain statistics such as variance inflation factors (VIFs), tolerance values, condition indices / eigenvalues, and variance proportions by simply running a linear regression analysis using the same outcome and IVs (Field, 2000; Menard, 2002; Tabachnick & Fidell, 2001). Based on this we find several variables to be highly correlated – such as the venture-related control variables 'age' and 'development stage', but particularly between our theoretical variables. This leads us to simultaneously include only those control variables in our final analyses that are not highly correlated, and to run separate models for each of our theoretical variables (see section 'analytical approach' below).

Finally, it should also be mentioned that logistic regression assumes that *responses of different cases are independent* of each other. That is, it is assumed that each response comes from a different, unrelated case. Thus, logistic regression is basically a between-subjects strategy. But if multiple observations are made of the same individuals at different time points (e.g. before and after some treatment), the assumption of independent observations is violated; and the estimated standard errors can lead to incorrect inferences (Tabachnick & Fidell, 2001). This assumption is likely to present the most serious problem to our main examination of Hypothesis 1 since this analysis, to a certain extent, also includes observations of the same units of analysis (investments) investing in several rounds of the same venture and/or in different ventures. In the following section we also explain how we deal with this issue.

F.IV.2.b) Analytical approach

From the above, two potentially problematic issues emerged for our analysis: the high correlation between (most of) our theoretical, and the non-independence of (some of) our observations (for a general discussion of the latter issue, see also Chapter E.a on 'sampling and data'). In the following we explain how our analytical approach aims to address these two aspects.

We address the issue of multicollinearity amongst our theoretical variables, by running separate analyses, which comprise the same baseline models (control variables) and use the same units of analysis (investments for which we have information on all examined variables) but include only one of the theoretical variables at a time. This both circumvents the problem of multicollinearity and allows us to examine our hypothesis (that the negative relation between VCs' knowledge and VCs' propensity to syndicate is the more pronounced the more specific the knowledge/proxy is) by comparing both the coefficients of the individual theoretical variables and the overall predictive power of the different models based on those theoretical variables.

Regarding the second issue, the non-independence of (some of) our observations, in our main analysis the units of analysis are the investments made by all VC in all ventures in our sample. However, if a VC in our sample has made several investments (in several rounds of the same venture or in different ventures) he will enter our analysis several times whilst a VC who has made only one single investment will enter our analysis only once. Similarly, also a venture that has received several investments by VCs in one round and/or in several rounds enters our analysis several times. In this context, one might argue - and several econometricians support this line of reasoning - that the observations (investments) are 'almost' independent since the VCs and the ventures will change over time (i.e. between investments).[161] Nevertheless, one can argue that our observations are not fully independent - violating one of the assumptions underlying logistic regression. If this were the case, some factors related to the VCs and/or ventures that enter our analysis several times but are outside our control might unduly affect our findings. For instance, it might be that a VC firm has a general investment policy to syndicate, or not to syndicate - independent of his knowledge. To assess the potential bias, and to check the robustness of our findings from the main analysis, we therefore conduct two extra analyses on subsamples only.

First, we conduct an analysis using only the first investments by the same VC in the same venture (which is not necessarily identical to first round investments in those ventures). This considerably reduces the number of multiple entries by the same investors and the same ventures in the analysis. Specifically, in this analysis, each VC enters only once in combination with the same venture. However, some VCs (and some ventures) might still enter the analysis several times, for instance, because the same VCs might make several first investments in different ventures, and because the same ventures might receive several first investments by different VCs.

Therefore, we conduct another analysis using only the last investment ever made by a VC during our sampling period. This approach completely eliminates the possible problems resulting from multiple entries by the same VC into our analysis as each VC can only have one last investment. Whilst also this approach does not fully eliminate the potential problem of multiple entries by the same venture in our analysis (since several VC might have their last investment in the same venture), we believe this is less of a problem since it is the VC who makes the decision whether to syndicate or not, and venture-related factors are likely to be only one group of factors with potential influence on this decision (which we control for to some degree).

We are aware that also the above two checks of robustness might entail certain problems, such as a sample selection bias when analysing only first or last investments. But we nevertheless consider this a reasonable approach to develop a feeling for the potential bias in our main analysis.

[161] For instance, over time, a VC will have acquired additional knowledge and/or a venture might have developed from a start-up stage to a later stage in its development.

Together, the above results in a total of 15 models (from 1-1 to 3-5) that differ in the theoretical variable and in the observations included in the analysis, as depicted in Table F-2 below.

Table F-2: Overview over the different models analysed in the context of Hypothesis 1

	Observations included in analysis		
Dependent variable: syndicated investment yes/no	**All investments**	**First investment by VC in focal venture**	**Last investment by VC in any venture**
Control variables:	Model 1(i-iv)	Model 2(i-iv)	Model 3(i-iv)
Theoretical variables:			
VC age	Model 1-1	Model 2-1	Model 3-1
VC non-biotech experience	Model 1-2	Model 2-2	Model 3-2
VC total experience	Model 1-3	Model 2-3	Model 3-3
VC biotech expertise	Model 1-4	Model 2-4	Model 3-4
VC biotech-stage expertise	Model 1-5	Model 2-5	Model 3-5

F.V. Results

This section first presents the descriptive statistics and regression results, and then summarizes and discusses the findings.

F.V.1. Descriptive statistics

In the following, we provide an overview over the descriptive statistics and correlations of the variables used for examining Hypothesis 1. Here, we focus only on those variables used in the main analyses (i.e. on models 1-1 to 1-5 in Table F-2 above, but not on our additional analyses in models 2-1 to 3-5, which mainly serve to test the robustness of the findings from the main analysis), and Panel A shows the descriptive statistics for all investments whilst Panels B and C show the summary statistics for syndicated and unsyndicated investments, respectively.

We also refer the reader to our Chapter E, which provides an exploratory overview over the development of the key variables for Hypothesis 1 over time. However, it should be noted that in the exploratory analysis before we used all observations for which information was available on a particular variable; but in the present analysis we only use observations for which we have information on all examined variables. The latter also explains why the sample size used for our analysis (N=9,560) is considerably smaller than the total number of investments (N=14,730) in the raw data used for our exploratory analysis.

The descriptive statistics for our analysis are shown in Table F-3 below.

*** INSERT TABLE F-3 HERE ***

A number of observations are noteworthy with view to Table F-3 (Panels A-C).

The vast majority of investments (about 86% of the total) were syndicated.

The time period during which the investments in our sample took place was characterized by a substantial expansion in the private equity markets in general, and also in biotechnology. This is visible, for instance, from the average annual percentage changes in the number of VCs investing venture capital (+12% p.a.), the number of biotech ventures receiving venture capital (+16% p.a.), and the amount of venture capital raised (+22% p.a.). Much of this expansion, furthermore, occurred in a five-year window within the overall sampling frame of more than 30 years: more than one third of the investments in our sample occurred during the boom period from 1996 to 2000.

Turning now to the investors in our sample, more than 70% of the firms are 'VCs in a narrow sense', i.e. independent limited partnerships; and they are geographically concentrated: more than 80% come from the US. Overall, the VCs seem to be familiar with syndication, since, on average, 75% of their previous deals were syndicated. However, comparing Panel B and C, it seems that syndication is habitual: a VCs' propensity to syndicate in the past is positively correlated with their propensity to syndicate a new investment - at least when it comes to investments in the biotechnology sector. To be specific, those VCs that do syndicate a new investment have syndicated about three quarters of their previous biotech investments, whilst those VCs that do not syndicate a new investment have 'only' syndicated about two thirds of their previous biotech investments.

Most obvious however, are the differences between unsyndicated and syndicated investments when it comes to the finance related control variables. Whilst the average deal size is more than $9Mio (median: $4.9Mio), it is striking that the total deal sizes, on average, are about five times as large in case of syndicated investments than in case of unsyndicated investments; and comparing the median values, the syndicated deals are even 12 times as large as the unsyndicated deals.[162] However, it should also be noted that there is a great variance in sizes of both syndicated and unsyndicated deals, where the range is from $0.01Mio to $150Mio for the former, and $0.01Mio to $76.7Mio for the

[162] This finding is consistent with the financial motive for syndication discussed above that argues for syndication as a means of reducing capital constraints and risk. Under those circumstances we should expect the average size of investment made by a VC as part of a syndicate to be lower than those made on a lone investor basis.

latter. At the same time, it is also noteworthy that the ratios of the current deal size to the VCs' average previous investment sizes in biotechnology, on average, is about five times higher in case of syndicated investments than in case of unsyndicated investments; and about 10 times higher when looking at the median values.[163] Together, these results seem to point towards a major role of finance related aspects (risk-reduction and/or resource-limitation motives) when it comes to syndicate, or not, an investment.

With view to the venture-related control variables, overall, about one fifth of the investments in our sample involve first round investments - although this proportion seems higher, at almost one third, in case of unsyndicated investments. Ceteris paribus, therefore, first round investments are less likely to be syndicated. This is consistent with the idea of a lead investor wishing to gain control of a business cheaply by investing substantially early on. This motive may outweigh the risk reduction motive discussed earlier.

As regards another source of risk, the stage of the venture, slightly more than half of the investments in our sample involve start-up, seed, or early-stage investments. This proportion is moreover more significantly higher for unsyndicated investments. In other words, on this measure, unsyndicated investments are often more risky than syndicated ones.

Even more pronounced are the differences between the two groups when it comes to another source of risk: first investments in a firm by a VC. The data show that a VC's propensity to syndicate an investment is visibly higher (ca. 51%) when he hasn't invested in a venture before than when he already had a chance to learn about the venture by investing previously in it (ca. 45%). The risk-reduction motive for syndication is clearly consistent with the data in this case.

It is not too surprising and borne out in the data that most VCs (ca. 88%) syndicate 'locally' (i.e. in their own country).[164] However, whilst foreign investments might seem to be more risky than home-country ones, the data

[163] This is again consistent with the idea that a high marginal investment size relative to the average presents the VC with either a capital constraint or with a problem of excess risk.

[164] In this context two facts should be kept in mind. First, our sample is clearly dominated by U.S. ventures and VCs; and, second, our control variable for differences in the VCs' and ventures' nation of origin is rather crude in that it only considers different nations but not the actual geographic distance between venture and VC- although the latter might well be relevant, for instance, in case of a VC from the American east cost investing in a venture from the American west cost.

shows that it makes no difference for the VCs' propensity to syndicate whether or not the target venture is from the same country as the VC.[165]

Finally, turning to what is in the focus of our interest, the various proxies for VCs' knowledge, several results are worth noting.

To begin with, the typical VC investor was a reasonably seasoned at investment in the period in question, being about 11 years old and having made more than 122 investments overall.[166] However, it is also obvious that for the typical VC biotechnology is a minor interest: the VCs' in our sample in fact made the vast majority (85%) of their investments outside biotechnology. Thus, on average, less than 15% of their total experience (i.e. total number of previous investments) is related to biotechnology; and, on average, VCs have made less than 24 (median: 9) investments in biotech ventures overall, with less than six (median: 2) investments in biotech ventures at the same development stage. Intuitively, this suggests that the VCs making these investments, although generally very experienced, did not really have much relevant experience to go on when making biotech investments.

Despite this, some VCs in our sample have considerable biotechnology experience, with a maximum of 378 previous investments in this sector. Particularly interesting for our project, however, is a comparison of the VCs' knowledge between syndicated and unsyndicated investments. Here, among the knowledge proxies we consider only the VCs' age is higher (ca. 8%) in case of syndicated investments; the opposite is true for all other knowledge proxies, which, on average, are higher in case of unsyndicated investments (non-biotech experience: ca. 5%, total experience: ca. 8%, biotech expertise: ca. 24%, and biotech-stage expertise: ca. 17%). This is consistent with the resource-based theory of VC: VCs with experience tend to prefer to go it alone and keep the extra profits; novice investors by contrast prefer to syndicate and learn even though (cet. par.) they lose expected returns by so doing.

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[165] This may of course arise for a different reason, consistent with risk reduction, namely shortage of partners in a foreign country. A test of this would of course be whether VCs that had long been established in a foreign country were more likely to syndicate than those new to it.

[166] Once more, as the standard deviations show, this average figure again conceals a great deal of variation.

F.V.2. Regression results

In the following we describe the results of our logistic regression analyses testing Hypothesis 1. Our focus is on the main analysis (see Table F-4, Panel A), covering all investments in our sample for which information is available on all variables used in the analysis. However, we also briefly summarize the results of additional analyses on subsamples conducted as robustness checks for the findings from the main analysis. These consist of analyses of first and last investments, depicted in Panels B and C.

F.V.2.a) Main analysis

For our main analysis, as discussed above, we develop the statistical model in a stepwise manner, adding sequentially four blocks of control variables, namely context-, VC-, finance-, and venture-related variables (Panel A, baseline models 1-i to 1-iv). Then, in parallel models, we add our five theoretical variables (the different proxies for VC knowledge, models 1-1 to 1-5).

*** INSERT TABLE F-4, PANEL A, HERE ***

F.V.2.a.i. Baseline-model

Block i: Context-related control variables

The inclusion of context-related control variables in the baseline model (1-i) results in a significant improvement over the initial model that only includes the constant (block-chi-square: $p<.05$). However, the overall explanatory power of the model is very low, as indicated by both the R_{CS}^2 (<1%) and the R_N^2 (<1%). Also, the HL-test (Hosmer and Lemeshow test) indicates that the observed data are highly significantly ($p<.000$) different from the values predicted by the model.

With view to the individual context-related variables/coefficients, we note that the annual *change in the number of investors providing venture capital* is not significantly related to the VCs' propensity to syndicate investments (short: syndication) in any of the models. In contrast, the annual *change in the number of biotech ventures receiving venture capital* is highly significantly and positively related to syndication throughout all models. In other words, our finding suggests that the faster the growth in the biotech investment activity in the economy the greater the tendency to syndicate a given investment. Looking at the financial aspect of this, we note that the annual *change in the total amount of venture capital raised* is only significantly and negatively related to syndication in the baseline models i and ii; but it becomes insignificant in all subsequent models that include further control variables and/or the theoretical variable(s). The opposite is the case for the dummy variable for *investments in the years 1996-2000*, which is significantly negatively related to syndication in all but the first two baseline models. Thus it is the growth in the aggregate numbers of biotech investments that matters for syndication rather than the growth in the funds available.

Block ii: VC-related control variables

The inclusion of VC-related control variables in the baseline model (1-ii) results in a highly significant improvement over both the initial model (model-chi-square: p<.000) and the previous block of the baseline model (block-chi-square: p<.000). However, the additional inclusion of VC-related factors only reduces the -2LL by about 2% compared to the previous baseline model; and the overall fit of the model is still very low, as indicated by the R_{CS}^2 (2%) and the R_N^2 (4%). Also, the HL-test indicates that the observed data are highly significantly (p<.000) different from the values predicted by the model.

With view to the individual VC-related variables/coefficients, the dummy variable for *true private equity partnership investors* is significantly negatively related to syndication in the baseline models 1-iii and 1-iv as well as in the main models 1-1 and 1-2. Its negative sign remains but now registering insignificantly in the remaining models. In contrast, the dummy variable for *investors from the US* is only significantly and positively related to syndication in baseline model 1-iii and main model 1-3. The proportion of *previous investments by a VC that were syndicated*, finally, is highly significantly and positively related to syndication throughout all models containing this variable. VCs that have syndicated in the past are more likely to syndicate in the future.

Block iii: Finance-related control variables

The inclusion of the two finance-related control variables in the baseline model (1-iii) results in a dramatic and significant improvement over both the initial model (model-chi-square: p<.000) and the previous baseline model (block-chi-square: p<.000). In fact, with about 21% change over the previous baseline model, the additional inclusion of finance-related control variables leads to the greatest reduction in the -2LL of any of the examined blocks of variables. This is also reflected in the drastic increase in both the R_{CS}^2 and the R_N^2 to about 17% and 31%, respectively. Nevertheless, the HL-test indicates that the observed data are still very different (p<.000) from the values predicted by the model.

With view to the individual finance-related variables/coefficients both the total *round-amount* and the *relative deal size* (marginal to average) are highly significantly and positively related to syndication throughout all models, but the former consistently shows slightly higher values for the exponentiated beta. This finding is consistent with capital constraints and risk reduction motives for syndication.

Block iv: Venture-related control variables

The inclusion of venture-related control variables in the baseline model (1-iv) results in a further highly significant improvement over both the initial model (model-chi-square: p<.000) and the previous baseline model (block-chi-square: p<.000). However, the additional inclusion of venture-related factors hardly reduces the -2LL compared to the previous baseline model. Similarly, both the R_{CS}^2 and the R_N^2 show only a marginal improvement over the previous model, each increasing only by about 1% to, 18% and 32% respectively. Consequently, also the HL-test still indicates that the observed data are highly significantly (p<.000) different from the values predicted by the model.

With view to the individual venture-related variables/coefficients, all of them show a consistent pattern in their significances and signs throughout all models. The dummy variable for *first round investments* indicates a highly significant negative relation to syndication throughout all models. This is consistent with the idea of a lead investor going it alone to gain control of a company on first rounds, holding stage of investment constant. In fact, the exponentiated beta for this variable shows the strongest negative relation to syndication of all variables tested in any of the models, suggesting that in first round investments the likelihood to syndicate is only half that of investment in later rounds. In direct contrast, the dummy variable for *investments in start-up/seed/early-stage ventures* shows a highly significant positive relation to syndication, which seems to be stronger than that of any other examined variable. This is consistent with the risk-reduction motive of syndication discussed above. Similarly, also the dummy variable for *first investments by VCs in a focal venture* is highly significantly and positively related to syndication; and it shows the second strongest positive relation of any of the examined variables. This is inconsistent with risk reduction but consistent with the idea of gaining control by the lead VC by getting a substantial share at the outset. Finally, the dummy variable indicating that *VC and venture are from different nations*, shows no significant relation to syndication at all.

F.V.2.a.ii. Theoretical variables

Turning now to what is in the focus of our interest, in the following, we separately describe the findings for the models that examine the impact of the theoretical variables – the various proxies for VCs' knowledge – on the likelihood of VCs to syndicate investments over and above the full baseline model (1-iv).

VC age

The inclusion of VC age as an theoretical variable to proxy for VCs' knowledge (model 1-1), results in a significant improvement over the initial model (model-chi-square: p<.000), but does not result in a significant improvement over the full baseline model (block-chi-square: p>.1). Furthermore, the inclusion of VC age hardly reduces the -2LL compared to the full baseline model. Also, it does not change the R_{CS}^2 and the R_N^2 compared to the previous model, which both remain constant at 18% and 32%, respectively. Consequently, also the HL-test still indicates that the observed data are highly significantly (p<.000) different from the values predicted by the model.

With view to the coefficient of the theoretical variable, the relation between VC age and syndication is only marginally significant (p<.1) and negative; and the value of the exponentiated beta suggests only a very small impact of VC age on syndication.

VC non-biotech experience

The inclusion of VC non-biotech experience as an theoretical variable (model 1-2), does result in a highly significant improvement over both the initial model (model-chi-square: p<.000) and the full baseline model (block-chi-square: p<.01). However, the inclusion of VC non-biotech experience hardly reduces the -2LL compared to the previous baseline model. Furthermore, it does not change the R_{CS}^2 and the R_N^2 compared to the previous model, which both remain constant at 18% and 32%, respectively. Consequently, also the HL-test still indicates that the observed data are highly significantly (p<.000) different from the values predicted by the model.

With view to the coefficient of the theoretical variable, the relation between VC non-biotech experience and syndication is highly significant (p<.000) and negative - although the value of the exponentiated beta still suggests only a very small impact of VC non-biotech experience on syndication.

VC total experience

The inclusion of VC total experience as an theoretical variable (model 1-3), result in a highly significant improvement over both the initial model (model-chi-square: $p<.000$) and the full baseline model (block-chi-square: $p<.000$). However, also the inclusion of VC non-biotech experience hardly reduces the -2LL compared to the full baseline model; and it does not change the R_{CS}^2 compared to the baseline model (18%) and it only marginally changes the R_N^2 by 1% to 33%. Consequently, also the HL-test still indicates that the observed data are highly significantly ($p<.000$) different from the values predicted by the model.

With view to the coefficient of the theoretical variable, the relation between VC total experience and syndication is highly significant ($p<.000$) and negative - although the value of the exponentiated beta still suggests only a very small impact of VC non-biotech experience on syndication.

VC biotech expertise

The inclusion of VC biotech expertise as an theoretical variable (model 1-4), results in a highly significant improvement over both the initial model (model-chi-square: $p<.000$) the full baseline model (block-chi-square: $p<.000$). However, also the inclusion of VC biotech expertise hardly reduces the -2LL compared to the previous baseline model. Furthermore, compared to the baseline model, it does not change the R_{CS}^2 (18%), and it only marginally changes the R_N^2 by 1% to 33%. Consequently, also the HL-test still indicates that the observed data are highly significantly ($p<.000$) different from the values predicted by the model.

With view to the coefficient of the theoretical variable, the relation between VC biotech expertise and syndication is highly significant ($p<.000$) and negative; and although the value of the exponentiated beta still suggests only a very small impact of VC non-biotech experience on syndication, this impact seems stronger than that of the previous knowledge proxies.

VC biotech-stage expertise

The inclusion of VC biotech-stage experience as an theoretical variable (model 1-5), results in a highly significant improvement over both the initial model (model-chi-square: $p<.000$) the full baseline model (block-chi-square: $p<.000$). Compared to the other examined knowledge proxies, this variable leads to the greatest reduction in the -2LL compared to the previous baseline model, although still only by about 3%. Furthermore, compared to the baseline model, it does not change the R_{CS}^2, which remains at 18%, and it does only marginally change the R_N^2 by 1% to 33%. Consequently, also the HL-test still indicates that the observed data are highly significantly (p<.000) different from the values predicted by the model.

With view to the coefficient of the theoretical variable, the relation between VC biotech-stage expertise and syndication is highly significant (p<.000) and negative; and although the value of the exponentiated beta suggests only a small impact of VC non-biotech experience on syndication, this impact nevertheless seems stronger than that of the previous knowledge proxies.

F.V.2.b) Additional analyses

As mentioned before, one possible criticism regarding our above findings, which are based on the inclusion (pooling) of all investments in our sample, results from the fact that some of the observations might not be fully independent. Specifically, some VCs (and also some ventures) enter our analysis several times. At least in theory, this might impact our findings because some factors that are related to VCs (or ventures) but that we cannot control for might impact the VCs' decision to syndicate an investment.

One preliminary method to test the robustness of our findings, therefore, consists in analyses that only use sub-samples, in which the possible problems resulting from the non-independence between some observations are reduced. In this context, we conduct two additional analyses that only use first investments by a focal VC in a venture (Panel B), and last investments by a focal VC (Panel C), respectively. Of these two analyses, the later seems particularly relevant with respect to the potential problem of non-independence between some observations because here each VC can enter the analysis only once – since he can only have made one last investment.

The results of these two analyses are described in the following two sections, where we focus only on noteworthy deviations from the above-described findings of our main analysis.

F.V.2.b.i. First investment by a VC in focal venture

*** INSERT TABLE F-4, PANEL B, HERE ***

Overall model parameter

Comparing, in Table F-4, the model summaries in Panel A (all investments) with those in Panel B (first investment by a VC in a venture), one finds only relatively small changes in most model parameters – despite the fact that the overall sample size for the analysis on first investments by VCs in a venture is only about half that of the analysis that includes all investments. For instance, the results of the test of block/step/model coefficients seem to follow a similar pattern in both analyses. The baseline model experiences the greatest proportional rise in its predictive power when including the finance-related control variables; the inclusion of VC age does not result in a significant increase; but all other knowledge proxies result in a (sometimes: highly) significant increase in the predictive power of the models. Also, the –2 Log likelihood, the R_{CS}^2 and the R_N^2 seem to follow similar patterns when adding new (blocks of) variables into the analyses. The former measure (-2LL) only decreases visibly when including the finance-related control variables, but remains relatively stable over all subsequent models. Similarly, the two later measures (R_{CS}^2 and R_N^2) are close to zero in the first two baseline models; they experience a dramatic rise to 14% and 25%, respectively, when including finance-related control variables; but they only change marginally by 1-2% when including any further variables. Finally, similar to what has been found in the main analysis, the HL-test suggests that the outcome values predicted by all models are highly significantly different from those observed.

Individual coefficients/variables

Comparing, in Table F-4, Panel A (all investments) and Panel B (first investments), it is evident that in the analysis that only includes the first investments by VCs in a venture, several control variables that were significantly related to syndication in the analysis that included all investments now are insignificant. This mainly affects the context- and the VC-related factors, but not the finance- and venture related control variables. At the same time, it is also worth mentioning that, overall, the signs of the coefficients in the baseline model do not seem to change between the model that includes all investments and the model that only includes first investments by VCs. With view to the theoretical variables, finally, the patterns in the sign and significance of their coefficients are very similar in Panels A and B. Specifically, in the analysis that only includes first investments by VCs in a venture, the VC age is negatively but not significantly related to syndication; but all other knowledge proxies are highly significant and negatively related to syndication. Although the magnitudes of the negative relations (exponentiated betas) between those knowledge proxies and syndication are similarly small as they were in the main analysis, the overall pattern is the same: it rises from VCs' non-biotech experience, over VCs' total experience and VCs' biotech expertise, to VCs' biotech-stage expertise.

F.V.2.b.ii. Last investment by a VC

*** INSERT TABLE F-4, PANEL C, HERE ***

Overall model parameter

Comparing, in Table F-4, the model summaries in Panel A (all investments) and Panel C (last investments by each VC in any venture), one again finds only relatively small changes in most model parameters - despite the fact that the overall sample size for the analysis on the last investments by each VC is only about one ninth that of the analysis that includes all investments. For instance, the results of the test of the block/step/model coefficients seem to follow a similar pattern in both analyses. Also in the analysis of last investments only, the baseline model experiences the greatest proportional rise in predictive power when including the finance-related control variables. However, in the analysis of last investments only, the inclusion of VC age does result in a significant increase in block and model chi-square. This is in contrast to the analysis of first round investments (Panel B), but in line with the analysis of all investments (Panel A). Also in line with the main analysis, the inclusion of all other knowledge proxies results in a highly significant increase in the predictive power of the models. Furthermore, also the -2LL, the R_{CS}^2, and the R_N^2 seem to follow similar patterns when adding new (blocks of) variables into the analyses. The former measure (-2LL) only decreases visibly when including the finance-related control variables, but remains relatively stable over all subsequent models. Similarly, the two later measures, are close to zero in the first two baseline models, experience a dramatic rise to 16% and 28%, respectively, when including finance-related control variables, but only change slightly (by 2-3%) when including any further variables. Finally, the HL-test again suggests that, similar to what has been found in the main analysis on all investments, the values predicted by all models are highly significantly different from those observed.

Individual coefficients/variables

Comparing, in Table F-4, Panel A and C, it is evident that in the analysis that only includes the last investments by each VC, the signs of all coefficients remain unchanged. However, fewer of these coefficients remain statistically significant. For instance, none of the context-related variables, and only one of the VC-related variables (ratio of previously syndicated investments) remains significant. Of the venture-related control variables, first round investments remain negatively related to syndication, but less significant than in the pervious two analyses. Furthermore, whilst there is hardly any difference with view to start-up/seed/early-stage investments (highly/significantly) positively related to syndication, the dummy variable for first investments by VCs in a focal venture, contrary to the main analysis, now is insignificantly (also still positively) related to syndication (note: although this analysis uses only the last investments by each VC, in some cases - when the VC has made only one singly investment in our sample - this is simultaneously his first investment). With view to the theoretical variables, finally, the patterns in the sign and significance of their coefficients are again very similar to those in the main analysis that included all investments. Specifically, the VC age again is significantly (but not highly significantly) negatively related to syndication, but all other knowledge proxies are highly significant and negatively related to syndication. Furthermore, although the magnitudes of the negative relations (exponentiated betas) between the knowledge proxies and syndication are again very small, the overall pattern is the same: it rises from VCs' non-biotech experience, over VCs' total experience and VCs' biotech expertise, to VCs' biotech-stage expertise.

Finally, it should also be mentioned that we conducted a number of additional, unreported analyses that were based on smaller sub-samples of VCs and/or ventures, but that essentially showed similar results with respect to the relation between VC knowledge and syndication as those analyses described above.[167]/[168]

[167] In this context it should also be again referred to unreported preliminary analyses that were based on sub-samples of ventures for which we had information about patents. Since we only have patent-information for about 30% of the ventures in our sample (i.e. for about 50% of the investments), we decided not to include this variable in our main analysis, as it would have reduced our sample size even further. However, it is worth mentioning that our analyses on this smaller sub-sample essentially showed the same findings with respect to the relation between VC knowledge and syndication. This relation was negative independent of the knowledge proxy used; it was non-significant for VCs' age; and it was the stronger the more specialized the knowledge proxy was (i.e. the magnitude of the negative relation rose from VC non-biotech experience, over VC total experience, to VC biotech expertise, and VC biotech-stage expertise. Again, this seems to confirm our assertion that our results regarding the theoretical variable(s) are robust across different samples.

[168] In additional unreported analyses, which did not include 'outliers/influential cases in the solution' of the original main analysis, we 'managed' to raise the R_N^2 to close to 50%. But, as explained further above, we opted not to focus on those results because a closer inspection of the outlier/influential cases provided no reason to believe that those cases were not part of the overall population. In addition, Tabachnik and Fidell (2001) also note that a statistically significant difference between a fitted model and the observed frequencies (representing the perfect model) may not indicate a poor model with large samples. Therefore, when interpreting the results, one has to keep

F.VI. Summary and discussion

F.VI.1. Findings in the light of the hypothesis

Summarizing the above findings, our Hypothesis 1 is supported: controlling for various context-, VC-, finance-, and venture-related factors, we find a negative relation between all examined proxies for a VC's knowledge and his likelihood to syndicate an investment. Furthermore, the results also support our assertion that this negative relation is the more pronounced the more specialized (the better matched) the VC's knowledge is to the current opportunity. In other words, the deeper and more relevant a VC's past experience to his current investment opportunity, the lower the chances he will syndicate with others.

This proposition is evident examining both the overall model fit and the individual coefficients, although both have to be interpreted with some caution.

To begin with the (change in the) model/block/step parameters, they provide support for our Hypothesis 1. In our main analysis (of all investments), the inclusion of each proxy for VC knowledge – with the exception of VC age - results in a highly significant change compared to the baseline model in the step/block chi-square, as well as in an increase in the R_{CS}^2 and R_N^2, whilst the -2LL decreases. This suggests a greater predictive power of the models that use more specialized knowledge proxies.

At the same time however, it should be noted that our large sample size is likely to produce significant coefficients even if it has no practical importance (Tabachnick & Fidell, 2001). Thus it is important to examine the *quantitative* importance of VC knowledge in syndication as well as its correlation with syndication activity. Furthermore, we are aware that the explanatory power and predictive ability even of the best models we have estimated is limited. For instance, the maximum R_N^2 is still less than 33%; and the HL-tests consistently show highly significant deviations between the observed values and those predicted by our models. However, it should be mentioned that these measures of fit are based on 'unexpurgated' samples and so if anything understate the explanatory and predictive power of the models.

In this context, it must also be mentioned that the addition of our theoretical variables to the baseline model has a much smaller impact on the model

in mind both the effects of sample size (big: more likely to find significance) and the way the test works (good fit: significant improvement).

parameters than the addition of some other (blocks of) control variables to the baseline model. Although we will not discuss the findings regarding the baseline model in detail (because, as noted above, our focus is on the role of VCs' knowledge as a motive for syndication), it is noteworthy that by far the largest change in the model parameters is caused by the inclusion of finance-related control variables, suggesting that these factors are much better in explaining the syndication of an investment. Our findings here are also novel: we find for example that the marginal investment size plays a significant role in addition to the absolute size of the investment that is traditional in the literature.

In sum, we clearly have to interpret our results regarding the impact of VCs' knowledge with some caution. From a practical perspective, the additional explanatory power of VCs' knowledge on their syndication behaviour clearly seems quantitatively small, and certainly smaller than the impact of some other factors included in our baseline model.

Nevertheless, overall, our findings consistently support the hypothesis of a negative relation between VC knowledge and syndication. Furthermore, similar results are also to be found in the additional analyses that use only sub-samples, where the potential problems of non-independence between observations from some (same) VCs are either significantly reduced (analysis on first investments by each VC in a venture) or even completely eliminated (analysis on last investments by each VC). This suggests that our findings are robust with respect to the assumptions of the statistical model estimated.

Our Hypothesis 1 is also supported when looking at the coefficients (exponentiated beta) and significances of the examined theoretical variables. For instance, in our main analysis of all investments, the VC's age – arguably the most general proxy for a VC's knowledge – is only marginally significantly negatively related to syndication, as predicted by our theory. All other knowledge proxies, however, are highly significantly negatively related to syndication; and within those proxies the magnitude of the negative relation increases (i.e. exponentiated beta decreases) from non-biotech experience, over total experience, to biotech expertise, and biotech-stage expertise. This confirms the second part of the Hypothesis that what really counts in the syndication decision is the match of experience to that required by current opportunities.

At the same time though, with view to the individual variable coefficients, we acknowledge that the magnitude (exponentiated betas) of the relation between our theoretical variables (the various proxies for VC knowledge) and syndication is very small, and sometimes even considerably smaller than that of the relation between several control variables and syndication. For instance, in our full model (1-5), a one unit change in the VC's biotech-stage expertise (i.e. one additional prior investment by the VC in a biotech venture of the same stage as the one under consideration) only decreases the odds of the VC syndicating this investment by about 1.9%. In contrast, if the investment involves a first round, this decreases the odds of the VC syndicating this investment by more than 40%; and a if the investment involves an early-stage venture, this increases the odds of the investment being syndicated by more than 90%. Also a one-unit change in the total 'round amount' (i.e. one extra $Mio invested in a venture) increases the odds of the investment being syndicated by 14%. Again, this suggests a substantially greater significance of venture- and/or finance-related aspects than of knowledge related aspects as motives for syndication.

However with view to the relative small magnitude (exponentiated betas) of the relation between our (independent) variables and syndication, one might argue that part of the reason might be that our sample shows a very unequal distribution of the dichotomous outcome variable. For instance, in our main analysis, only about 14% of the observations stem from unsyndicated investments. In this context, Tabachnick and Fidell (2001) point out, sample correlations may be lower than populations when there is restricted range in sampling of cases or very uneven split in the categories of dichotomous variables ('deflated correlations'). The correlation between a continuous variable and a dichotomous variable, or between two dichotomous variables (unless they have the same peculiar split), is too low if most (e.g. over 90%) responses to the dichotomous variable fall into one category. Then, even if the continuous and dichotomous variables are strongly related in the population, the highest correlation that could be obtained is well below 1. In those situations, some recommend dividing the obtained (but deflated) correlation by the maximum it could achieve given the split between the categories and then using the resulting value in subsequent analyses. However, as Tabachnick and Fidell (2001) point out, whilst this procedure is attractive, it is not without hazard. We therefore accept the relatively low correlations but point out that they may (also) be due to the above described problem of uneven split between the categories.

Finally, also the fact that the coefficients of our theoretical variables keep their signs and – with the exception of VC age in the additional analysis of first investments by a VC in a venture – remain at least significantly negatively related to syndication across the different analyses (whilst several control variables loose their significance from the baseline to subsequent models) seems to provide further support for the reliability of our findings.

F.VI.2. Findings in the light of the literature

In the following, we relate our findings to the existing theoretical and empirical literature - first with a view to the main findings of our study regarding the role of VCs' knowledge as a motive for syndication, and then with a view to additional findings from our study.

Main findings

Overall, our finding that a VC's knowledge has an impact on his syndication decision can be seen as providing further support for the existing literature, both theoretical and empirical, which suggests a role for knowledge-related factors in motivating VCs' syndication behaviour (e.g. Barry et al., 1990; Brander et al., 2002; Bygrave, 1987, 1988; Hopp & Rieder, 2004; Lerner, 1994; Lockett & Wright, 1999; Manigart et al., 2004; Seppa & Jaaskelainen, 2002; Sorenson & Stuart, 2001; Valliere & Peterson, 2004).

For example, our study can be understood as providing further, but 'negative', support for the resource-exchange model by Pfeffer and Salancik (1978). According to this model, Bygrave (1987, 1988) explains, syndication can be an important means to deal with (knowledge) resource constraints and uncertainty. Thus, our finding of a negative relation between a VC's knowledge and his propensity to syndicate might arise from a more knowledgeable VC perceiving less (knowledge) resource constraints and uncertainty than his 'ignorant peers', making him less inclined to collaborate with what in fact are competitors.

In a similar vein, one might also understand our results as providing 'negative' support for some of the general empirical literature on inter-organizational collaboration, which finds that collaboration serves - as a vehicle for organizational learning - to gain access to complementary skills and assets (e.g. Kogut, 1988b; Kogut et al., 1995; Mitchell & Singh, 1992; Dodgson, 1993; Dyer, 2000; Gulati, 1998; Hagedoorn, 1993; Hamel & Prahalad, 1990; Teece, 1988).

However, relating the findings from our study directly to the empirical literature on syndication in the venture capital context is more difficult. This is because previous studies either do not directly focus on VCs' propensity to syndicate or they measure VCs' knowledge in different, arguably inferior, ways (see Table F-1 for an overview over those studies).

Lerner (1994), for instance, is not interested in the VCs' syndication decision as such, but only in the VCs' choice of syndication partners. To examine this, he focuses on one particular industry (biotechnology), but he differentiates between VCs' mainly on the basis of their size (and age). Doing so, Lerner finds that smaller (and younger) VCs syndicate disproportionally often with each other, but significantly so only in first rounds. Thus, from his study it seems that VCs' 'knowledge', as approximated by their size or age, could explain the choice of a syndicate partner, at least to some extent. Here, one might speculate whether Lerner's study would result in more significant or altogether different findings if he used not the VCs' size or age but the VCs' previous number of (biotech) investments to differentiate between VCs. This seems quite possible taking into account that we found that VCs' syndication decision in first rounds was not related to their age but to their biotech experience. Overall, however, it is important to note that Lerner's study does not provide any further insights into the VCs' propensity to syndicate in the first place.

Similarly, Sorenson and Stuart (2001) are not interested in the VCs' syndication decision as such, but in the role VCs' network position (previous syndications) and experience play (as the independent/control variables) for the VCs' geographical and industry 'investment reach' (as the dependent variable). In this context, the authors differentiate between VCs on the basis of both their previous investments overall and in the focal venture's industry. In doing so, Sorenson and Stuart (2001) show that VCs total experience indeed has a positive effect on the VCs' investment reach (although VCs' industry experience hasn't), but this effect vanishes when also VCs' previous syndications are included in the models. Based on this the authors conclude that a VC's experience primarily influences the geographic scope of his investment reach through the development of networks through syndication, but they make no statement regarding the role VCs' knowledge plays as a motive for syndication.

Bygrave (1987, 1988), by contrast, examines the relation between VCs' knowledge and the proportion of their investments that are syndicated. For this purpose, he differentiates between VCs on the basis of whether they mainly invest in high- or low-innovation ventures. In doing so, he finds that those VCs that primarily invest in high-tech ventures are more prone to syndicate, arguably because their investment opportunities are more risky. However, as discussed further above (Chapter C), the way in which Bygrave differentiates between VCs seems inadequate to serve as a proxy for VCs' actual knowledge, for instance, because it does not take into account the actual experience a VC has with investing in a certain high-tech sector. But if one assumed that those VCs primarily investing in high-innovation sectors indeed are more experienced, the findings of Bygrave's study would contradict those of our study. At the same time though it should also be noted that the VCs' 'syndication ratio' used by Bygrave is only an imprecise measure to approximate VCs' propensity to syndicate. Thus, overall, it is difficult to compare our findings with those of Bygrave's study.

Lockett and Wright (1999, 2001) examine VCs' syndication motives directly by asking them in a questionnaire and by differentiating between VCs based on their self-stated investment-industry and -size preferences. In doing so, the authors find only weak evidence for knowledge-related motives (e.g. missing expertise regarding industry and/or stage of an investment) but much stronger evidence for finance-related motives to syndicate. We note that the self-stated industry expertise in Lockett and Wrights' study clearly is a very imprecise measure of VCs' actual knowledge. As such it is possible that their results could look differently if they had employed more adequate proxies for VCs' knowledge. Nevertheless, it is certainly interesting that Lockett and Wright's study - by actually asking the VCs for the factors they *perceive* to be important for their syndication decision - overall results in findings similar to our own study (e.g. with view to the relative smaller importance of knowledge- vs. finance-related factors as motives for syndication). Whilst our research hypothesis was based on the assumption that more knowledgeable VCs' would perceive less uncertainty, making them less inclined to syndicate, we couldn't actually test this assumption because of the nature of our data. Thus, Lockett and Wright's findings could be seen as further proof of our own findings not simply being 'artefacts', which might have nothing to do with the VCs' actual perception.

Similar arguments can also be made with view to the findings from the study by Manigart et al. (2004), which follows a similar approach as the study by Lockett and Wright (1999, 2001) and which also comes to similar conclusions in that it shows a dominance of finance-related motives for syndication over knowledge-related motives. But in addition, this study also shows that VCs who are more specialized with view to a certain industry (self-stated specialization) do not perceive gaining access to partners' knowledge for reasons of deal selection to be an important motive to syndicate

Thus, with a view to the existing literature on the role of VCs' knowledge as a motive for syndication, our study seems most closely related to that by Hopp and Rieder (2004). These authors differentiate between VCs on the basis of their previous investments (overall, but not with view to a particular industry), and they find that more experienced VCs have a lower syndication ratio (proportion of syndicated to unsyndicated investments). As outlined before, the authors themselves point out that the results of their study - a working paper in progress - have to be taken with some caution, for instance, with a view to the syndication ratio that could be imprecise and biased. But notwithstanding those deficiencies, it is interesting that this study also finds indications for a *negative* relation between the VCs' size and the VCs' syndication ratio. This seems clearly in line with our own findings, although our study also shows that this negative relation is even more pronounced for the more specific proxies for VCs' knowledge.

In this context, it should also be noted that both our study and that by Hopp and Rieder (2004) are unique in that they provide further insights into the VCs' decision *not* to syndicate. As mentioned above, the general literature on inter-organizational collaboration has noted that collaboration entails potential costs as well as benefits to the participant. For example, these costs might take the form of opportunistic behaviour, the possible loss of critical proprietary information, and, last but not least, revenue sharing (e.g. Doz, 1996; Gulati et al., 1994; Kugut, 1989; Hamel, 1991; Hamel et al., 1989; Hsu, 2003; Porter, 1990). Consequently, an organization's decision to collaborate or to syndicate is likely to be the outcome of a benefit-risk trade-off. However, previous research in venture capital has totally neglected this issue. Some scholars acknowledge its likely relevance (e.g. Kaplan & Stromberg, 2002, 2003; Lerner, 1994; Steier & Greenwood, 1995; Wright & Lockett, 2003), but with the exception of Hopp and Rieder (2004) no empirical study has explicitly examined the role of VCs' knowledge as a motive for *not* syndicating an investment.

In sum, the main findings of our study overall seem in line with the existing literature that suggests some relation between VCs' knowledge and VCs' syndication behaviour. However, our study adds to this literature by presenting one of the few empirical examinations of the impact of VCs' knowledge on their propensity to syndicate. Our study also adds to this small literature by measuring VCs' knowledge in a much more fine-grained way than elsewhere. As we have shown, not all proxies used in the existing literature are (equally) suitable for an examination of the impact of VCs' knowledge on their syndication behaviour. What really seems to count is how well matched the VCs' knowledge is with respect to the particular investment opportunity under consideration. Finally our study also adds to the literature in that it examines and demonstrates the role of VCs' knowledge as a motive for *not* syndicating an investment. In combination with previous studies that examine the perceptions of VCs, our study suggests that the VCs' syndication decision could in fact be a consequence of the VC's assessment of the trade-off between the benefits and risks/costs associated with syndication. The more valuable a VC's knowledge is, the less likely he is to incur the potential risks or costs associated with syndication.

Additional findings

Besides the main findings on the role of VC knowledge in the decision to syndicate, our study also generates a number of additional findings that can be related to the existing literature. Since they are not the main focus of our research, we shall not discuss these additional findings in detail but just highlight the most noteworthy elements.

To start with, it is worth mentioning that our study, in line with much previous research, clearly shows the commonness of syndication in the venture capital context. Specifically, our finding that about 60% of all rounds, and more than 80% of all investments, are syndicated closely resembles the findings from previous studies, both inside and outside of the biotech sector (e.g. Hochberg et al., 2004; Manigart et al., 2004; Sorenson & Stuart, 2001; Wright & Lockett, 2003). Thus, our findings do not seem to be only a result of our particular industry focus.

Equally important to mention is that our study indicates – in line with some previous research – that the VCs' syndication decision is related to a variety of factors, of which VCs' knowledge is but one. In the empirical analysis we controlled for several context-, finance-, venture- and VC-related factors, and found a number of them to be significantly related to syndication

This fact is in line with the general literature on inter-organizational collaboration, which shows that collaboration not only serves to gain access to missing/complementary resources and skills (e.g. Kogut et al., 1995; Mitchell & Singh, 1992; Gulati, 1998; Hamel & Prahalad, 1990; Teece, 1988), but also to attain economies of scale (e.g. Gomes-Casseres, 1994), or to overcome environmental uncertainty (e.g. DiMaggio & Powell, 1983; Hannan & Freeman, 1989).

In this context, it should be mentioned that we found finance-related factors to be more strongly related to syndication, and explain more of the variability found in syndication, than knowledge-related aspects. This is in line with those theoretical arguments and empirical findings emphasising financial motives - such as capital constraints and/or portfolio diversification - for syndication (e.g. Lockett & Wright, 1999, 2001; Manigart et al., 2004; Sahlman, 1990; Wright & Robbie, 1998).

But also our findings regarding the venture-related control variables provide further support for existing literature that emphasizes the role of the risk/uncertainty associated with the particular investment opportunity when it comes to syndication. For instance, as already suggested by some previous literature, we find a strong positive relation between syndication and venture-related variables such as 'early-stage investment' and 'first investment by a VC in the venture', which arguably capture high-risk investment scenarios (e.g. Bygrave, 1987, 1988; Lerner, 1994)

Interestingly though, in this context, we don't find a positive relation between syndication and 'first round investment' that had been suggested by some previous literature (e.g. Lerner, 1994). Instead, we find that first round investments are significantly but negatively related to syndication.

One plausible explanation for this finding might have to do with the financial characteristics of first round investments. Indeed, although not shown here, first round investments are on average considerably smaller than later round investments (specifically, the average round amount is about $4.9Mio in first rounds but $6.7Mio in later rounds; and the difference is even more evident when looking at first round investments in early-stage ventures, which present the majority of the first round investments in our sample). Therefore, and taking into account the apparent significance of finance-related factors for syndication, it seems plausible to assume that first round investments are negatively related to syndication because they involve a relatively smaller financial risk for the investor.

Another or additional possible explanation for the unexpected finding of less syndication in first rounds could be that VCs generally want to have a first-mover advantage, getting cheap equity stakes and correspondingly more control in the ventures they finance. This is most likely to be the case when investing in first rounds of ventures.

In sum, our findings provide support for the literature on inter-organizational collaboration in general, which emphasizes that collaboration is a trade-off the benefits and risks of which have to be carefully weighed in the particular situation; and they provide support for both 'main streams' of extant venture capital literature on syndication: whilst finance-related motives seem to play a dominant for syndication, knowledge-related motives are important nevertheless - and they are the more important the more specialized the VCs' knowledge is.

F.VI.3. Limitations and future research

Although our findings provide overall support for our hypothesis, several limitations of our research design prevent us from drawing too far-reaching conclusions.

In the following we highlight some of those limitations specific to our tests of Hypothesis 1, also to direct future research in this particular area. However, at this point, the reader is also referred to our synthesis Chapter J, where we discuss the more general limitations of our approach affecting the analyses of all three hypotheses.

Units of analysis

To begin with, of possible constraint of our (main) analysis concerns the *possible non-independence of some observations in our sample.* As already discussed in more detail above (in the methodology section of the current chapter, and also in the section on 'sampling and data' in Chapter E), the pooling of all investments in our sample (whether or not they involve the same VCs and/or ventures) could introduce some bias in our findings.

For instance, it might be that (VC) firm-specific effects, other than the VCs' knowledge, impact the VCs' syndication decision. Into this direction also point the finding for our control variable for the VCs' 'percentage of previously syndicated biotech deals', which turned out to be significantly positively related to the syndication of the focal investment. In other words, a VC who had previously syndicated biotech deals is more likely to syndicate the current deal. We have already discussed the limitations of this control variable before and we will come to it again further below when discussing the limitations of our control variables. At this stage, it should just be mentioned that we acknowledge that there might be more firm-specific effects that we have not controlled for, and that might introduce additional bias into our findings.

Thus, to develop a feeling for this potential bias and to check the robustness of our findings, we conducted several additional tests on sub-samples (i.e. first or last rounds only), which partly or completely eliminated potential biases resulting from non-independent observations. These tests resulted in very similar findings with respect to our theoretical variables as did our main analysis, and therefore seem to prove the robustness of our findings from the main analysis across different samples.

Nevertheless, we are aware that those additional analyses involve other possible problems, such as sample selection bias. As a consequence, future research might try to deal with the issue of potential non-independence in our data in a more sophisticated manner, for instance, with a Panel data analysis that observes the syndication behaviour of individual VCs over time to find out about possible additional firm-specific effects.

However, it should be mentioned that also this approach would be not without problems. Specifically, our data would result in a very unbalanced Panel, with many firms entering only with one single observation (investment) and many other firms entering with many observations (investments). Furthermore, also the time-intervals between observations would be very uneven, because VCs don't make investments throughout the year but not in regular intervals.

Dependent variables

Another possible limitation of our study concerns its *dependent variable*. In our analysis, we look at the relation between VCs' knowledge and VCs' decision to syndicate, or not to syndicate, in general; and we find that such a relation exists.

However, as some previous research suggests, the VCs' motives for syndication might be different when it comes to either syndicating *out* or syndicating *into* a deal (Lockett & Wright, 1999, 2001). This might also affect the importance of knowledge (or the lack thereof) as a motive for the syndication decision.

For instance, our main proposition was that a knowledgeable VC should be reluctant to syndicate (out) an investment because he should be confident in his initial investment decision and/or in his capability to provide the relevant monitoring/support services to ensure a successful outcome of the investment. This, in turn, might make him less willing to share the potential profits from the investment and to incur the potential costs/risks of syndication. Our findings suggest that this is the case in general. But it seems plausible to assume that even a knowledgeable VC should be happy to join an existing syndicate of ignorant VCs if he feels - based on his own judgement/due diligence - that it is a promising opportunity.

As such, it might well be that differences exist regarding the relation between VCs' knowledge and the decisions to syndicate in or out an investment. For our large sample analysis we did not have the relevant information to test this possibility. Future research that differentiates between syndicating in and out a deal, therefore, might reveal some additional insights on this issue.

However, it should also be referred to our case studies in Chapter I, which provide some additional insights in this context.

Control variables

Yet another possible limitation of our analysis concerns the *control variables*. Here, the overall low predictive power of our models suggests that the variables included in our baseline model might be insufficient and/or there might be many more factors of likely relevance.

For instance, with view to the *context-related controls* in our baseline model, we realise that the annual changes in the numbers of VCs providing venture capital and/or of biotech ventures receiving venture capital are rather crude proxies for the actual numbers of VCs potentially being willing to provide venture capital and/or biotech ventures looking for venture capital: we only observe those VCs/biotech ventures that actually invest/receive venture capital, but we don't know how many VCs/ventures would have liked to invest/receive venture capital – although the latter might also impact the VCs' syndication behaviour. Therefore, whilst we believe that our context-related control variables provide some reasonable first impression of what is going on in the markets, it is obvious that we cannot draw far-reaching conclusions regarding potentially relevant context-related issues such as competition between VCs or possible deal-flow. For this purpose, it might be interesting, for instance, to also control for the impact of additional external events (e.g. 'announcement of the completion of the human genome project' or 'product problems/scandals in the pharmaceutical industry') as additional factors of potential relevance for VCs activity, including VCs' syndication.

Similarly, also some of our *VC-related controls* are limited to some degree. For instance, since our sample is clearly dominated by US VCs, a dummy variable for US VCs alone might be considered insufficient to capture the potential variance in the syndication behaviour of VCs from different nations. More severe, however, might be the limitation of the variable capturing proportion of a VC's previously syndicated deals. With view to this variable we certainly have to caution about far-reaching conclusions. First, this is because this variable is only based on previous biotech deals, but it does not take into account a VC's syndication history in non-biotech deals. Furthermore, this variable does not consider previous syndications between certain pairs of VCs – although some previous research indicates that a VC's prior experience with a particular partner might influence his future syndication behaviour.

Finally, there are also limitations with view to our *finance-related controls*. For instance, whilst our analysis suggests that finance-related aspects could present an important motive for syndication overall, we cannot draw any further conclusions about which, if any, finance-related motive for syndication – e.g. capital constraints or portfolio diversification - that has been suggested by previous literature might be more dominant. On the one hand this is because we don't have information in our data about the actual funds available to a VC at the time of an investment – which would be necessary to examine potential financial constraints. On the other hand, this is because our variable 'relative deal size' is based on a simple division of the total round amount by the number of VCs participating in a round. Whilst we assume that this is a fair approach because it seems unlikely that different VCs in a syndicate make very different financial contributions to a deal, this might nevertheless be the case – rendering our 'relative deal' size a rather imprecise measure.

In this context it should be emphasized again, that the focus of our project was not to model all the factors of possible impact on the VCs' syndication behaviour. What we were mainly interested in was the role of VCs' knowledge in the VCs' decision to syndicate or not to syndicate an investment. From this perspective, we feel confident, that our main findings are meaningful in that they show that VCs' knowledge is related to VCs' syndication decision even when controlling for a number of variables that seem much more strongly related to syndication.

Nevertheless, we acknowledge the possibility that our models – including their predictive power and generalizability - might be improved in future studies including additional and/or more refined control variables than have been available to us.

Causality

Another issue that needs to be addressed with respect to our study concerns the *causality* of the relation of the identified relation between VCs' knowledge and syndication decision, and the *validity* of our theoretical variables in this context.

The assumption underlying our hypothesis was that more knowledgeable VCs should be more confident in his own abilities to realistically assess and subsequently manage an investment. Thus, he should perceive less uncertainty to be associated with an investment opportunity, and therefore should be less inclined to incur the possible risk/cost of syndication.

However, one might also argue that more knowledgeable VCs (according to our definition) are in fact those with deeper pockets – because their track record of previous investments might make it easier for them to attract (larger) funds from investors. If that was the case, the more knowledgeable VCs' reluctance to syndicate investments might be less a consequence of their greater confidence in their own abilities but more of their reduced need to spread financial risk and/or to obtain additional financial resources from syndicate partners.

In this context, we note that we found a negative relation between VCs' knowledge and VCs' propensity to syndicate even controlling for financial aspects, including the absolute deal size and the deal size of the current investment relative to the VCs' average previous deal sizes.

Furthermore, if the VCs' number of previous investments would merely capture financial- and not knowledge-related aspects, we would not expect to find what we have found, namely that different types of previous investments to be differently related to the VCs' propensity to syndicate, and that the negative relation between syndication and the knowledge proxies proposed is the more pronounced (negative) the better the match between knowledge and the investment venture under consideration. All that should matter is how many investments a VC had previously made, but not into what types of ventures, and how closely related those ventures were to the venture now under consideration.

This, together with the findings from previous studies that directly asked VCs about their motives for syndication (and that found at least some evidence that knowledge-related factors can play a role as motives for syndication over and above finance-related factors), makes us confident that the relation we find is indeed due to differences in VCs' knowledge and not just to differences in VCs' financial characteristics, and that our proxies indeed capture what they intend to capture, namely the different levels and types of VCs' knowledge.

Nevertheless, we acknowledge that due to the nature of the data available to us, we could not fully separate knowledge- and finance-related motives for syndication. Our finance-related control variables are too imprecise to capture the funds actually available to a VC at the time of an investment. Furthermore, we only controlled for finance-related aspects but we did not examine likely interrelation effects between finance- and knowledge related factors.

As such, we can conclude that, on average, knowledge-related motives play a role for the syndication decision. But it seems plausible to assume that the actual impact of VCs' knowledge for this decision varies when interacted with VCs' financial characteristics. For instance, one might assume that a cash-deprived expert VC is more inclined to syndicate - for financial reasons - than his cash-rich expert colleague.

Thus, we recommend future research in this area to look into more detail at the impact of the funds actually available to a VC at the time of the syndication decision, and to examine the interaction effects of both finance- and knowledge-related factors.

Implications

Finally, a comment on the implications of our study: we acknowledge that our findings are of academic rather than practical nature.

This is for several reasons.

To begin with, as already highlighted above, our models suggest that our theoretical variables have only a very limited explanatory power.

Furthermore, our analysis does not provide any further insights into the performance-implications of syndication, and also not into the role the VCs' knowledge plays in this context.

For instance, one might expect that if more knowledgeable VCs tend not to syndicate, the average knowledge of the syndicates might be relatively lower than that of lone investors. This, in turn, might have implications for both the VCs' investment approach and the performance of VCs' investments.

We will deal with these aspects, to some extent, in the next two chapters. However, we believe there is much more work to be done on this aspect in future research.

CHAPTER G: VCS' KNOWLEDGE & STAGING OF DEALS

G.I. Introduction

It will be recalled that the guiding question of our project is: What role does VCs' knowledge play in the financing of entrepreneurial high-tech ventures; and, how does this knowledge affect their investment approach and performance?

In the previous chapter, we found that one distinctive feature of the VCs' investment approach, the syndication decision, is indeed empirically influenced by VCs' knowledge.

However, syndication is just one of several distinct features in the VCs' investment approach, which all could be impacted by VCs' knowledge. Furthermore, when being interested in the relation between VCs' knowledge and VCs' investment approach, a VC's decision to syndicate, or not, arguably is a special case in that there it is the individual VC's knowledge (or the lack thereof) that is of relevance. But once a VC decides to syndicate an investment, it will not just be his own knowledge anymore that is relevant for the subsequent steps of the investment process, but the syndicate's knowledge.

Therefore, in this chapter, we examine empirically another feature of the VCs' investment approach, namely the staging decision.

An infusion of venture capital is said to be *staged* if the provision is made not in one but in several distinct tranches or 'rounds', often conditional on the venture meeting some well-defined progressional 'milestones'. Such stages may or may not involve the same VCs or the same syndicates of VCs.[169]

Our choice of staging as a feature of VCs investment approach has two main motivators: a) staging is a secularly common and important feature in the

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[169] In this context, Kaplan and Stroemberg (2002, 2003) point out that one can distinguish between two different forms of staging: ex ante (or within-round) and ex post (or between-round) staging. In an *ex ante* staged deal, part of the VC's funding that is committed upfront is contingent on non-/financial performance/milestones. However, the authors note, although many VC financings are not explicitly staged ex ante, most of them are implicitly staged *ex post*, in the sense that even when all the committed funding in the round is released (immediately or 'ex ante'), in most cases, future financing will be needed – in additional rounds ('ex post') to support the venture until the IPO. Therefore, unless stated otherwise, in the following, we use the term 'staging' to refer to 'ex post' staging; and we measure the intensity of staging in terms of the '*round-length*', i.e. the time between the beginning of one round and the beginning of the next, where a shorter round-length is understood as more intense staging.

venture capital investment process, and b) staging is not well researched empirically, particularly with respect to VCs' knowledge.

There is considerable anecdotal evidence of the importance and commonness of staging in VC investments (e.g. Gorman & Sahlman, 1989; Gompers, 1995; Gompers & Lerner, 1999; Kaplan & Strömberg, 2002, 2003).

Sahlman (1990: 506-507), for instance, explains the rationale of staging as follows:

> 'The most important mechanism for controlling the venture is staging the infusion of capital [...]. Each company begins life knowing that it has only enough capital to reach the next stage. By staging capital the venture capitalists preserve the right to abandon the project whose prospects look dim. The right to abandon is essential because an entrepreneur will almost never stop investing in a failing project as long as others are providing capital. [...] Misuse of capital is very costly to venture capitalists but not necessarily to management. To encourage managers to conserve capital, venture capital firms apply strong sanctions if it is misused. These sanctions ordinarily take two basic forms. First, increased capital requirements invariably dilute management's equity share at an increasingly punitive rate. Second, the staged investment process enables venture capital firms to shut down operations completely. The credible threat to abandon a venture, even when it might be economically viable, is the key to the relationship between the entrepreneur and the venture capitalist [...]. By denying capital, the venture capitalist also signals other capital suppliers that the company in question is a bad investment risk'.

Sahlman further notes that the seemingly irrational act of shutting down an economically viable entity is rational when viewed from the perspective of the venture capitalist confronted with allocating time and capital among various projects (i.e. amongst a portfolio of projects): although the individual company may be economically viable, the return on time and capital to the individual venture capitalist is less than the opportunity cost, which is why the venture is terminated. At the same time Sahlman (1990: 506-507) also provide an explanation why entrepreneurs accept the staged capital process: 'because they usually have great confidence in their own abilities to meet targets. They understand that if they meet those goals, they will end up owning a significantly larger share of the company than if they had insisted on receiving all of the capital up front'.

Consequently, Gompers and Lerner (1999: 139) argue that 'staged capital infusions are the most potent control mechanism a VC can employ', and 'this technique plays a critical role in controlling potential conflicts between the entrepreneurial team and investors' (Gompers & Lerner, 2001: 47).

Given the above motivation, it is not surprising that the staging of investments is very widespread in the venture capital industry. Gompers and Lerner (1999), for instance, find in a random sample of 794 ventures from various industries that the average number of rounds received per venture was about 2.7.

Our own data for the biotech industry also shows staging to be very common. Figure E-3 c) in the 'exploratory overview' over our data, Chapter E.b, for example, shows that more than half of the ventures in our sample received two or more rounds of funding. The average company has about 3 rounds of investment, each involving about 3 VCs on average. Looking at the time dimension we find that on average ventures in our sample receive a round of funding every 445 days (median: 313 days).[170]

However, whilst there is little doubt about the commonness of staging in venture capital at the aggregate level, the phenomenon of staging, and the factors influencing staging are not well researched empirically. This especially concerns the role VCs' knowledge plays for their staging decisions.

Bergemann and Hege (1998: 705), for instance, develop a dynamic principal-agent framework for the staging of venture capital investment in which asymmetric information and VC learning play a central role. They note that 'one of the most challenging problems in venture financing is to determine when to release funds for continued development and when to abandon a project'. The same authors also point out that 'surprisingly, the dynamic interaction of both aspects [the financing decision and the acquisition of information about the investment project] has received little attention in the literature'.

Similarly, Lerner (1998: 736), in an empiricist study, argues that staged financing, as 'one of the most important mechanisms that venture capitalists employ to control entrepreneurs [is] an issue that surely deserves greater theoretical and empirical attention'. The same author continues: 'to be sure, the entrepreneurial setting is not the only one where projects can be continued long after they would rationally be terminated. The popular business press and the

[170] Here, it must be mentioned that a considerable number of our sample ventures have only been founded recently, during the pre-2000 high-tech Bubble. Although many of those ventures might not be viable in the long-term, one might expect many others to receive further rounds, once the markets become more bullish again. This, in turn, would increase the average number of rounds received by the ventures in our sample.

organization behaviour literature present numerous examples of corporate investments, which become very difficult to terminate.... A more intensive examination of the problem of the inefficient continuance of projects, and of the ways in which this issue can be addressed in both entrepreneurial and corporate settings, is a ripe area for future research by financial and organizational economists'.

The above clearly suggests that the VCs' knowledge (information) may play an important role in their decision to stage an investment. However, this aspect apparently has been largely neglected in the literature so far. Schertler (2000: 18), for instance, points out:

> 'The staging of capital infusions is sufficiently explained by various incentives problems, such as entrepreneur' hold-up behaviour or double-sided moral hazard problems [...] further research on venture capital [...] should pursue the following direction: how does the experience and expertise of venture capitalists affect the contractual arrangement between them and the entrepreneurs? This experience and expertise may differ due to exogenous characteristics but also due to their specific technological knowledge accumulated over time. [...] Therefore, it might matter whether an experienced or a relatively inexperienced venture capitalists signs a venture capital contract with an entrepreneur'.

In sum, although there is plenty of anecdotal evidence suggesting the relevance of staging to the VCs' investment approach, the academic literature – both theoretical and empirical - on VC staging is limited. In particular, no attempts have been made to examine the role of VCs' knowledge in staging at the empirical level. A better understanding of staging is however likely to be important in understanding venture capital investment decisions and performance.

In the following we therefore review the relevant literature, guided by the question:

What role does VCs' knowledge play in the staging of their deals?

G.II. Literature review

G.II.1. Theoretical literature

The limited literature on staging of investments by VCs deals with staging either as part of the VC's contract structure or as part of the VCs' monitoring/control activities. If this literature is grounded in theory at all, it is commonly based on arguments developed in principal-agent and related contracting theories.

Here, one can broadly distinguish two strands of literature. On the one hand, these are studies that develop theoretical arguments with respect to staging in an *informal* way; and, on the other hand, these are studies that develop *formal* models of staging.

G.II.1.a) Informal theoretical perspectives

In the informal literature on staging, authors tend to offer verbal rationales for the role of staging in venture capital investment without formally worked out models. These rationales moreover are rarely accompanied by detailed empirical tests (see references in our introduction to this chapter). However, two studies - Gompers (1995) and Kaplan and Strömberg (2002, 2003) - present noteworthy exceptions in that they not only develop arguments (mainly based on principal-agent / contracting theory) regarding the factors likely to influence the staging of investments, but also go on to test those predictions empirically.[171] We review their theoretical arguments next and their empirical findings later in the chapter.

Gompers (1995) is interested in the relation between the agency risk associated with an investment and the corresponding VC deal structure, of which staging is one aspect. In this context, he argues that if asymmetric information and agency costs did not exist, the structure of financing would be very simple, and state-contingent contracts would suffice to deal with the risk. However, symmetric information does not exist; and, from a principal-agent perspective, the private benefits occurring for entrepreneurs from managing their ventures may not always be perfectly correlated with shareholders' monetary returns. With private information entrepreneurs have, for example, incentives to continue running projects they know have a negative net present value.[172] Therefore, the asymmetric information associated with start-up companies should make project governance and monitoring extremely important: VCs monitor the venture's progress and if they acquire negative information about future returns, the project should be cut off from new financing.

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[171] Gompers' (1995) study was republished in Gompers and Lerner (1999) with some minor changes, which we refer to where relevant.

[172] In this context, Gompers and Lerner (1999: 143) note: 'for example, a biotechnology company founder may choose to invest in a certain type of research that brings great recognition in the scientific community but proves less return for the venture capitalist than other projects. Similarly, because the entrepreneur's equity stakes are essentially call options, they have incentives to pursue high variance strategies'.

At the same time, monitoring incurs costs for the VC. If VCs could costlessly monitor ventures, they would monitor and infuse cash *continuously*. In practice, the monetary costs of conducting due diligence audits and generating reports are considerable and also take time away from other VC activities. Each time capital is infused, contracts are written and negotiated, lawyers are paid, and other associated costs are incurred (Gompers & Lerner, 2001).

As a consequence, Gompers (1995) argues the monitoring of investments should be affected by a combination of expected returns and expected agency costs and monitoring costs. VCs will weigh up these potential costs and benefits at the margin when determining their monitoring intensity. This, according to Gompers (1995), explains why funding occurs in discrete stages: because monitoring is costly and cannot be performed continuously, a VC periodically checks the project's status and preserves the option to abandon it. Major review of progress, due diligence, and the decision to continue funding are usually done at the time of the refinancing.

Based on the above arguments, Gompers (1995) makes a number of predictions regarding the staging of VCs' investments. To begin with, he argues, the relative value of monitoring should be larger the larger the likely information asymmetries and corresponding agency risks; and this should become manifest in shorter duration of a particular round (a metric for the intensity of monitoring) and the deal size in a round.[173] In this context, he identifies a number of factors of likely relevance to explaining round-length, such as the 'age/development stage of the venture', the 'nature of the assets in the venture's industry' (tangibility/specificity) and the future 'growth opportunities in this industry', and the 'liquidity of the VC markets'.[174]

[173] Similarly, Gompers and Lerner (2001: 48) argue: 'firms that fail to make milestones or have particularly big information gaps normally are put on a shorter leash. The time between evaluations decreases and the frequency of re-evaluation increases as the venture capitalists expects there to be greater potential conflicts with the entrepreneurs. For example, early-stage investments are usually associated with greater potential for disagreements between venture capitalists and entrepreneurs about the feasibility of continuing the operation. The motivations and goals of the venture capitalist and the entrepreneur are likely to be most at odds at this point in the company's development. As such most early-stage venture rounds are smaller and are intended to last for a shorter time than latter-stage investments'.

[174] It should be noted here that the industry-related factors with possible influence on the VCs' staging decision proposed by Gompers (1995) will not be in the focus of our own empirical research, which looks at one particular industry, biotechnology.

Building on the same arguments, also Gompers and Lerner (1999: 139) note: 'the shorter the duration of an individual round of financing, the more frequently the venture capitalist monitors the entrepreneur's progress and the greater the need to gather information. The role of staged capital infusions is analogous to that of debt in highly leveraged transactions, keeping the owner/manager on 'tight leash' and reducing potential losses from bad decisions'.

In the same vein, and also based on a principal-agent perspective, Kaplan and Strömberg (2002) argue that agency risks are likely to play an important role for the contractual design between VCs and investee ventures, including the staging of deals. By providing less funding in a given round, and hence shortening the time until the next financing round, the VC increases the ability to liquidate the venture if performance is unsatisfactory.[175]

As a consequence, Kaplan and Strömberg (2002) predict that staging should be related to the uncertainty associated with an investment opportunity. Specifically, the authors argue that the relevant determinant of staging should be whether or not a venture is already generating revenues, whether or not an entrepreneur has already successfully brought a previous venture to IPO or acquisition), whether or not the round is the first VC round in the venture, the venture's industry long-term debt ratio, and the venture's particular industrial sector.[176]

At the same time, Kaplan and Strömberg (2002) also point out that in most empirical work on agency and information problems in corporate finance no

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[175] In this context, Kaplan and Stroemberg (2002) note that financial contracting theory predicts that, particularly in situation of high uncertainty about the venture quality and founder ability, the investor should hold a debt-like claim. This is because debt-like claims provide him with seniority and the ability to take control and liquidate the venture when performance is bad. Based on this, the authors look at the staging of investments with a reference to theories that focus on debt and/or the allocation of liquidation rights (Hart & Moore, 1998). Those theories assume that entrepreneurs can steal or expropriate venture output, and, where venture cash flows/profits are not observable/verifiable/contractible, they suggest that the optimal financial contract is a debt-like claim in which 1) the entrepreneurs promises a fixed payment to the investor, and 2) the investor takes control of the projects and liquidates the assets if the payment is not made.

[176] Again, it should be noted here that the industry-related factors with possible influence on the VCs' staging decision proposed by Kaplan and Stroemberg (2003) will not be in the focus of our own empirical research, which looks at one particular industry, biotechnology. With a view to the other – entrepreneur- and venture-related - factors suggested by the authors, we acknowledge that they are of possible relevance for the VCs' staging decision. Unfortunately though, in our own data, we have no information about these aspects.

distinction is made between different types of uncertainty - although these differences may result in different predictions. In this context, the authors suggest to differentiate between a) *internal uncertainty* (e.g. regarding management quality, previous performance, capital at risk), b) *external uncertainty* (e.g. regarding market size, customer adoption, competition, exit conditions), and c) *complexity uncertainty* (e.g. regarding product/technology and business model/strategy).

In this context, the authors argue that in the case of internal uncertainty the relevant information is internal to the venture and therefore the VC is more likely to be less informed than the entrepreneur, - giving rise to information asymmetries and corresponding agency costs. In case of external uncertainty, in contrast, the relevant information is external to the ventures and therefore it is more likely that the VCs and the entrepreneur are equally (un-) informed.[177]

Based on the same theoretical arguments outlined above (but not differentiating between different risk categories) Kaplan and Strömberg (2003) predict - in an other paper - that staging should be impacted by aspects of uncertainty associated with an investment opportunity, such as whether or not a venture is already generating revenues, whether or not an entrepreneur has already successfully brought a venture to IPO or acquisition, the time since the first VC financing round, the deal size in the round, the venture's industry size, volatility and long-term debt ratio, as well as the venture's fixed assets.

G.II.1.b) Formal theoretical perspectives

In addition to the above-described informal theoretical arguments to explain VC staging, a number of studies have developed formal models of the staging decision, once more grounded largely in an agency-perspective.

Bergemann and Hege (1998), for instance, propose a simple model to analyse the optimal financing of venture projects when learning and moral hazard interact. For their model, which depicts the interactions between a single entrepreneur and a single VC, the authors make several assumptions: the entrepreneur initially has the bargaining power in the negotiations, VCs are not differentiated, and dynamic interactions between several VCs in different rounds

[177] With respect to 'complexity' uncertainty, the authors do not specify any predictions regarding the information advantages of either the entrepreneur or the VC. As such, it remains open whether there are any information asymmetries, and if so regarding what aspects of complexity (e.g. product/technology and/or business model/strategy).

are not considered. The value of the venture project is initially uncertain and can turn out to be one of two types: good or bad. However, good projects are not revealed immediately; more information arrives by developing the project over time, allowing the VC and the entrepreneur to update their prior estimates regarding the likely success of the venture (Bayesian learning). In each period, there is some probability that the project will be revealed to be good and generate a fixed return. The probability of a successful outcome is increasing with the amount of external funds invested in the venture. Whilst both VC and entrepreneur have the same initial information about the venture's prospects, possible information asymmetries can arise in any period stemming from the fact that the VC cannot observe how the entrepreneur uses the funds provided. In some cases, the entrepreneur may employ the invested capital for his own prerequisites in a way that does not advance the venture's progress – reflecting a moral hazard problem for the VC. The resulting model predicts that a) the agency costs imply a reduction in the funding horizon, which might even lead to abandonment of potentially profitable projects (because the capital budget allocated to the project will be severely curtailed since the information rent has to be compounded over the entire expected time horizon of the project), and b) the optimal investment contract should be a long-term contract, which allows for relationship financing, including costly monitoring by the VC. The model also predicts seemingly counterfactually that (i) the VC controls the venture's progress in the late stage more intensively than in the early developments stages, (ii) the least successful ventures receive the highest amount of capital infusions, and (iii) the VC decides on further capital infusions without receiving significant information about the progress of the venture. Furthermore, the authors also acknowledge that their model is consistent with both up-front financing and staged financing.[178]

[178] Lerner (1998), commenting on Bergemann and Hege's (1998) paper, points out that several important implications of and assumptions underlying this model appear to be at odds with the empirical evidence, such as a) the prediction regarding the development of the entrepreneur's share ownership over time (where the model predicts that the least successful ventures receive the most VC funding), b) the prediction that the VCs do not monitor the venture between rounds (basic model) or only at the end of the round (extended model), c) the assumption regarding the uniform development of information about the quality of the project over time (where Lerner argues that it is very unlikely that immediately after a new venture is financed, the probability that there will be significant information inflows is actually likely to be quite low whereas it will increase over time with progress in the project)

In a later article (Bergemann & Hege, 2003), the authors develop their model further. In contrast to their previous model, they consider the provision of venture capital in a dynamic framework with sequential research stages marked by benchmarks (i.e. discernible outputs at the end of a stage, such as a first research result). Here, the time and investment level needed to meet each benchmark are unknown. Furthermore, the allocation of funds is subject to moral hazard (e.g. entrepreneur's self-serving investments and/or bias towards inefficient continuation of projects). Based on this model, the authors find that the optimal contract provides funds at each stage to attain the next benchmark upfront. Benchmarking allows for contingent stopping of a project after failure in the previous stage, presenting a valuable sequential real option (to abandon the project) to the VC. Furthermore, benchmarking reduces agency costs, directly by shortening the agent's guaranteed funding horizon (the pre-defined, limited time horizon – of an individual stage instead of the whole project - reduces the information rent of the agent), and indirectly via an implicit incentive effect ('informal promise') of information rents in future financing rounds. As a consequence, benchmarking increases the total research horizon of the project across all stages (by reducing the likelihood of premature abandonment of potentially profitable projects suggested in Bergemann and Hege, 1998). Thus, for a given project research budget, the research horizon and the success probability will be larger the better defined and the better monitored the intermediate benchmarks are. Its initial value and return to the VC, as well as the value appreciation of the portfolio company from one financing round to the next should be increasing functions of the benchmark intensity. At the same time, the optimal capital allocated and the funding horizon are increasing from one stage to the next – emphasizing the notion that the early stages in an innovative venture are the riskiest. Finally, the authors argue that their model shows that the stylized evolution of funding over time can be explained as optimal choices: the research intensity is lower for early stages, explaining why a smaller budget is allocated to them, why their durations is shorter, and why their success probability smaller.

Neher (1999) takes an interesting and innovative approach towards modelling optimal staged financing. He assumes 'perfect certainty' rather than uncertainty, central to the real options view of staging. He also assumes, contrary to most of the literature, symmetric information between VC and entrepreneur. Whilst Neher (1999) also takes an agency perspective, his focus is not on the role of staging as a form of monitoring but as a reaction to the growth in a venture's ability to take on outside finance due to a diminishing hold-up problem.

Specifically, Neher's (1999) focus is on the use of staged financing to overcome the 'commitment problem' that arises from the fact that the human capital embodied in the entrepreneur is critical to the success of his venture: the entrepreneur cannot be contractually bound to work, but always retains the right to repudiate the contract with the investor and exit the venture. Since the venture's assets might - initially - be of little value without the entrepreneur, the later can 'hold up' the VC after the investment is made (i.e. leave him with a much diminished claim) and renegotiate the contract after the VC has 'sunk' his investment in the venture - but before the entrepreneur has completed the project. In this situation, the main result of Neher's (1999) model is the derivation of an optimal staged investment path in face of the commitment/hold-up problem. The model suggests that staging reduces the possibility of hold-up, because over the life of the venture the human capital of the entrepreneur gradually becomes embodied in the physical capital of the venture (and hence becomes alienable). This might be, for instance, in form of patents, a final product or a clearer view of the marketability of a product. The value of the physical capital without the entrepreneur in place (the venture's collateral value) grows over time, until, ultimately, all the entrepreneur's relevant human capital is embodied in the venture's physical capital.[179] Thus, when investments are staged, this collateral can support external funding in later rounds. The venture's early rounds are also safe from hold-up if they are small enough so that the claims held by the outside investor cannot be bid down further. He retains the power to renegotiate the contract. In sum, the model predicts - in accordance with empirical evidence – that the number of capital infusions increases with the degree of intangibility of the venture's assets.[180]

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[179] This, Neher (1999) points out, finds empirical support, for instance, in the study by Sahlman (1990), who notes that entrepreneurs are often replaced towards the end of the venture capital process when the venture has become less an entrepreneurial venture, and more a standard venture. At this point the management of the venture requires the skills of a standard manager, rather than those of an entrepreneur.

[180] In this context, Neher (1999) notes that, if uncertainty (such as assumed by the 'real options' models is resolved at points of significant development in the venture, the real option model delivers a similar prediction to his model regarding the coincidence of stages of investments and stages of development. Furthermore, the two models are similar in their predictions of how the tangibility of the capital investments affects the staged investment paths. However, Neher (1999) also emphasizes that the two models address two fundamentally different issues. A real option model is simply a model of investment under uncertainty and thus does not explicitly addresses the agency problem that surrounds the likely divergence in the objectives of the entrepreneur and the VC – whereas his model abstracts away from uncertainty to focus on the role of the entrepreneur and his

Cuny and Talmor (2003) develop a model that analyses and compares two different types of staging, and the circumstances under which each type is preferable. Specifically, the authors distinguish 'milestone financing' and 'round financing'. In the 'milestone financing' there is an upfront commitment by the VC to invest beyond the venture's immediate needs at a pre-determined price, depending on the achievement of certain, pre-specified technological or operational milestones. In 'round financing' there is no pre-commitment to invest beyond the current need, and any subsequent investment is priced based on the realization and the status of the venture at the time of the subsequent round. The authors model accounts for the fact that the success of the venture (defined by positive cash flows) might depend on the costly effort put into it by the entrepreneur but also by the VC (a version of the double-sided moral hazard problem).[181] Assuming symmetric information and risk neutrality of the partners, Cuny and Talmor's model makes several predictions regarding the preferred type of staging. For example, milestone financing may be advantageous in providing more flexibility across outcomes and generating better incentives for both parties to put in effort and increase the venture's value. Therefore, when the role of the VC's effort is much more productive than that of the entrepreneur's, milestone financing is more effective in maximising value.[182] But milestone financing can be more effective when the role of the entrepreneur is more important and his technology is a 'long-shot'. In contrast, when the role of the entrepreneur is more important than that of the VC and the technological success results in a simple scaling of cash flows and sensitivities to effort, round financing is more effective. Finally, when no party's effort is more important than the other's, the presence of either belief heterogeneity or VCs' liquidity preference implies milestone financing is preferable. Thus, the nature of the

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unique human capital. Yet, as Neher (1999) acknowledges, both agency and uncertainty are significant aspects; and future work therefore might incorporate them into a common framework.

[181] Here, the authors assume that both the entrepreneur's and the VC's effort can affect corporate cash flow, but the way in which they can do so differs. The entrepreneur, intimately involved with the day-to-day operation of the venture, is assumed to be able to directly affect cash flows with hard work in the early stags of the venture, whereas the VC has more of a strategic role. In addition, Cuny and Talmor's (2003) model accounts for potential differences in the differential beliefs about the likely success of the venture between the VC and the entrepreneur, and the possibility that the VC has a preference for liquid investments.

[182] Because round financing has a lower upfront commitment than milestone financing, consisting only of a commitment to finance the current stage, the VC receives lower compensation upfront. Therefore, the entrepreneur captures more of any increase in the venture value between the first and second financing stages, resulting in an increased incentive to expend personally costly effort.

venture, its cash flows, the sensitivity of cash flows to entrepreneurial and VC effort, and success of the underlying technology are important determinants of whether milestone or round financing is preferred.

Wang and Zhou (2004), finally, investigate staged financing in an environment where an entrepreneur faces an imperfect capital market and a VC faces moral hazard and uncertainty. The VC knows the distribution function of the - contractible - output at the beginning of the first stage and the entrepreneur's effort is unobservable/noncontractible until an output 'shock' is revealed at the beginning of the second stage. In their model staged financing plays two roles - to control risk and to mitigate moral hazard. Furthermore, the model shows that when used together with a sharing contract, staged financing acts as an effective complementary mechanism to contracting in controlling agency problems. With the flexibility of staged financing, many projects, which may otherwise be abandoned under upfront financing, become profitable, and the efficiency of staged financing in the model approaches the first best for highly promising ventures. However, according to Wan and Zhou's model, staged financing is not always dominant over upfront financing in terms of social welfare. When the project does not look very promising, staged financing is inferior to upfront financing because many VCs may underinvest in a project in the early stages when it does not look very promising, which may cause a viable project to fail and result in a loss of social welfare.[183]

G.II.2. Empirical literature

Although there now is a sizable body of literature on VCs' general monitoring activities and the factors influencing those activities, and although there is also an increasing body of theoretical (formal) literature on VCs' staging, to the best of our knowledge, there is virtually no empirical literature on the staging of investments.

The studies by Gompers (1995) and Kaplan and Strömberg (2002) present two noteworthy exceptions in this context. We have already described the theoretical

[183] Wang and Zhou (2004) acknowledge that, in reality, a VC's financing plan may involve many options, which have not been considered in their model. Control variables may include, for instance, the number of periods, the duration of each period and the amount to be invested in each period. In addition, a VC can also consider how to monitor a venture intensively, when to go public, and how to arrange control rights properly. The authors therefore note that a more comprehensive study of staged financing is needed for a better understanding of these issues.

arguments underlying these two studies in some detail above, and now focus on their empirical findings.

Gompers (1995), in testing the predictions of his model (see section on theoretical literature), uses Venture Economics data to derive a random sample of 794 companies (both high-and low-tech) receiving VC financing between January 1961 and July 1992. Based on this sample he finds the predictions of his verbal theorising regarding the relation between factors likely to increase information asymmetries and deal structure (duration of investment, size of investment, total number of rounds, and total amount invested in all rounds) is only partially supported. Table G-1 summarizes key findings from Gompers' (1995) study regarding the factors impacting the round-length.

Table G-1: Findings from Gompers' (1995) study on factors impacting the round-length

[+/-: direction of the relation; (): non-significant relation; !: relation opposite to predictions]

	Early stage venture[1]	Middle stage venture[1]	Venture age	Deal size
Full sample	(+)!	(-)	+	(+)
High-tech	(+)!	(-)	(-)!	(+/-)![2]
Low-tech	(-)	(-)	+	(+)

[1]) dummy variables for early- (seed, start-up) and middle-stage (early, other early, first) investments – with later stage investments serving as the base; [2]) sign varies depending on variables included in model

Regarding the *development stage* of ventures, Gompers (1995) finds - contrary to his prediction - no significant difference between the duration of early or middle stage financings and late stage financings. Overall, early stage rounds (seed/start-up) even appear to be *longer* than later stage investment rounds (although not significantly). On closer inspection, however, he finds that early stage rounds are only longer (although not significantly so) in case of high-technology ventures, but shorter in case of low-technology ventures.[184] The ventures' *age* at the time of financing, by contrast, is - as predicted - overall is positively and significantly related to financing duration, and it is negatively related to the size of the investment (although it is not clear whether significantly so or not). But – again contrary to his prediction – the age of the venture is only significantly positively related to the round-length in the low-tech

[184] At the same time Gompers (1995) finds that the development stage of ventures has an impact on the amount of financing per round. The average deal size per round generally rises with the development stage; early and middle stage ventures receive significant less money per round than latter stage ventures: Average early stage rounds are between $1.3 and $2.03 Mio smaller than comparable late stage rounds. Similarly, middle stage rounds are on average $0.7 to $1.21 Mio smaller than late stage rounds.

cohort but not in the high-tech cohort.[185] Interestingly, Gompers (1995) also finds that although one might expect that a larger *deal size* might lead to longer round-lengths this is not the case: none of the coefficients on amount of financing are significant![186] In addition, Gompers (1995) also finds that - as predicted, the financing duration declines with decreases in the industry ratio of tangible to total assets. Similarly, as the role of future investment opportunities in a venture's value increases (higher market-to-book ratios), duration declines. Also, higher R&D intensities in venture's industry lead to shorter funding durations. These results, he argues, indicate that venture- and industry-specific factors determine the round-length independent of the investment size. Moreover, Gompers (1995) finds - as predicted - that in periods when VCs are able to raise more capital for new investments they invest more frequently in the ventures they finance. Greater commitments of capital to new funds reduce the duration of financing. Greater commitments to new VC funds may measure entry of new, inexperienced VCs or free cash flow agency costs. Finally, as predicted, increases in the liquidity of the VC market also lead VCs to invest more money per round.[187]

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[185] Gompers (1995) further shows that the age of the ventures at their first rounds varies (although not significantly), and high-tech ventures appear to be younger at their first rounds than low technology ventures. For instance, biotech ventures seem to be the youngest at their first round (average/median age at their first round: 1.21/0.71). In this context, Gompers (1995) argues that the venture age may be more important in measuring potential asymmetric information for low-technology ventures but may have only a small impact on asymmetric information for high-technology companies. Here, Gompers and Lerner (1999) add that high-technology ventures may naturally pass through more milestones. As such, it might be that the more information is revealed, the more often the project is re-evaluated.

[186] At the same time, Gompers (1995) finds that the rate of *cash utilization rises for latter stage ventures*. This, he argues, probably is because the need for investment in plant and working capital accelerates as the scale of the project expands. However, it seems, Gompers does not control for cash utilization when examining the relation between deal size and round-length. Furthermore, Gompers (1995) also finds that *high-technology ventures receive greater total financing than low technology ventures*. The four industries with the highest total funding per venture were communications, computers, computer related, and biotechnology (although it should again be mentioned that Gompers does not appear to control for the age of the venture when analysing the total financing provided).

[187] In this context, Gompers (1995) notes that if VCs are capital rationed, larger cash commitments allow them to invest more often in positive NPV projects and with larger cash infusions. If, however, VCs are susceptible to free cash-flow agency costs, they might waist the extra cash by investing more, and more often, in bad projects. As such, the growth in new and inexperienced fund managers during the mid-1980s could have led to a deterioration in investment quality and monitoring.

With a view to those findings, Gompers (1995) concludes they are generally consistent with his prediction that the staging of VC investments can be understood in an agency and monitoring framework. VCs concentrate their investments in early stage companies and high-technology industries, where uncertainty spells both high downside and high upside potential, and where information asymmetries are likely to be high: VCs monitor entrepreneurs with increasing frequency as expected agency costs rise, and they try to minimize agency costs by infusing capital more often. By gathering information, VCs determine whether projects are likely to succeed and continue funding only those that have high potential. Gompers' (1995) suggestion that VCs (have to) weigh the expected agency costs against the costs of monitoring finds further support by an indepth case study of one venture and its VCs by Steier and Greenwood (1995), although more with a view to the costs incurring to the venture from too intense staging. Specifically, the authors show that - at least in cases - VCs might get in the way of the venture's progress by forcing the entrepreneur to be overly concerned with short-term results - particularly when it comes to new funding decisions. In this context, the same authors show that staging can incur substantial costs and even threaten the existence of viable companies - particularly if it involves several VCs in a syndicate. In the particular case, the venture had tight time-lines and a need for a constant supply of cash to progress across important milestones. But when further funds were required to proceed, the formal and hierarchical communication, coordination, and decision-making procedures between the syndicate partners consumed valuable time and financial resources. This, in turn, resulted in the venture running out of money and having to go into receivership - although it had accomplished its major milestones, and although at least one of the investors maintained that the company could have worked.

Kaplan and Strömberg (2002), furthermore, examine the staging of deals based on a sample of investment memoranda and contracts from investments by 11 VCs in 67 portfolio ventures (mainly high-tech ventures founded between 1996 and 1999). In this context, as described in more detail above (see section on informal theoretical literature on staging), the authors differentiate between *internal*, *external,* and *complexity uncertainty*. Based on this, the authors find that ex-post staging is only significantly (negatively) related to external risk. In addition, ex-post staging is also significantly (but positively!) related to first round investments.[188] Furthermore, ex-post staging is not significantly related to either internal risk or complexity risk.[189] Overall, the authors therefore suggest that the driving force for ex-post staging is not asymmetric information, but rather the option to abandon the project, which will be more valuable in volatile environments.[190]

Kaplan and Strömberg (2003), furthermore, in their study of actual VC contracts for 213 VC investments in 119 portfolio companies by 14 VC ventures (which includes the data from Kaplan and Strömberg, 2002) find that the length between rounds is positively related only with two of the examined variables. First, this is whether the venture's entrepreneur is a 'repeat entrepreneur'. This, the authors suggest, indicates that previously successful founders receive more funding in a given round (reducing the VC's liquidation threat). Second, this is the venture's industry long-term debt ratio, which is significantly and negatively related with the round-length. This, the authors suggest, indicates that the use of ex-post staging is complementary with the use of debt in the industry.[191] However, none of the industry variables identified by Gompers (1995), such as fixed asset ratio, R&D to sales, or market to book ratio, were found to be significant in Kaplan and Strömberg's (2003) study.

[188] In this context, it should be mentioned that Kaplan and Stroemberg (2002) analyse the impact of 'first round investments' on round-length separately from the other risk categories - although, from the general literature but also from the authors' own arguments, its seems reasonable to assume that this could well serve as a proxy for internal risk (or agency risk).

[189] Other tested factors - which were found to have no significant relation with ex post staging (round-length) - were the degree of internal risk, complexity risk, industry median long-term debt ratio, and dummies for 'pre-revenue venture', 'repeat entrepreneur', and industry variables (Biotech, IT/software, telecom, healthcare, retail, other). With view to the later, it should be mentioned that biotech - with an average of 8.2 months - had by far the shortest round-lengths (although not significant).

[190] At the same time, Kaplan and Stroemberg (2002) also examine the impact of those variables on ex ante staging; and their findings suggest that the uses of the two types of staging seem to differ depending on the type of risk. Specifically, ex ante staging (the amount of committed funds that are disbursed upfront) is - as predicted - significantly related to the degree of internal risk (as well as to the industry median long-term debt ratio). This, the authors note, is consistent with ex ante staging being a way for good ventures to signal their type, or for VCs to screen out bad ventures, similar to the way short-term debt is used in the model by Diamond (1991).

[191] As in their previous study, Kaplan and Stroemberg (2003) also examine the ex ante staging (% of committed funds paid upfront in a given round). Here, the authors also find significant relations with 'repeat entrepreneur' (positive), 'industry long-term debt ratio' (positive), and 'time since first round' (negative; indicating that ex ante staging is more common in earlier rounds).

G.II.3. Preliminary summary and conclusion

In sum, extant theoretical and empirical literature suggests that staging of investments is a key element of the VCs' investment approach that serves (a combination of) several purposes. Staging provides the VCs with better control over potential agency risks and moral hazards, such as continuation of negative-NPV projects, appropriation of investments (if cash flows are not observable) and/or shirking of job responsibilities (if effort is not observable) by the entrepreneur. Furthermore, staging also provides the VC with a 'real option' that helps him to avoid throwing money at bad projects and to limit the negative consequences of the general uncertainty associated with many (high-tech) projects.

But, at the same time, the literature also indicates that staging is costly, and that the VCs' (optimal) staging strategy is an outcome of the perceived cost/benefit trade-off.

With respect to the latter, most theoretically oriented literature takes an agency perspective, and identifies several venture-related factors likely to influence the VCs' perception of the (agency) risk, and, consequently, their monitoring/staging activities. Commonly mentioned factors are, for instance, the focal venture's industry, age, development stage, and track record. In addition, some literature also points out the likely relevance of context-related factors such as the liquidity of the venture capital markets.

The few empirical studies on staging, however, result in ambiguous findings, and they do not always seem consistent with the predictions from agency theory. Not all factors suggested by the theoretical literature seem to be related to staging, or at least not always.

There are several possible explanations for the ambiguous findings in the existing literature on staging.

One explanation, for instance, could be that the risks resulting from information asymmetries between VCs and entrepreneurs are in fact less relevant than suggested by the literature. For instance, it seems quite plausible to assume that, particularly in case of early-stage investments in high-tech sectors, a (more) important source of uncertainty is that inherent to (science-based) projects, which are prone to fail. This type of risk, however, may affect both entrepreneurs and VCs to a similar extent. Therefore, particularly in the early stages of high tech projects, agency theory alone might be insufficient to account for the different round-lengths found in the empirical research.[192]

Another or additional possible explanation for the ambiguous findings in the literature on staging could be that – whilst all studies look at venture-related factors with possible impact on the VCs' risk perception – hardly any study looks at VC-related factors that might impact the (VCs' perception of the) uncertainty associated with an investment. Furthermore, and critical from the perspective of our project, *no study looks at the VCs' knowledge as a possible determinant of the investment structure in general or the staging of investments in particular.*

This is surprising because if the staging of investments is indeed influenced by the VCs' assessment of the trade-off between, on the one hand, information-asymmetries (agency risk) and/or overall uncertainty (project risk), and, on the other hand, the (administrative) costs of staging, then it is plausible to argue that this assessment should vary not only with venture-related characteristics but also with VC-related characteristics, such as the VCs' knowledge.

Also Gompers (1995) provides, indirect, support for this assertion. He notes that his findings suggest that VCs use their industry *knowledge* and *monitoring skills* to finance projects associated with significant uncertainty and information asymmetries. Furthermore, he indicates that increased liquidity in the VC market might lead to the entry of new, *inexperienced* VCs that might have a different (this is: a flawed) perception of those aspects as well as different (this is: unsound) investment structures to deal with them. Specifically, he argues that in times of high VC activity (leading to entry of inexperienced VCs) the rounds are shorter. Consequently, Gompers (1995) recommends future research to

[192] Gompers (1995), for instance, acknowledges that a venture's age may be important in measuring potential asymmetric information for low technology ventures but may of less relevance in the context of high-tech ventures; and Lerner (1998) provides an possible explanation for this: immediately after a new venture is f(o)unded (i.e. in first round investments), the probability of significant information inflows - that might help resolving relevant risk - is likely to be low. In contrast, at some point thereafter, the probability that information will arrive increases dramatically, for instance, because the results of the clinical trial will emerge. This might also explain why Kaplan and Stroemberg (2002, 2003) find that round-length is not related to internal but to external risk, and that round-length is significantly longer in case of first round investments. The internal, and particularly the complexity risk is likely to be highest in first round investments; and this is even more likely to be the case taking into account that Kaplan and Strömberg's (2002) sample comprises about 75% high-tech ventures. Indeed, in their analysis of VCs' risks perception and venture characteristics, the authors find that the strongest (although not significant) relation between the two variables exists with respect to product/technology aspects of biotech ventures, which are generally considered to be very complex and risky (e.g. Gompers, 1995).

investigate the effect of growth in the VC industry such as with a view to the question: 'do free cash flow costs, liquidity constraints, or the entry of inexperienced VCs better describe VCs' responses to changes in capital commitments to new funds?'. Thus, although Gompers' (1995) study does not look in any detail at the role of VCs' knowledge regarding possible information asymmetries and agency costs, and/or interim monitoring costs, it indirectly suggests that VCs' knowledge could be of relevance in this context.

A similar argument can also be made on the basis of Kaplan and Strömberg's (2002, 2003), study, which indicates that ex-post staging of investments is not related to internal uncertainty (for which information asymmetries might exist between entrepreneur and VC) but to external uncertainty (of which entrepreneurs and VCs could be equally un-/informed).

Together, the above arguments indicate that not only venture-related factors could determine the investment structure and staging but also VC-related factors, and particularly VCs' knowledge.

Indeed, Schertler (2000: 18) points out that - whilst staging of capital infusions is sufficiently explained by various incentives problems, such as entrepreneur' hold-up behaviour or double-sided moral hazard problems - further research on venture capital should look at 'how does the experience and expertise of venture capitalists affect the contractual arrangement [...] it might matter whether an experienced or a relatively inexperienced venture capitalists signs a venture capital contract with an entrepreneur'.

With a view to those arguments, in the following, we develop our hypothesis on the relation between VCs' knowledge on the staging of investments ('round-length').

G.III. Hypothesis

Summarizing the above findings, it seems plausible to propose that VC knowledge should be related to the intensity of investment staging (or 'round-length'). In other words VCs' knowledge should influence their assessment of the trade-off between the (perceived) risks associated with an investment and, the costs (or the relative value) of monitoring this investment.

Here, we refer the reader back to our discussion of VCs' knowledge (Chapter D), in which we proposed that whilst the *level* of a VCs' (approximated by their number of previous investments) should be an important influence of their investment approach (proposition P1), at a given level of knowledge, the *type or* *specificity* of the knowledge (approximated by their number of previous investments in biotech ventures overall or in biotech ventures of the same stage as the focal venture) should be an even more important influence (proposition P2).

In the context of investment staging, it also seems reasonable to assume that the more specific a VC's knowledge is with respect to the investment opportunity under consideration, the more it should influence his staging behaviour. In other words, we expect the VCs' staging decision to be increasingly influenced in sequence by their age, non-specific experience, total experience, and industry- and industry-stage experience.

As an illustration consider the biotech industry. Most biotech ventures develop in distinct stages, each characterized by particular challenges, and all of which are likely to be quite different from the challenges faced by non-biotech ventures. In the case of a drug-developing venture, for instance, the early stages of target-identification and target-evaluation are likely to require considerable scientific understanding, whilst the later stages of clinical development arguably require considerable managerial and organizational knowledge/capabilities. Therefore, the more specific a VC's knowledge with a view to the particular venture under consideration the more capable he should be/feel, for instance, to foresee likely problems of a particular type/stage of venture, to design suitable contracts, to conduct relevant monitoring, to provide appropriate support, and to actually assess the performance of the venture (which often will not be assessable based on products or profits but only on the basis of more or less minuscule scientific advancements).

At the same time, it should be emphasised, we would not expect the above-mentioned types of knowledge to be of so much relevance in reducing potential agency risk and/or information asymmetries. Even the most knowledgeable VC (with knowledge approximated by previous investments in other ventures) will not be able to foresee with certainty bad intentions / moral hazards of the focal venture's management - particularly if he is investing in the venture for the first time). However, we expect these types of knowledge to be relevant for the assessment of the external, business and/or complexity uncertainty associated with an investment; and, as we have argued above, these latter types of uncertainty might be of even greater relevance than agency risks, particularly in the case of early stage and/or high-tech ventures.

Consequently, we now propose that, *other things equal, a more knowledgeable VC should have a different perception of this trade-off than an ignorant VC; and* *this, in turn, should also become manifest in different staging behaviour (choice of round-length) of the two types of VCs.*

However, whilst we propose that there should be some relation between VCs' level and type of knowledge and round-length - because VCs' knowledge should impact VCs' assessment of the costs and benefits of staging – the direction of this relationship is not clear as arguments can be adduced to support both negative and positive signs; and, as mentioned before, there is hardly any formal literature to build upon in this context.

Therefore, *two alternative hypotheses* about the relationship between knowledge and round length *can be* formulated – *one predicting a positive* sign *and one predicting a negative* sign.

Positive relation between VCs' knowledge and round-length

From our above discussions, it seems plausible to presume that more knowledgeable VCs are more confident in their initial pre-investment decision. They should have a better understanding of the market or systemic risk associated with an investment. Furthermore, they might perceive less private or unique risk because of their greater ability to correctly judge certain investment parameters (e.g. project quality and management potential). Finally, they might be more confident to be able to provide necessary value-adding/-securing services to the venture post-investment. At the same time, more knowledgeable VCs might (perceive to) have a higher efficiency of interim monitoring, and be more capable of gathering and analysing relevant information about the investment's progress even if it is not prepared in formal reports and even without in-depth due diligence (as is commonly the case between two subsequent rounds). Together, this may make them *less* inclined to incur the costs of discrete monitoring their investments in form of staged funding. Instead, they may prefer a less formal and less expensive continuous monitoring. Ultimately this might make more knowledgeable VCs more inclined to have *longer investment rounds*. This effect, furthermore, might be the more pronounced, the more specific the VCs' knowledge is with a view to the particular type of venture under consideration. Therefore, one might assume, a VC with lots of experience regarding, say, early stage biotech ventures might perceive less risk when confronted with an early stage investment opportunity in this sector. This is because a more knowledgeable VC should be more confident in his capabilities to realistically assess the 'true' potential of an investment opportunity and/or to provide missing/complementary resources to it once the investment decision has been made than a VC who has no or only limited experience in this context. This, in turn, might make him more inclined to accept longer rounds.

Negative relation between VCs' knowledge and round length

On the other hand, one might also expect a *negative* relation between VCs' knowledge and round-length. This is because, from our above discussions, it seems also plausible to presume that more knowledgeable VCs are more aware of the problems potentially arising from an investment and particularly of the unpredictable/unmanageable risks inevitably associated particularly with science-based high-tech ventures. At the same time, more knowledge may facilitate not only interim monitoring (as discussed above) but also discrete monitoring/staging. More knowledgeable VCs may have to put less time and effort into the due diligence process, and they may be more capable of analysing/interpreting the results from this process. So, more knowledge may not only increase VCs' awareness of the relevance of tight monitoring/staging, it may also reduce the costs of staging relatively to its value. Together this would suggest that a more knowledgeable VC might be less willing to take the risk of committing large funds upfront. Ultimately this might make more knowledgeable VCs more inclined to have *shorter investment rounds*. Again, this effect could be the more pronounced the more specific the VCs' knowledge is with a view to the particular type of venture. For instance, a VC with lots of knowledge regarding, say, early stage biotech investments might be more aware of the unpredictable problems associated with this stage, resulting in shorter round-lengths to contain the risk – and the sunk costs - by abandoning the project sooner rather than later. A similar argument might also be made with a view to later stage investments, which have their own specific risks. In the biotech context, for instance, ventures in later stages often require very specific knowledge to organize large-scale clinical trials, to manage the complicated application process for their (drug-) products, or to market their products. Clearly, a VC with lots of experience in those matters may have a different perception of the risk involved such later-stage investments than a VC without such knowledge. Consequently, we assume, that an examination of stage-relevant knowledge should not only be limited to knowledge related to early-stage ventures.

In sum, we expect that *there should be a relation between VCs' knowledge and round-length, the sign of which is indeterminate; and that this relation should be* *more pronounced the greater and the more specific the VCs' knowledge is with respect to the particular investment opportunity under consideration.*[193]

Now, our arguments so far have focussed only on the general relationship between VCs' knowledge and round-length. But, as outlined in detail above (see Chapter C, and particularly Chapter F), one important feature in the VCs' investment approach is the *syndication* of investments, i.e. the joint investment of several VCs in the same round of the same venture; where a 'lead VC' serves as the main point of contact between the syndicate and the investee venture.

Furthermore, as mentioned in the introduction to this chapter, we have chosen 'staging' as an interesting area of research on the relation between VCs' knowledge and VCs' investment approach also because we expected that here – contrary to the VC's syndication decision dealt with in the previous chapter – it should not only be the individual VCs' knowledge that is of relevance in this context, but also that of the syndicate.

This, however, raises the question: *Which, if any, knowledge is more relevant to round-length, the average knowledge of all VCs in the syndicate or the knowledge of the (most knowledgeable) lead VC participating in a round?*[194]

Extant empirical literature on staging has almost completely neglected the fact that many investments are made not by individual VCs but by syndicates of VCs; and from the wider literature on venture capital, there is some (anecdotal) evidence that it could either be the syndicate's or the lead VC's knowledge that might be of greatest relevance in this context.

At this point, the reader is also referred to our Chapter D, and particularly to proposition P3; but in the following we briefly restate our arguments.

Relevance of the syndicate's (average) knowledge

On the one hand, it seems reasonable to assume that the VCs in a syndicate make many (investment) decisions and manage their investments jointly. Indeed, as described in some detail in the previous chapter, knowledge-related factors are amongst the determinants of the decision by a VC to syndicate. Thus,

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[193] In other words, when looking at one particular type of knowledge, the greater this knowledge the stronger the – negative or positive - association to round-length; but when keeping the level of VCs' knowledge constant and comparing different types of knowledge, the strength of the – negative or positive - association should increase from the VCs' age, over their non-biotech and total experience, to their biotech and biotech-stage expertise.

[194] For obvious reasons, this question is only relevant to the case of syndicated rounds.

when examining the relation between VC knowledge and staging, one might look at the overall (i.e. average or cumulative) knowledge of all VCs in the syndicate.

This assertion finds some indirect support in the extant literature. For instance, Lerner (1998: 739) notes that 'several venture organizations indicate that concerns about inefficient decisions to continue financing ventures lead them not only to undertake staged financing, but to take additional steps such as requiring that each refinancing of a portfolio venture involve at least one additional venture organization that has not previously invested in the venture'. Similarly, Wright and Locket (2003), note that although the lead VC is the most influential member of the syndicate in the decision making process, decisions are likely to be reached through a process of collective discussion and the reaching of consensus. In general, decisions might not be made by the lead VCs or in proportion to the VCs' equity holdings.

Together, this could support the idea that it is particularly the syndicates' combined knowledge that is important when making decisions regarding the investment structure, including the round-length.

Relevance of the lead VC's knowledge

On the other hand, it seems at least equally plausible to argue that the lead VCs' knowledge is most relevant in this context. He might ultimately be responsible for the initial investment decision, including the deal structure and the staging of the deal.

The literature argues that the 'lead VC' usually is the biggest, oldest, or most knowledgeable VC in the syndicate. Lockett and Wright (1999, 2001), for instance, suggest that the lead VC is the party bringing the most resources to the syndicate in terms of the specific skills to identify, screen, and monitor the investment. Kaplan and Strömberg (2003) also note that 'in a typical financing, one VC leads the round by negotiating the terms. If the VC chooses to syndicate the round, other VCs typically invest on the same terms as the lead VC. Similarly, Valliere and Peterson (2004) find that, in a considerable number of occasions, VCs exclusively rely on the due diligence activities of a trusted syndicate partner who effectively takes on the lead role in the syndicate. Together, this might suggest, that it is particularly the lead VC's knowledge that determines the deal structure, including the round-length.

From the above discussion it is evident that there is no clear answer as to which, if any, knowledge - i.e. the lead VC's knowledge and/or the syndicate's knowledge is likely to be most relevant for investment performance.

However, given the choice between the above two alternatives, we reckon that if there is any relation between VC/syndicate knowledge and staging (round-length) at all, this should be particularly pronounced with a view to the knowledge of the most knowledgeable VC in the syndicate – independently of whether he actually is the lead VC or not.

This is because it seems unlikely that the most knowledgeable VC would agree to invest in the opportunity if he wasn't happy with the deal structure, including the staging of the deal. Furthermore, it is not evident why the syndicate should not make use of the experience of its highest-quality member, even if it is not the lead investor. Therefore, one might conclude, it should be the most knowledgeable VC in the syndicate who should impinge on important decisions such as deal structure, deal size and, by this token, round-length. In case of unsyndicated rounds, the sole VC obviously is also by definition the most knowledgeable VC.[195]

As a consequence, and following our arguments in Chapter D, we propose that, on the round level, *the knowledge of the most knowledgeable 'lead' VC should be more influential for the syndicate's investment approach than the average knowledge of the syndicate; but both the 'lead' VC's knowledge and the average syndicate's knowledge will be the more influential the more specific that knowledge is with respect to a particular venture under consideration.*

Together, the above, results in our **Hypothesis 2:**

Other things equal, there is an unsigned relationship between VCs' knowledge and round-length; and this relation is more pronounced:

a) the better matched the VCs' knowledge is with respect to the investee venture under consideration; and

b) for the knowledge of the most knowledgeable 'lead' VC than for the average knowledge of the syndicate participating in the round.

As is evident from the above hypothesis, our main focus in the empirical work will be on the role of VCs' knowledge for the staging (round-length) of investments. This is because the extant literature has neglected the fact that VC-

[195] Although we assume that the above arguments suggest a stronger relation between the 'lead' (most knowledgeable) VC's knowledge and round-length than between the syndicate's knowledge and round-length, we are aware that this is a rather speculative assumption. Therefore, as we will outline further below in our methodology section, we examine both types of knowledge, the 'lead' VC's knowledge and the syndicate's (average) knowledge.

related factors in general, and VCs' knowledge in particular, are likely to impact VCs' assessment of the cost-benefit trade-off of staging.

However, as the first part of our hypothesis ('other things equal') indicates, we are aware that not only VCs are likely to differ with respect to their knowledge, but also other factors that might affect VCs' perception of the risk associated with an investment opportunity, and therefore also the VCs' assessment of the above-mentioned 'staging trade-off'. Therefore, as we will describe in more detail in the following section, we also control for a number of additional - context-, venture- and VC-related - variables in our analysis.

G.IV. Methodology

In the following section we describe our methodology for examining Hypothesis 2. This includes a description of the variables and their operationalization, the statistical method used, and the analytical approach taken.

G.IV.1. Variables and their operationalization

G.IV.1.a) Dependent variable

In our main analysis, the dependent variable (DV) to measure the staging-intensity is the (continuous) *round-length*, operationalised as the time in days between the beginning of one round to the beginning of the next.[196]

As already outlined in Chapter E.a ('Sampling and Data'), in our original sample, there are several cases with very short 'rounds'. For instance, about 1% of what Venture Economics (VE) calls 'rounds' are less than 30 days long, and about 8% are less than 90 days long.

We reckon that those very short 'rounds' (i.e. those lasting less than 90 days) are unlikely to be distinct 'rounds'. Rather, the short round-length might be due to mistakes by VE (either coding or data input errors). This assertion is also supported by Lerner (1994), who finds that VE sometimes lists as different rounds what is instead a different investment in the same round. We therefore combine 'rounds' shorter than 90 days with the previous rounds and adjust all variables correspondingly.[197]

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[196] This entails some problems, which we will address further below in the section on the analytical approach.

[197] In further unreported analyses, we do the same for all investments in the same venture made with in 30 days (instead of 90 days), obtaining essentially the same results.

G.IV.1.b) Theoretical variables

As already discussed in detail above (Chapter D), the theoretical variables for the examination of our hypothesis are *five different proxies for VCs' knowledge*: the VCs' 1) age, 2) non-biotech experience, 3) total experience, 4) biotech expertise, 5) biotech-stage expertise.[198]

These variables and their operationalization have already been described further above, and we therefore refer the reader to our propositions in Chapter D for more details.

In short, however, we operationalise VCs' age by the time (in years) between the VC organisation's foundation and the date of the particular investment under consideration[199]. All other theoretical variables are operationalised as the cumulative number of a VC's investments until the year prior to the investment under consideration, respectively in: non-biotech ventures (non-biotech experience), all types of ventures (total experience), biotech ventures (biotech expertise), and biotech ventures of the same stage as the venture under consideration (biotech-stage expertise).

Since we conduct our analysis at the round level (where the round might involve syndicates or sole VCs), and since we are also interested in a comparison of the relation between the overall syndicate's knowledge versus the 'lead' VCs' knowledge and round-length, we then average the knowledge of all VCs participating in a round to obtain the *average knowledge of the syndicate*. We identify the most knowledgeable VC in each syndicate to obtain the *knowledge of the 'lead' VC*. With respect to the latter, it should further be mentioned that - depending on the specific proxy for the VCs' knowledge analysed - the identified 'lead' VC in a syndicate might change. To illustrate this: in a syndicate there might be one old VC, who would be considered the 'lead' VC in this syndicate when analysing the relation between the VCs' age and round-length; but there might be another VC in the same syndicate, who has the most biotech investments under his belt, and therefore would be considered the 'lead' VC in this syndicate when analysing the relation between the VCs' biotech expertise and round-length.

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[198] At this stage, it should be mentioned that we do not include the 6th proxy discussed in Chapter D, the VCs' biotech-sub-sector expertise, in our final analysis because preliminary analyses have shown that the results for this proxy are qualitatively the same as for the VCs' biotech-stage expertise.

[199] In those cases where a VCs' foundation date is unknown we use the date of the VCs' first investment noted in the Venture Economics database.

G.IV.1.c) Control variables

Whilst our focus is on the above-mentioned theoretical variables, we acknowledge that several other factors are likely to be related to round-length as well. They broadly fall into four groups: context-, VC-, finance-, and venture-related factors. With a view to those factors, without much extant research to build upon, it often seems too speculative to hypothesise about the direction/sign of this relationship. However, we control for these other factors in our baseline model to discover the strength of association between our theoretical variables (the proxies for VC knowledge) and the dependent variable (round-length) over and above these extraneous factors.[200]

Context-related control variables

Although it is clear that VCs' decisions do not take place in a vacuum but are instead influenced by the situation in the (venture capital) markets, this issue has been neglected in research on staging of venture capital investments. Only Gompers (1995) notes that the round-length is likely to be impacted by contextual aspects such as the liquidity in the venture capital markets. Therefore, to remedy this omission in our baseline model, we control for four contextual variables.[201] These are as follows.

Number of active VCs: One factor with possible impact on the round-length is the total number of VCs actively investing in a given year. In this context, it

[200] Here, it should be mentioned that there are also some other factors with likely influence on the round-length that were identified in previous research. Kaplan and Stroemberg (2002), for instance, predict that staging should be related to several aspects of uncertainty associated with an investment opportunity, such as whether or not a venture is already generating revenues, whether or not an entrepreneur has already successfully brought a previous venture to IPO or acquisition, and/or the venture's industry long-term debt ratio. Similarly, Cuny and Talmor's (2003) model points towards the likely relevance of the venture's particular technology and the required non-monetary inputs by the VC to realize this technology for the most appropriate type of staging. We acknowledge that those aspects potentially might be of relevance, but unfortunately we do not have the necessary information in our data to control for them.

[201] In preliminary analyses, we also tested some additional context-related factors such as the time (individual years or periods of 2-5 years) when the investment took place, as well as the U.S. Prime rate, the Dow Jones Industrial, the Nasdaq, and the Nasdaq Biotech indices - and their % changes in the year of the investment compared to the previous year. Overall, those variables showed no consistent relation to round-length. At the same time though, their inclusion did not increase the explanatory power of the models, but, instead, caused some problems of multicollinearity with other context-related factors that were included in the models. As a consequence, we opted to leave out those factors from the analysis and to keep only those factors, which did not cause problems of multicollinearity and for the inclusion of which we had plausible theoretical arguments.

seems recommended to consider all VCs, independent of whether they have already invested in the focal industry (biotechnology) or not, because even if a VC hasn't previously invested in biotech, he might decide to do so, and by this become a 'biotech VC'. Furthermore, because of the cyclicality in the markets - that might make it difficult for the (number of) VCs to adjust to the number of investment opportunities - and because the absolute number of VCs dramatically increases towards the end of our sampling period, we feel it is more appropriate to consider the change in the number of VCs rather than the absolute number of VCs in this context.[202] Therefore, we control for the percentage *change in the number of VCs investing venture capital* in the year of the investment under consideration compared to the previous year.

Number of 'active' biotech ventures: Related to the above, it seems also likely that the number of biotech ventures receiving venture capital influences the round-length. Again, we feel it is more appropriate to use the percentage change rather than the absolute number because the later increases towards the end of our sampling period.[203] Therefore, we control for the percentage *change in number of biotech ventures receiving venture capital* in the year of the investment under consideration compared to the previous year.

Venture capital raised: If the round-length is related to the deal size (see our discussion further below), than it seems plausible to assume that also the overall

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[202] However, it is not clear what direction the relation between these two variables has, if it exists at all. On the one hand, one might expect a positive relation between this variable and round-length because an increase in the number of VCs – unless it coincides with a similarly sized increase in the number of biotech investment opportunities – should increase competition between VCs and this, in turn, the negotiating power of ventures, which generally can be assumed to prefer longer round-length. At the same time though, it might be that the investment activity in the biotech sector follows other trends than the overall VC investment activity. As such, an increase in the number of all VCs might not necessarily lead to an increase in competition for investments in biotech; and it could be possible that the increasing proportion of VCs mainly invests in other sectors. In this case we wouldn't expect no or a positive relation between this variable and round-length.

[203] Also with a view to this variable, it is not obvious what direction its relation to the round-length might have. We would generally expect a negative relation between the change in the number of biotech ventures receiving venture capital and round-length. This is because an increase in investment opportunities is likely to decrease competition between VCs for such opportunities and, in turn, the negotiating power of ventures looking for funding. This assertion, however, is only likely to hold as long as the increase in the number of investment opportunities does not coincide with a parallel (or bigger) increase in the number of VCs. If the latter occurs, competition amongst VCs would remain the same or even increase; and, in this case, one might expect no, or even a positive relation between the two variables.

liquidity in the venture capital markets is related to the round-length (cf. Gompers, 1995). In this context, we again suggest that it is more appropriate to consider the change in venture capital raised than the absolute amount of venture capital raised, because the latter increases dramatically towards the end of our sampling period. Furthermore, and identical to our arguments further above, we feel it is more appropriate to use the total amount raised, and not just the biotech amount raised, because biotech investments represent a sub-sample of all investments by VCs. Although VCs often raise funds from their investors for investments in particular types/industries of ventures, many VCs also have considerable discretion about their investment decisions. As such, if there are good investment opportunities perceived to exist in biotechnology, more funds should go into this sector.[204] Therefore, we control for the percentage *change in the total venture capital amount raised by all VCs* in the year of the investment under consideration compared to the previous year.

Boom years 1996-2000: Finally, it seems also plausible to assume that whether or not a deal took place during the unprecedented high-tech-boom years between 1996 and 2000 should be related to the round-length of this deal as well. During this period, there was to be observed a massive capital inflow into the venture capital industry; many new and arguably inexperienced VCs entered

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[204] Again it is not obvious what sign the relation between the liquidity in the VC markets and the round-length has, if it exists at all. If more funds are available for investments, this should reduce the VCs' financial constraints, and might make them more inclined to accept longer rounds. This might be, for instance, because VCs generally prefer the economies of scale coinciding with larger investments. Gompers (1995), for instance, suggests that in times of low capital inflows VCs would like to make more and bigger investments but they are unable to raise enough money to invest in all of these projects. Whilst constraints restrict investment, greater commitments to new funds might generate free cash flows, which might lead VCs to invest *more money per round and to invest more often*. Indeed, Gompers (1995) finds that in periods when VCs are able to raise more capital for new investments they invest more frequently in the ventures they finance. As such, the relation between increasing liquidity in the venture capital markets and round-length might depend on whether VCs invest more often (more funds) in the same or in different ventures. In the former case one might expect a negative relation between liquidity and round-length, in the latter case a negative relation. Furthermore, growth of the VC pool may measure entry by inexperienced VCs; and these new entrants may over-invest and may not monitor companies as effectively as experienced VCs. At the same time, it might also be that additional entry of new VCs leads to an increases in competition amongst active VCs, resulting in a increased negotiating power of ventures looking for funding, and, correspondingly to a even stronger positive relation between 'change in venture capital funds raised' and round-length. Finally, as mentioned before, it is also possible that the venture capital investment activity in biotechnology is 'decoupled' from the overall venture capital investment activity. Then, there might not necessarily be a (positive or negative) relation between the overall funds raised by VCs and the round-length of biotech deals.

the arena; and even many established VCs were said to have suffered from an 'irrational exuberance'. Overall, this might have resulted in the 'normal laws' – if there are any – determining VCs' deals were set out of power during those boom years. But for the same reasons already outlined in the previous two sections it seems even more speculative to Hypothesise about the direction of a possible relation between the 'boom'-dummy and round-length. Therefore, we control for whether or not a round occurred during the *high-/biotech-boom years (1996-2000)* by a dummy variable that takes the value of '1' if the investment takes place in the years 1996-2000, and the value of '0' otherwise

Venture-related control variables

The next set of control variables for our baseline models covers venture-related aspects as likely (co-) determinants of the round-length. Some of these have already been suggested in the extant literature (mainly by Gompers, 1995), and some are suggested by us for the first time.

Venture stage: Extant literature suggests, from an agency perspective, that VCs should show tighter monitoring – i.e. shorter round-lengths - when investing in ventures where information asymmetries are high. For reasons outlined above, this is likely to be the case with a view to ventures in start-up, seed, or early stages of their development. However, some empirical literature finds this not to be the case.[205] Therefore, we control for whether or not a round involves an

[205] Sorenson and Stuart (2001: 1558), for instance, note 'the difficulty of opportunity appraisal and the importance of monitoring vary with the target company's development stage. Evaluating extremely early-stage companies proves difficult because they lack track records for making informed quality assessments. In contrast, venture capitalists can judge the quality of the management team in light of its performance on a number of different performance metrics in latter stage companies. In addition to offering more data to inform the due diligence process, latter stage companies might also require less intensive monitoring'. Similarly, Kaplan and Stroemberg (2002, 2003) predict that staging should be related, amongst other factors, to whether or not a venture is already generating revenues – which is particularly unlikely in the venture's early development-stages. Also Bergemann and Hege's (2003) model predicts that the funding horizon are increasing from one stage to the next – emphasizing the notion that the early stages are the riskiest in an innovative venture. Similarly, Hsu (2003: 9) points out: 'it is important to study early-stage financing rounds. [...] earlier rounds of financing are usually associated with more technical and demand uncertainty'. However, there is also some indication that early-stage rounds are not necessarily shorter than later rounds. Gompers (1995), for example, finds – contrary to his predictions – no significant relation between the stage of an investee venture and round-length; and early stage rounds appear even to be longer than latter stage investments rounds (although not significantly so). Furthermore, also Bergemann and Hege's (1998) above-mentioned model of staging, which predicts that VCs might control a venture's process more intensively in latter stages of its development, because only then there is sufficient information available to distinguish good from bad projects.

'*early-stage venture*' by a dummy variable that takes the value of '1' if the round under consideration involves a venture that is in the start-up, seed, or early stage of its development (according to the Venture Economics categorisation), and the value of '0' otherwise.

Venture age: This variable is likely to be related, but not identical, to the previous variable (venture stage at round), in that most ventures over time (with increasing age) go through subsequent stages of their development. Therefore, the age of the venture - independent of its stage - is likely to be of relevance for the VCs' risk perception, too. This is because, even although an older venture might not have progressed into the next steps, the sheer fact of its longer existence should allow the investor to make more informed judgements, for instance, regarding the general abilities of the venture's management team. However, in the extant literature, theoretical predictions and empirical findings on this aspect sometimes diverge.[206] Therefore, we control for the '*age of the venture*' at the time of the round, measured by the time in years between the venture's foundation date and the date of the particular financing round.

Venture first round of funding: Controlling for whether a round is a first round or not seems important for our project for several reasons. Most extant research on staging has neglected the fact that many ventures receive funding in several rounds from the same or different syndicates - with one exception being Kaplan and Strömberg (2002), who predict that staging should be related, amongst other things, to whether or not the round is the first VC round in the venture, but who actually find - contrary to their predictions - that the length of first rounds is (significantly) longer than the length of later rounds.[207] Therefore, we

[206] Gompers (1995), for instance, expects that holding the stage of development and all else constant, informational asymmetries are smaller in older than in younger ventures, making tight monitoring of older ventures less critical; and he indeed finds a positive relation between the venture's age and round-length - although only in case of low- but not in case of high-tech ventures. This could be because, in case of very young ventures (particularly in high tech sectors), in the very beginning it is unlikely that significant information emerges and/or because the cash burn of very young ventures are likely to be smaller.

[207] Here, we would generally expect a negative relation between first round investments and round-length. When investing in a first round, a VC will usually conduct an in-depth due diligence. However, this will provide him mainly with information about the external risks and uncertainties associated with an investment; but it will only provide limited information about the internal risks, uncertainties, and information asymmetries associated with the particular investment. Therefore, in first rounds, the information asymmetries between investors and ventures are particularly high. As a consequence, in first round investments the VCs' should be particularly wary, leading to tighter control and shorter investment rounds. In later rounds information asymmetries are likely to be

control for whether or not the round under consideration is a *'first round'* by a dummy variable that takes the value of '1' if it is a first round, and the value of '0' otherwise.

Venture from US: Although previous literature on staging has neglected the nation of the ventures, in which the investment takes place, we believe that it is appropriate to control for this aspect because there is growing attention to the differences between venture capital markets in different countries (Black & Gilson, 1998; Jeng & Wells, 2000; Kaplan et al., 2003; Manigart et al., 2002; Sapienza et al., 1996).[208] Therefore, we control for whether or not the round under consideration involves a *'venture from the US'* by a dummy variable that takes the value of '1' if the venture under consideration is located in the US, and the value of '0' if it is located in any other nation.

Venture sector 41: One of the shortcomings of most previous research on venture capital might be seen in the fact that those studies did not (or not appropriately) differentiate between different – e.g. high- and low-tech - industries of investee companies. This is despite the fact that those differences are likely to translate into differences in risks, and thus also into different investment approaches by VCs, including the decision on round-length.[209] Whilst

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smaller, for instance, because the same VC had already invested in a previous round of the same venture (and thus gathered valuable internal information about it). But even if the VC invests for the first time in a latter round, the venture will have a longer (and possibly documented) track record to base an investment decision on. Furthermore, first-time latter round VCs might have access to previous investor's (due diligence and/or venture performance) documentation. Whatever the specific information available to the VC in a latter round, it should help him in reducing the information asymmetries and uncertainties that are particularly likely to exist earlier investment rounds.

[208] Indeed, some previous research suggests that there are differences in the investment approach of VCs from different countries, for instance with a view to their syndication behaviour (Lockett & Wright, 2003; Manigart et al., 2004). For instance, it seems, U.S. VCs tend to syndicate more frequently than their European peers. However, without much previous research to build upon in the context of staging, we feel it is too speculative to hypothesize about the potential direction in the relation between the venture's nation and round-length. For instance, it seems equally likely that in the U.S., as the nation with the most mature venture capital and biotechnology industry round-lengths are longer or shorter than in other nations.

[209] This assertion also finds some support form other researchers. As outlined before, Gompers (1995), for instance, argues that the nature ('tangibility') of the assets in a venture's industry is likely to influence the deal structure, including the round-length. The less tangible those assets and the more important the future growth options in the venture's industry, the greater the potential agency risks, and the tighter therefore should be the control by the VCs. Also, Kaplan and Stroemberg (2002) predict that staging should be related to the venture's particular industrial sector.

we exclusively focus on one particular high-tech industry, biotechnology, we acknowledge that also within this sector there are likely to exist important differences between various sub-sectors, which might involve different technologies, business models, and challenges for both entrepreneurs and investors. For instance, biotech companies might be active in comparatively 'low'-risk sub-sectors such as 'development of environmental cleaning/protection technologies; or they might be active in very high-risk subsectors that not only face the 'normal' risk of project failure for scientific reasons but also the additional risk of official approval failure. With a view to the latter, the VE sub-sector 4100 (development of human drugs; see Appendix I for the VE categorization of biotech sub-sectors) is arguably most risky because its projects not only face enormous scientific risks, but are also extremely time- and cash-consuming, and subject to very rigid approval procedures (see Appendix I for a description of the drug-developing process).[210] Therefore, we control for whether the round under consideration involves a *'venture from sector 41'* by a dummy variable that takes the value of '1' if the venture under consideration is mainly engaged in research and development of human drugs (VE biotech-subsector: '4100') and the value of '0' otherwise.

Finance-related control variable

Round amount ('deal size'): One key factor to control for when one is interested in the relationship between VCs' knowledge and round-length is certainly the amount received by a venture in this round: all other things equal, the larger the deal-size, the longer a venture should be able to 'survive' before it has to get a new capital infusion.[211] Therefore, we control for the *round amount* ('deal size'),

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[210] One might expect high-risk sub-sectors, such as sub-sector 4100, to be associated with shorter round-lengths. However, it seems also possible that this sub-sector in fact is associated with longer round-lengths, because it might take more time for ventures in this sub-sector to reach milestones that allow evaluating their actual progress.

[211] We acknowledge that the assumption 'all other things equal' represents a strong simplification. In practice, the relation between round amount and round-length is likely to be more complicated: different ventures, and even the same ventures over time (i.e. in different development stages), are likely to have different cash-burn-rates. So, given the same deal size, one venture will last longer than another venture, as will one round in one venture in a particular stage compared to another round in the same venture in a different stage. However, we also control for the ventures stage and age and therefore feel entitled to make the assumption of a positive relation between round amount and round-length, other factors constant. At the same time, the reader is referred to Gompers' (1995) above-mentioned findings that larger financing rounds do not lead to longer round-lengths. From this Gompers (1995) concludes that venture- (and industry-specific) factors determine the

measured as the total amount invested by all VCs participating in a deal (and by the sole VC in case of an unsyndicated deal).

VC-/syndicate-related control variables

The fourth and final set of control variables concerns VC-related factors, other than their knowledge, which we believe are likely to be related to the round-length but neglected by previous research.

Syndicated round: Although extant literature on staging has neglected the fact that most deals involve more than just one VC, we include this variable in our baseline model since it seems reasonable to assume that syndication reduces the risk associated with an investment for the individual VC. As discussed above in more detail (see Chapter F), this is because a) syndication will typically reduce the financial contribution of the individual VC to a particular venture thus allowing him to spread his investments over several different ventures, and/or b) because other VCs may bring additional expertise to assess an opportunity prior to the investment and/or to manage it after the investment has taken place. In addition, as shown in the previous chapter, syndicated deals are usually larger than unsyndicated deals; and a larger deal size might be assumed to increase the lifeline of a venture or be matched to a longer period of venture activity. As such, we would assume that if a round is syndicated, this should be positively related to the round-length. However, as we have also shown in the previous chapter, more knowledgeable VCs are less inclined to syndicate. From this it seems possible that syndicates are, on average, less knowledgeable than sole VCs; which could also become manifest in different deal structures and round-lengths. Therefore, we control for whether or not the round under consideration is a '*syndicated round*' by a dummy variable that takes the value of '1' if the focal round is syndicated between two or more VCs, and the value of '0' otherwise.

Investor type: Although, to our knowledge, no prior research exists on whether there are differences in the deal structures of different types of investors, it seems reasonable to assume that this is the case, for instance, because 'true' private equity investors might be assumed to be most proficient in identifying and dealing with the risks associated with those ventures looking for venture capital. But again, without any previous research to build upon, we feel it is too speculative to hypothesize about the potential direction in the relation between

round-length independently of the investment size. However, as mentioned above, it is not evident in this study whether he controls for different cash burn rates.

the VCs' type and round-length. Therefore, we control for the investor type '*private equity partnership*', measured as % of VCs in a syndicate that – according to VE - are true independent private equity partnerships (VC in a narrow sense).[212]

VC-venture proximity: To control for this variable seems of relevance because considerable literature points out that VCs as relationship investors that take an active role in the management and/or control of their investments. Clearly, it is more difficult for VCs to fulfil this role if they are geographically and/or culturally distant from their investment venture. For instance, Sorenson and Stuart (2001) find that the likelihood that VCs invest in new ventures declines sharply with geographic distance. Generally, we would expect the proportion of VCs coming from the same country as the investee venture to be positively related to round-length, because it should ease continuous monitoring in form of onsite visits, participation on boards etc. At the same time though, we have to acknowledge that our operationalization of this variable is rather crude since it considers, say, a Californian venture and a New York VC as coming from the same nation, but not a German venture and a French VC– although the later are clearly closer to each other from a geographically perspective. Nevertheless, we reckon, because the later pair is more distant than the former from a cultural, language, political, and legal perspective, it makes sense to control for this by the variable suggested. Therefore, we control for the '*VCs from same country as venture*', measured as % of VCs in a syndicate that - according to VE - come from the same country as the venture.[213]

G.IV.2. Statistical method and analytical approach

In this section wee describe the statistical method and the overall analytical approach used to test our Hypothesis 2.

G.IV.2.a) Statistical method

Our dependent variable (DV), round-length, is continuous, our theoretical/ independent variables (IVs) are continuous, and our control variables are a mixture of continuous and dummy variables. Therefore, we employ multiple

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[212] Unreported analyses that use dummy variables for the different investor types instead of % values result in qualitatively similar findings.

[213] Unreported analyses that use dummy variables (taking the value of 1 if at least one VC from the syndicate comes from the same country as the venture) instead of % values result in qualitatively similar findings.

regression analysis (MR) to examine our Hypothesis 2. Our approach mainly follows the recommendations by Hair et al. (1998), Tabachnick and Fidell (2001), and Gujarati (2003).

The objective of MR is to fit a statistical model to the data and use that model to predict values of the DV from one or more IVs. This is allows one to go a step beyond the data that one actually possesses. The model fitted to the data is a linear one in the parameters and summarizes the scatter of points in a 2-dimensional space with a straight line. Any straight line can be drawn if one knows two things: 1) the slope (or gradient) of the line, and 2) the point at which the line crosses the vertical axis of the graph (the intercept). As such, the equation of a straight line (with just one IV) is defined as:

$$Y = \beta_0 + \beta_1 X_1 + \varepsilon_1$$

where Y is the DV that one wants to predict; X_i is the *i*th subject's score on the predictor variable; β_0 is the intercept and β_1 is the gradient of the line; and the residual term, ε_i, represents the difference between the score predicted by the line for subject *i* and the score that subject *i* actually obtained. This easily generalises to n-dimensions in which case we fit an n-dimensional hyper plane to the set of points.

There are several ways to fit a straight line to the data collected. The most commonly used mathematical method is the *method of least squares*. This method searches for the 'line of the best fit' ('regression line') that, of all possible lines, results in the least amount of differences (residuals) between the values predicted by the line, and the data that were actually observed.

Once one has found the 'line of best fit', it is important to assess how well this line fits the actual data, i.e. to assess *the goodness-of-fit of the model*, and to asses the explanatory contribution of the individual IVs, and to test whether their estimated coefficients are generalizable beyond the sample data to the overall populations (Hair et al., 1998).

To *assess the overall model*, commonly used measures are the: R^2, the adjusted R^2, and the ANOVA/F-ratio-change. The R^2 (coefficient of determination) describes the amount of variation in the outcome variable that is accounted for by the model. The adjusted R^2 additionally takes into account the number of IVs included in the regression equation and the sample size. It is useful for comparison between equations with different numbers of IVs and/or different sample size. It becomes smaller as one has fewer observations per independent variable. Although the addition of IVs will always cause the R^2 to rise, the adjusted R^2 may fall if the added variables have little explanatory power and/or if the degrees of freedom become too small. Whereas R^2 tells how much of the variance in Y is accounted for by the regression model, the adjusted value tells how much variance in Y would be accounted for if the model had been derived from the population from which the sample was taken. The *Anova* tests whether the model is significantly better at predicting the outcome than using the mean as a 'best guess'. As such it tells whether the model, overall, results in a significantly good degree of prediction of the outcome variable (but, in MR, it does not provide information about the individual contribution of variables in the model). Here, the F-ratio (mean squares of model / mean squares of residuals) is a measure of how much the model has improved the prediction of the outcome compared to the level of inaccuracy of the model; it is used as a statistic in the F-test. If a model is good, one expects the improvement in prediction due to the model to be large and the difference between the model and the observed data to be small. In short, a good model should have a large F-ratio (greater than 1 at least) because the top half of the equation will be bigger than the bottom half. The exact magnitude of this F-ratio can be assessed using critical values for the corresponding degrees of freedom.

To *test the statistical significance of the IVs' $\beta_{0/i}$ coefficients* is necessary when the analysis is based on a sample and not the overall population.[214] In that case one is interested not only in the estimate for just that sample but in how generalizable the results are to the population, i.e. of whether the estimated coefficients will indeed be different from 0 across a larger number of samples of a certain size. This is tested with the t-test, where the t-statistic is calculated as: $t = (\beta_{observed} - \beta_{expected}) / SE\beta = \beta/SE\beta$; where $\beta_{expected}$ is the value of β that one would expect if the null hypothesis (i.e. the coefficient is 0) were true. The values of t can be compared to the values that we would expect to find by chance alone; if t is very large then it is unlikely to have occurred by chance, and the corresponding p-value would be small (e.g. $p<0.1$); and, SE tells one something about how different β values would be if one took many samples of

[214] The $\beta_{0/i}$ coefficients of the IVs indicate the individual contributions of each predictor variable to the model, where β_0 can be interpreted as the value of the outcome when the predictor values are 0, and β_i presents the change in the outcome resulting from a unit change in the predictor i. (NB: the β values in the regression model are the unstandardized values, in the units of the corresponding variables).

data and calculated the β values for each of them.[215] The smaller the significance and the larger the value of t, the greater the contribution of a predictor – and the more likely it its that one is right to accept the hypothesis that the β value is significantly different from 0 and that the predictor variable contributes significantly to our ability to estimate values of the outcome.[216] If the SE is very small, then it means that most samples are likely to have β values similar to the one in the sample collected (because there is little variation across the samples). As such the t-test tells us whether β is significantly different from 0 relative to the variation in β values for similar samples. When the SE is small, even a small deviation from 0 can reflect a meaningful difference because β is representative for the majority of possible samples.

When a MR analysis is done, the resulting equation is correct for the sample of observed values. However, usually one also wants to know whether the model generalizes. The basic issue here is whether, in course of calculating the regression coefficients and predicting the DV, the *assumptions of the MR analysis* have been met; and if one finds that the model is not generalizable, one must restrict any conclusions to the sample used.

In this context, the most fundamental assumptions of MR are *linearity* of the phenomenon measured, *normality*, *homoscedasticity*, *independence* and *absence of serial correlation in the error terms*. Furthermore, it is recommended to test for outliers/influential cases in the solution. Finally, for the estimation of the parameters of the regression to be computationally possible the data matrix X'X should be non-singular. Violation of this assumption is described as a situation of perfect (multi) collinearity amongst the independent variables (IVs).[217]

Since the multivariate model acts collectively for the variables in the analysis it must meet the same assumptions as the individual variables, and the evaluation

[215] Hence one can use the SE (i.e. the SD of this sampling distribution) as a measure of similarity of β values across samples. The standardized β values tell us the number of SDs that the outcome will change as result of one SD change in the predictor. To interpret these values literally, one needs to know the SDs of all the variables (to be found in the SPSS output on the descriptive statistics)

[216] NB: since the magnitude of the β values depends on the units of measurements, the t-test is calculated by using standardized β values, i.e. taking account of the SE.

[217] If those assumptions are met, the coefficients and parameters of the regression equation are said to be unbiased, and the model for a sample can be accurately applied to the population of interest. However, even an unbiased model only says that *on average* the regression model from the sample is the same as the population model; but even if all assumptions are met a sample model might not always be identical to the population model.

of assumptions has to be done twice: first, for the individual original variables, and, second, for the variates after the multivariate model has been estimated. With a view to the latter, the principal measure is the residual – the difference between the observed and predicted values of the DV (which represent the total effect of the variate).[218]

Violations of each assumption can be identified by specific patterns of the residuals, and several statistical tests that are specific for each assumption can complement the visual analysis.[219]

In the following, we describe how we test those assumptions and how we address situations where they are not met.

One assumption underlying MR is that of *linearity*, i.e. that there is a straight-line relationship between two continuous variables.[220] In the pre-analytical stage, we test for linearity in the relationship between each individual IV and the DV by partial regression plots, and in the post-analytical stage, by residual plots, where standardized residuals are plotted against predicted values. In those cases where we find indications of non-linearity, we try several transformations of the involved variables. However, since those transformations do not qualitatively change our findings, we base our main analysis on - and report the results for - the original, untransformed variables.

Another fundamental assumption underlying MR is that of *normality* of the variables included in the analysis, and particularly of the dependent variable

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[218] When examining residuals, some form of standardizations is recommended, as it makes the residuals directly comparable (in their original form, larger predicted values naturally have larger residuals). The most widely used is the *studentized residual*, whose values correspond to t values. This correspondence makes it quite easy to assess the statistical significance of particularly large residuals.

[219] One plot of particular interest is the *null plot*, the plot of residuals when all assumptions are met. It shows the residuals falling randomly, with relatively equal dispersion around 0 and no strong tendency to be either greater or less than 0. Likewise, no pattern is found for larger versus small values of the IV.

[220] Linearity is important in a practical sense because MR is based on the concept of correlation, which only captures the linear relationships and ignores nonlinear relationships. The result of non-linearity is an underestimation of the actual strength of the relationship. However, often two variables have a mix of linear and curvilinear relationships: one variable generally gets smaller/larger as the other gets larger/smaller, but there is also a curve to the relationship. The linear components may be strong enough that the curvilinear component might be ignored; but usually a curvilinear pattern (in the residuals) indicates that corrective action will increase both the predictive accuracy of the model and the validity of the estimated coefficients.

(DV).[221] In the pre-analytical stage, we test for the normality by checking the values of the skewness and kurtosis of the distributions of the individual variables as well as by the corresponding Kolmogorov-Smirnov test for Normality. In the post-analytical stage, we graphically inspect the distributions of the residuals in residual plots and normal probability plots. Again, we find indications of non-normality of several variables, including the DV: most of the variable distributions are highly skewed to the left and are more/less peaked than a normal distribution would suggest. As a consequence, we try several transformations (e.g. square root, log, log plus constant inverse, inverse plus constant) of our key variables to make their distribution more normal. Furthermore, we estimate the regression analysis with both the original and transformed variables. However with the exception of a log-transformation of the dependent variable (round-length), most transformations amend the non-Normality of our variables only to some degree; and the problem of skewness and (more or less) long tails largely persists; and the transformations do not change our results qualitatively.

Therefore - following Hair et al. (1998), who note that although regression analysis has been shown to be quite robust even when the Normality assumption is violated - for our final analysis, we only used the transformed version of the DV (log of round-length), but kept all other variables in their untransformed version.

Moreover, an important assumption of MR is that of homoscedasticity.[222] We test this with the Levene test (which measures the equality of variances for a single pair of variables) and visually by inspecting the 'partial plots' between the

[221] Generally speaking, if the variation from the Normal distribution is very large, all resulting statistical test may render invalid as normality is required to use the F and t statistics governing the overall significance of the regression and of the individual (or groups of) explanatory variables. Although, large sample sizes are said to diminish the detrimental effects of non-Normality, this may not always be warranted. Statistical inference is said to become less and less robust as the distribution of the DV departs from Normality.

[222] Homoscedasticity means that, at each level of the IV(s), the variance of the residual terms of the regression should be constant. Otherwise, there is heteroscedasticity. Many times, a number of violations occur simultaneously, such as heteroscedasticity and non-Normality. Remedies for one of the violations often corrects the problems in other areas as well. For example, because heteroscedasticity often is the result of non-Normality, a correction to remedy non-Normality might also remedy the unequal dispersion of variance. Therefore, heteroscedasticity might be remedied through data transformations similar to those used to achieve Normality. However, if at all, heteroscedasticity can only be remedied by transformations of the DVs (whilst non-Normality transformations usually involve the IVs).

residuals of the outcome variable and each predictor variable when both variables are regressed separately on the remaining predictors. Again, we try several transformations that do not result in qualitatively different findings, and therefore report the results of the untransformed data.

MR also is based on the assumption of *independence of the predicted values, i.e. absence of correlation between the prediction errors.*[223] We test for correlations between errors with the Durbin-Watson test, which examines whether adjacent residuals are correlated. Whilst we do not report the results of those tests, it should be mentioned that we do not find any indication of dependence in the predicted values / correlation in the prediction errors.

In addition, for the MR results to be generalizable, it is also important to assess *outliers* and *influential cases*. We have already described our general approach to identifying and dealing with those cases further above in Chapter E, to which the reader is referred to at this point. In a short version though, we test for uni- and multivariate outliers in the pre-analytical screening phase and in the solution. Based on this, we identify a number of cases that might potentially present outliers or influential cases. This is mainly due to extreme values of individual variables. However, a closer examination of those cases across different variables does not provide reason to believe that they are not part of the overall population. Furthermore, in preliminary analyses we run our regression models with and without those cases included. Since the results of those analyses do not differ qualitatively, we opt to run and report the final analyses with all cases included.

Finally, another important aspect in the context of MR is the absence of *multicollinearity* or singularity.[224] In the pre-analytical/screening stage, we test

[223] This means that the predicted values are not related to any other prediction, they are not sequenced by any variable, and their prediction errors are uncorrelated with each other. Otherwise, one might assume some unexplained systematic relationship in the dependent variable. If such a situation exists, one cannot be confident that the prediction errors are independent of the levels at which on is trying to predict, and Some other factor might be affecting the results, but is not included in the analysis. One possible reason might be the existence of separate groups in the observations, where similar factors affect one group but not another. If the observations from both groups are combined, then the final estimated relationship must be a 'compromise' between the two actual relationships.

[224] These are data problems, not problems of model specification, that occur when two or more variables are very highly correlated (multicollinearity) or redundant (singularity).

Multicollinearity and singularity cause both logical and statistical problems. The logical problem is that it is not good to include redundant variables (e.g. $r>.7$) in the same analysis because they are for this by visually examining the bivariate correlation coefficients in correlation matrices. In the post-analytical stage, we use multivariate collinearity diagnostics to identify potentially problematic variable(s). For this purpose, SPSS provides several diagnostics such as variance inflation factors (VIF), tolerance values, eigenvalues, condition indices, and variance proportions. At this stage, it should be mentioned that in course of several preliminary analyses, we identified several cases of (too) high bivariate and multivariate correlations both control variables and theoretical variables (e.g. non-biotech/total experience, biotech/-stage expertise, and/or age), which resulted in very instable parameter estimates. As a consequence, in the final (reported) analyses, we included only those variables that did not show any problems of multicollinearity.

G.IV.2.b) Analytical approach

Main analysis

As described above, our main analysis involves a multiple regression with the round-length as the continuous DV, five proxies for VCs' knowledge as theoretical variables, and several control variables; and it is based on all financing rounds in our sample for which we have information on all the relevant variables.

In this context, we hypothesized that the relation between VCs' knowledge and round-length would be the more pronounced (negatively or positively) the more specific the VCs' knowledge is at the point of investment. Therefore, we test the different proxies for VCs' knowledge individually using separate models. This allows us to contrast and compare both the overall predictive power of the models comprising the different proxies and the individual coefficients of each proxy.

Moreover, we are interested in the relation between round-length and the average syndicates' knowledge versus the 'lead' VCs' knowledge. Therefore, we conduct the above analyses in parallel for both syndicates and 'lead' VCs.

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not needed and because they inflate the size of the error terms, and by this actually weaken the analysis. The statistical problems (e.g. regarding matrix inversion) created by multicollinearity and singularity are said to occur at higher levels of correlation (e.g. r>.9) (Tabachnick & Fidell, 2001). The impact of multicollinearity is to reduce any IV's predictive power by the extent to which it is associated with the other IVs. As collinearity increases, the unique variance explained by each IV decreases and the shared prediction percentage rises. This further reduces R (as a measure of the multiple correlation); and it often also results in unstable values for the regression coefficients.

As such, our main analysis comprises 10 different models (excluding the baseline models 0-1 to 0-4), each testing one knowledge proxy for either the syndicate (models 1-1 to 1-5) and for the lead VCs (models 2-1 to 2-5), respectively; but all using the same units of analysis (i.e. all rounds in our sample, for which we have information on all relevant variables).

Additional analyses

The above-mentioned approach to the main analysis, however, involves two potential problems.

One possible problem concerns the units of analysis employed. Specifically, one might argue that pooling *all* rounds in our sample could violate the assumption of independence between observations and introduce bias into our findings.[225] However, to test for this we examine (following our discussion above) the correlations between the regression error terms, and in fact do not find this in reality to be a problem. Nevertheless, we consider it important to double-check the findings based on sub-samples, in which possible problems resulting from the non-independence between some observations are reduced or eliminated.

For this purpose, we conduct one additional analysis using the same variables but only first rounds as the unit of analysis. In doing so we add two additional perspectives to our main analysis.

On the one hand, the approach ensures that each venture enters our analyses only once (since a venture can by definition have only one first round). This eliminates potential problems of non-independence between observations at the venture level and the potential problem of multiple entries of the same VCs in combination with the same ventures. It also significantly reduces the multiple entries by the same VCs into the data.

This approach is also interesting in that it looks only at situations where by definition the VCs have no previous 'insider' knowledge about the venture under consideration. Therefore, by using first rounds only we can study the effect in the focus of our interest, namely the role of VCs' knowledge that was acquired during previous investments in *other* ventures. This knowledge is in its 'purest' form, i.e. without being impacted ('watered down') by the VCs' specific knowledge regarding the venture under consideration. However, as mentioned

[225] For instance, some ventures enter our analysis several times because they receive several rounds of funding. Similarly, some VCs enter our analysis several times because they invest in different ventures and/or in different rounds of the same venture.

above, first rounds may be different in other aspects from later rounds. Therefore, we conduct the same analysis also for later rounds only.

Yet another issue in our main analysis concerns the DV, round-length. Specifically, this DV is truncated because, for many ventures in our sample we do not know the length of their last round.[226] As a consequence, we cannot include the last rounds of most ventures. This issue could be particularly problematic with a view to those ventures that have only received one round of funding (i.e. their first round, which simultaneously is their last round) during our sampling period. In those cases, we do not have any information on the length of this round (unless the venture goes public or gets acquired after receiving the first round); and, as a consequence, we cannot include those ventures. This not only reduces our sample size but it also may introduce some additional bias into the findings of the main analysis. For instance, we only examine the round-length of those ventures that have been successful enough to receive at least two rounds (and/or go public or get acquired). However, those ventures that have received only one round during our sampling period may either never receive a next round (and just get liquidated) or they may receive their next round any time after our sampling ends.

Therefore, we conduct an additional analysis using a sub-sample of observations (rounds) from those ventures that have had a real chance to receive at least a second round. Specifically, we use a sub-sample of ventures that have received at least one round of funding five years before our sampling ends (i.e. before 1998).[227]/[228]

The structure of the main and additional analyses is summarized in Table G-2.

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[226] An exception is those ventures whose last round ends with an event such as an IPO or an acquisition, for which we have a specific date.

[227] This corresponds to the mean round-length plus 2.5 standard deviations in our total sample. We acknowledge that also this approach does not completely eliminate potential biases, for instance, because the average first round-length might have changed over the years; but we consider it an adequate first step that at least eliminates the problem of excluding those ventures that simply have not had enough time yet to receive a second round of funding during our sampling period.

[228] Furthermore, we conduct, on the full sample of all rounds, a Cox regression analysis that accommodates for right-censoring in the data. Whilst we do not report the results of this analysis in detail, it should be noted that its results are qualitatively very similar to those of our main analysis.

Table G-2: Overview over the different models analysed in the context of Hypothesis 2

	Main analysis	**Additional analyses**		
Units of analysis:	**All rounds**	**first rounds**	**later rounds**	**Pre-1998 rounds**
Results in:	**Table G-4 Panel A**	**Table G-4 Panel B**	**Table G-4 Panel C**	**Table G-5 Panels A&B**
Baseline model (control variables):	Models (0-1 – 0-4)	Models (0-1 – 0-4)	Models (0-1 – 0-4)	Models (0-1 – 0-4)
Theoretical variables:				
Lead VC age	Model 1-1	Model 1-1	Model 1-1	Model 1-1
Lead VC non-biotech experience	Model 1-2	Model 1-2	Model 1-2	Model 1-2
Lead VC total experience	Model 1-3	Model 1-3	Model 1-3	Model 1-3
Lead VC biotech expertise	Model 1-4	Model 1-4	Model 1-4	Model 1-4
Lead VC biotech-stage expertise	Model 1-5	Model 1-5	Model 1-5	Model 1-5
Avg. syndicate age	Model 2-1	Model 2-1	Model 2-1	Model 2-1
Avg. syndicate non-biotech experience	Model 2-2	Model 2-2	Model 2-2	Model 2-2
Avg. syndicate total experience	Model 2-3	Model 2-3	Model 2-3	Model 2-3
Avg. syndicate biotech expertise	Model 2-4	Model 2-4	Model 2-4	Model 2-4
Avg. syndicate biotech-stage expertise	Model 2-5	Model 2-5	Model 2-5	Model 2-5

Finally, we compare (using a t-test) characteristics of ventures in our sample that have only received one round of funding during our sampling period (and therefore are not included in our main analysis) with those that have received at least two rounds (and therefore are included in our main analysis). This is intended to identify possible differences between those ventures, which might indicate potential biases in the results of our main analysis (the results of this test are to be found in Table G-6).

G.V. Results

This section presents the descriptive statistics and results for both the main analysis and the additional analyses in the context of our examination of Hypothesis 2.

G.V.1. Descriptive statistics

Table G-3 Panel A shows descriptive statistics for the variables used in the main analysis (all rounds). Panels B and C in Table G-3 show the descriptive statistics for two of our additional analyses, namely those of first rounds and later rounds, respectively.

However, before we turn to those tables in more detail, it must be mentioned that the total number of valid observations for our main analysis of all rounds (N=2,837) is considerably lower than the total number of observations in our sample of raw data (N=5,012) that built the basis for our descriptive overview in Chapter E. This arises for several reasons. Most importantly, as discussed above, we could include only those rounds in our analysis, for which the 'terminal' event was known – for example, the beginning of a new round, an IPO or an acquisition. Furthermore, to be able to compare models, we could only use those observations that had no missing values for any of the explanatory variables.[229]

Summary statistics

With a view to the summary statistics for our main analysis (all rounds) in Panel A in Table G-3 several points are noteworthy.[230]

*** INSERT TABLE G-3, PANEL A, HERE ***

To begin with our *dependent variable*, column 3 in Panel A shows that the average round-length in our sample of all rounds was 445 days (median: 313 days).

With a view to the *context-related controls*, it is evident that the venture capital markets during our sampling period expanded considerably. The, average annual increase in the number of VCs investing venture capital was 15%, and in the number of biotech ventures receiving venture capital was 18%. Furthermore, the average annual increase in venture capital raised was 34%. At the same time, it is also evident that a substantial part of the activity in the biotech venture capital activity took place during a relatively short time in our sampling period.

[229] Specifically, our raw data comprise a total of about 5,000 rounds in about 1,700 ventures. As each venture has one last round during our sampling period, this results in 1,700 last rounds. However, about 350 ventures in our sample went public so that we can determine the length of the last round, leaving us with about 1,350 last-rounds of unspecified length. Of those, about 700 cases involve ventures that have only received one single round of funding during our sampling period, resulting in their complete dropout from our main analysis. Furthermore, for a number of ventures and/or rounds we do not have information on all variables included in the analysis, also leading to their dropout from the analysis. For instance, we had no information about the deal size of ca. 10% of all rounds, also leading to the exclusion of these observations. Finally, for the reasons discussed further above, we excluded (about 8%) observations of rounds lasting less than 90 days by combining them with the previous round. Together this results in a sample size of only about 2,800 instead of 5,000 for our main analysis (ca. 56% of original sample size).

[230] Panels B and C in Table G-3 show the descriptive statistics for our additional analyses on first rounds and on later rounds only.

Specifically, the five boom years from 1996 to 2002 account for more than one third of all observations (financing rounds) in our main analysis.

With a view to the *venture-related controls*, it should also be noted that about one quarter of our observations involve first rounds; more than half involve start-up, seed, or early-stage ventures; almost two thirds involve ventures active in the development of human drugs (sector 4100 according to VE); and close to 90% of the rounds in our sample involve US ventures. Furthermore, we note that the age of a venture in the sample is rather young, recorded with an average of 3.7 years (median: 3.0 years).

With a view to the *finance-related control* variable, deal-size, the average round amount was historically quite high at $5.5Mio (median: $2.5Mio).

As is evident when looking at the *VC-related controls*, most investments were done jointly with others; in fact about two thirds of the investment rounds involved syndicates of VCs. Most (about two thirds) of these investments were moreover performed under the umbrella of limited private equity partnerships. The preponderance of investments (four out of five) was 'local' being made in the same country as the investing VC.

Finally, regarding the *theoretical variables*, Panel A shows that that the VCs in our sample gained the bulk of their knowledge by investing in sectors other than biotechnology, although this average masks a substantial variation. For syndicates, the average age of a VC is about 10.8 years (median 10 years), non-biotech experience of a syndicate member averages at 136 investments (median: 75), total syndicate experience of such a member averages at 151 investments (median: 86), biotech expertise averages at 24 investments (median: 12), and their biotech-stage expertise average is at about 6 investments (median: 3). For 'lead' VCs these values are on average over 60% higher, indicating that the lead VC tends to be considerably more experienced than the 'followers'.[231]

Although not in the main focus of our analysis, a comparison between all rounds (Panel A) and first and/or later rounds (Panels B and C, respectively) in Table G-3 provides further insights into the data.

*** INSERT TABLE G-3, PANELS B-C, HERE ***

[231] Here it should be noted though that the 'lead' VC actually includes both 'true' lead VCs in syndicates and sole VCs in unsyndicated investments (see our discussion on this issue in the final Chapter J, 'synthesis')

To begin with, first rounds last much longer than later rounds: the average length of first rounds is 533 (median: 395 days) as opposed to an average length of later rounds of 416 days (median: 286). This is despite the fact that the deal size in first rounds, with an average of $4.7Mio (median: $1.8Mio), is smaller than that of later rounds with an average of $5.8Mio (median: $2.7Mio).

At the same time, and particularly interesting from our perspective, the average 'lead' VC knowledge is considerably lower in case of first round investments than in case of later round investments. For instance, the 'lead' VCs' biotech expertise is a startling 80% higher in later rounds than in first rounds. Similar results also hold for the average syndicate knowledge.

Correlations

Table G-3 also shows the bivariate correlations between the variables used in our main analysis on all rounds (Panel A) and in our additional analysis on first and later rounds (Panels B and C). Although not shown, most correlations between the variables are significant - arguably as a consequence of the large sample size. However, the strongest correlations are to be found between the theoretical variables, which we employ only in separate models. Consequently, although not reported here in detail, none of or analyses shows problems of multicollinearity, as indicated by measures such as Variance Inflation Factors, Tolerance values, and/or variance proportions.

G.V.2. Regression results

This section presents the main findings from our analyses of Hypothesis 2, which are illustrated in Table G-4. In this context, our focus is on the main analysis that uses all rounds (Panel A). However, later on we also summarize the results of our additional analyses that are conducted to test for the robustness of the findings from the main analysis – i.e. for the potential impact of non-independence between some observations (Panels B and C). With respect to those additional analyses though, our focus will be primarily on the theoretical variables, and we only deal with the control variables where they significantly deviate from those in the main analysis.

*** INSERT TABLE G-4, PANEL A, HERE ***

G.V.2.a) Main analyses

Following the methodology outlined above, we first develop a baseline model that includes sequentially blocks of context-, venture-, finance-, and VC/syndicate-related control variables (models 0-1 to 0-4) in the regression.

Based on the full baseline model (0-4), we then test each of our five theoretical variables (knowledge proxies) in a separate regression for the average syndicate (models 1-1- 1-5) and for the 'lead' VC (models 2-1 to 2-5). These models are summarized in Table G-4, Panels A-1 to A-3).[232]

Each of these analyses is based on the same set of observations (rounds) for which we have information on all variables. This approach allows us to compare the model-parameters and coefficients across models.

We begin with a description of the findings from the baseline model, followed by a description of the findings for the theoretical variables.

G.V.2.a.i. Baseline-model

Block 0-1: Context-related factors

The inclusion of context-related control variables results in a significant improvement over the initial model including only the constant term (F-change block: p<.000). However, the overall variability accounted for by the model is very low, as indicated by an adjusted R^2 of 0.6%.

With a view to the coefficients of the individual context-related control variables, the '*annual change in the number of investors providing venture capital*' is not significantly related to the round-length, neither in any of the baseline models nor in the subsequent models that include the theoretical variables. The '*annual change in the number of biotech ventures receiving venture capital*' is only marginally significantly and positively related to the round-length in the first baseline model; but it is insignificant in all subsequent models that include further variables. The '*annual change in the total amount of venture capital raised*' is significantly and positively related to the round-length throughout all baseline models as well as all other models in the main analysis. The dummy variable for the '*years 1996-2000*', finally, is always negatively related to round-length, but significantly so only in the last baseline model and in all subsequent models including the theoretical variables.

Block 0-2: Venture-related factors

The additional inclusion of venture-related control variables in the baseline model results in a highly significant improvement over both the initial (constant-only) model and the previous baseline model (F-change block: p<.000).

[232] Panels B and C in Table G-4 show the results of our additional analyses on first rounds and on later rounds only.

Furthermore, the inclusion of venture-related factors also results in a visible change in the R^2 (change: 0.018), which - although still small - represents the single largest change in R^2 observed in any of the models. This is also reflected in an increase in the adjusted R^2 over the previous baseline model by about 0.016, from 0.6% to 2.2%.

When looking at the individual coefficients of the venture-related control variables, however, it is obvious that the relatively 'large' changes in the model parameters are mainly (if not exclusively) due to one single venture-related variable. Specifically, of the venture-related control variables, only the dummy variable for *'first round investments'* is highly significant - but contrary to our expectations - positively related to round-length in all models. Thus, first rounds, on average, last significantly longer than later round investments. In contrast, none of the other venture-related control variables - i.e. the dummy variables for *'US ventures', 'sector 41 ventures'*, and for *'start- up/seed/early-stage ventures'*, as well as the *'venture age variable'* - show a significant relation to round-length.

Block 0-3: Finance-related factors

The inclusion of the finance-related control variable, 'round amount' (or 'deal size), in the baseline model results again in a highly significant improvement over the previous baseline model (F-change block: p<.000). However, the inclusion of the deal size hardly accounts for any additional variability in the model. Specifically, it only leads to an adjusted R^2 of about 2.8%, compared to 2.2% in the previous baseline model.

As expected, the *'deal size'* is highly significantly positively related to the round-length throughout all models.

Block 0-4: VC-related factors

The inclusion of VC-related control variables results in a further highly significant improvement over the previous baseline model (F-change block: p<.000). Furthermore, it also visibly accounts for some extra variability. Although the inclusion of VC-related factors results only in a small R^2 change compared to the previous model (0.008), it raises the adjusted R^2 from 2.8% to 3.5%.

With a view to the individual VC-related coefficients, the dummy variable for *'syndicated deals'* is constantly significantly and positively related to the round-length. In contrast, the *'% of independent private equity investors participating in the round'* is, sometimes highly, significantly negatively related to round-length. The '*% of VCs participating in the round that come from the same nation as the venture*', finally, is not significantly related to round-length.[233]

G.V.2.a.ii. Theoretical variables

Turning now to the focus of our interest, in what follows, we describe the findings of the five parallel analyses on the relation between the theoretical variables – the five proxies for VCs' knowledge – and round-length. As outlined above, in our main analyses, we test and compare the effects of the different proxies on round length using in turn the average knowledge of the syndicate (models 1-1 to 1-5 in Panel A-2, Table G-4) and the knowledge of the 'lead' VCs (i.e. the most knowledgeable VCs in the syndicates, or the sole VCs in unsyndicated rounds; models 2-1 to 2-5 in Panel A-3, Table G-4). We report the findings sorted by the different proxies for VCs' knowledge, and for each proxy first with a view to the syndicates and then with a view to the 'lead' VCs.

VC age

As model 1-1 shows, the inclusion of the *'syndicate age'* as a theoretical variable, does not result in a significant improvement over the complete baseline model (F-change block: p>.1). This is also reflected in the fact that there is no change in the adjusted R^2 (3.5%) compared to the baseline model. The fact that the 'syndicate age' is not related to round-length is also evident when looking at the coefficient of this variable: whilst negative, it is not significant.

Similarly, as model 2-1 shows, also the *'lead VC age'* does not result in a significant improvement over the complete baseline model (F-change block: p>.1); and it also does not account for any additional variability compared to the baseline model: the adjusted R^2 (3.4%) is even slightly lower than in the baseline model. Furthermore, the coefficient for the 'lead VC' age also suggests no significant relation to round-length.

VC non-biotech experience

Model 1-2 shows that the inclusion of the *'syndicate non-biotech experience'* results in some improvement over the complete baseline model (F-change block: p<.05). However, it accounts for hardly any additional variability compared to the baseline model, as indicated by the small increase in the adjusted R^2 from

[233] Although not reported here, it should again be mentioned that we also ran preliminary analyses that used dummy variables indicating the presence of independent private equity investors and of VCs from the same country as the investee venture rather than the percentage values, but with essentially the same results.

3.5% to 3.6%. Nevertheless, the coefficient of the *'syndicate non-biotech experience'* suggests a significant ($p<.05$) negative relation to round-length.

By contrast, model 2-2 shows that the inclusion of the *'lead VC non-biotech experience'* as a theoretical variable results in no significant improvement over the complete baseline model (F-change block: $p>.1$), as is also evident from the unchanged adjusted R^2. Furthermore, when looking at the coefficient of the *'lead VC non-biotech experience'*, one finds that there is a negative, but insignificant relation to round-length.

VC total (non-/biotech) experience

Model 1-3 shows that, similar to the previous proxy (syndicate non-biotech knowledge), the inclusion of the *'syndicate total experience'* as a theoretical variable results in some improvement over the complete baseline model (F-change block: $p<.05$). But, again, it hardly accounts for any additional variability, as indicated by the small increase in the adjusted R^2 from 3.5% to 3.6%. Nevertheless, the coefficient of the *'syndicate total experience'* suggests a significant ($p<.05$) negative relation to round-length.

In contrast, model 2-3 shows that the inclusion of the *'lead' VC's total experience'* as a theoretical variable leads to results that are very similar to those obtained previously for the non-biotech experience. Specifically, the inclusion of this variable does not result in any improvement over the baseline model (F-change block: $p>.1$), and it does not change the adjusted R^2. Also the coefficient of the *'lead VC's total experience'* mirrors that previously obtained for the non-biotech experience: it is again negatively but not significantly related to round-length.

VC biotech expertise

Model 1-4 shows that the inclusion of the *'syndicate biotech expertise'* as a theoretical variable does result in a substantially more significant improvement over the complete baseline model than the previous knowledge proxies, as indicated by the largest F-ratio of any of the examined models (F-change block: $p<.001$). Similarly, also the increase in the adjusted R^2 from 3.5% to 4.3% is the largest in any of the examined models. Furthermore, the coefficient of the *'syndicate biotech expertise'* indicates a highly significant negative relation to round-length.

Model 2-4 shows that the inclusion of the *'lead VC biotech expertise'* as a theoretical variable results in findings that are qualitatively similar to those obtained for the 'syndicate biotech expertise, but contrary to those obtained for the previous lead VC knowledge proxies. Specifically, the *'lead' VC's biotech expertise'* results in a highly significant improvement over the baseline model as indicated by the largest F-ratio reached in any of the models using the lead VC knowledge proxies (F-change block: p<.000). It also accounts for the largest proportion of the variability of all proxies for the lead VC knowledge, as indicated by an increase in the adjusted R^2 to 3.9%, from 3.5% in the baseline model. Furthermore, as expected, the coefficient of the 'lead' VC's biotech expertise is - highly significant - and negative, again showing the strongest relation to round-length of any of the lead VC knowledge proxies.

VC biotech-stage expertise

Model 1-5 shows that the inclusion of the *'syndicate biotech-stage expertise'* results in similar - but slightly less pronounced - findings to the inclusion of the 'syndicate biotech expertise'. Specifically, it leads to a highly significant improvement over the complete baseline model (F-change block: p<.000), and to an increase in the adjusted R^2 from 3.5% to 4.2% (which is only slightly smaller than the adjusted R^2 for the syndicate biotech expertise). Similarly, the coefficient for the *'syndicate biotech-stage expertise'* shows a highly significant and negative relation to round-length.

Model 2-5, finally, also shows very similar results for the *'lead' VC biotech-stage expertise'* to those previously obtained for the 'lead' VC biotech expertise'. Again, the inclusion of biotech-stage expertise results in a highly significant improvement over the complete baseline model (F-change block: p<.000). However, the changes in the model parameters compared to the baseline model are slightly smaller when including the biotech-stage expertise than the general biotech expertise. This is evident, for instance, from the slightly smaller F-ratio. At the same time, the adjusted R^2 is the same (3.9%) when using the general biotech expertise or biotech-stage expertise. As expected, the coefficient of the 'lead' VC's biotech-stage expertise is - highly significant - and negative; and its magnitude is almost the same as that of the biotech expertise in the previous model.

G.V.2.b) Additional analyses

As outlined above, we conduct several additional analyses to check the robustness of the findings from our main analysis, and to address a number of issues connected with it. This includes an analysis of first rounds only (to address the potential non-independence of some observation in the main analysis), an analysis of rounds before 1998 (to address the truncation of our

DV), and a comparison of the characteristics of those first rounds included in our main analysis with those not included in our main analysis (to address the potential bias due to the exclusion of those ventures that have only received one round during our sampling period). In the following, we briefly summarize the findings of those additional analyses.

G.V.2.b.i. Analysis of first and later rounds only

As mentioned before, one potential criticism regarding our above findings might concern the simultaneous inclusion of all rounds in our sample. This, one might argue, leads to correlation of the error terms of the regression because some ventures enter our analysis several times by receiving several times (i.e. in several rounds of funding). One method to deal with this issue, and to test the robustness of our findings, is to conduct analyses based only on sub-samples of observations, in which possible problems resulting from the non-independence between some observations are reduced or eliminated. Therefore, we conducted several additional analyses, of which two are based on first and later rounds.[234]

The results of our analyses of first rounds and later rounds are summarized in Panels B and C, Table G-4, and discussed below, where we focus only on noteworthy deviations from the above described findings of our main analysis compared to those of the analysis on first rounds only. At the same time it should also be referred to the descriptive statistics for first and later rounds that have been already discussed further above (see Table G-3).

*** INSERT TABLE G-4, PANELS B AND C, HERE ***

Comparing the overall fit of the models based on all rounds ('main analysis'; Panel A in Table G-4) with those based on first rounds only ('first round analysis'; Panel B in Table G-4) one finds only relatively small differences – despite the fact that the sample size for the first round analysis, with about 720, is only about one quarter of that used for the main analysis. For instance, the adjusted R^2 values are very similar – and similarly low - for all models in the first round analysis (with a range of 1.5% to 3.9%) to those in the main analysis

[234] Although not reported in detail here, it is worth mentioning that we conducted further analyses on other sub-samples, such on ventures for which we had additional patent information. Those analyses resulted in qualitatively similar findings regarding our key theoretical variables (i.e. a negative relation between syndicates'/VCs' knowledge and round-length that is stronger the more specific the knowledge). As such, also those analyses further support the idea that our findings form the main analysis seem robust across a number of sub-samples.

(with a range of 0.6% to 3.9%). Also the changes in the F-ratios between subsequent models overall seems to follow a similar pattern in the first round analysis as in the main analysis.[235] Most importantly though, the changes in the model parameters of the main analysis and the first round analysis are very similar when it comes to the inclusion of our theoretical variables, the various proxies for VCs' (i.e. syndicates or 'lead' VCs) knowledge. In both analyses, the VCs' age (models 1-1 and 2-1) does not result in an increase in the adjusted R^2, nor in a significant change of the F-ratio compared to the previous baseline models. Furthermore, in both analyses, the largest relative change in the model parameters is to be observed when including the VCs' biotech expertise (models 1-4 and 2-4), closely followed by VCs' biotech-stage expertise (models 1-5 and 2-5). The 'biggest' difference between the two analyses is the fact that in first rounds the inclusion of the *'lead'* VCs' non-biotech and total experience (models 2-2 and 2-3) results in (marginally) significant changes of the F-ratios compared to the baseline model, whilst it doesn't in the main analysis. This could suggest a (marginally) greater importance of the 'lead' VC's non-biotech and total knowledge in case of first rounds than overall.

Comparing the coefficients of individual variables - regarding their magnitude, sign, and significance - between the first round analysis and the main analysis one again finds only minor differences.[236] This also holds for the theoretical

[235] In this context, and with a view to the baseline model 0-2 in the first round analysis, it seems worth mentioning though that the introduction of venture-related control variables does not result in a significant change of the F-ratio. This is contrary to the scenario in the main analysis. However, this finding might be explained by the fact that in the first round analysis the 'dummy for first rounds' obviously is a constant and therefore omitted from the model. The remaining venture-related variables however are not significantly related to round-length in either the main analysis or the first round analysis. Arguably more surprising is the fact that in the first round analysis, in contrast to the all rounds analysis, the inclusion of the deal size (model 3) does not result in a significant change of the F-ratio or in any change of the adjusted R^2.

[236] Most noteworthy with a view to the baseline models in the first round analysis seem the following observations: the 'annual change in ventures receiving biotech venture capital' is positively and significantly related to round-length throughout all models (whilst it was only positively and significantly related in model 0-1 of the main analysis); the 'dummy variable for rounds in 1996-2000' is negatively and significantly related to round-length only in models 0-1 and 1-1 (whilst it was negatively and significantly related to round-length in all models but model 1-2 in the main analysis); the 'deal size' is not significantly related to round-length in any model (whilst it was significantly and positively related in all models of the main analysis); and the '% true private equity investors participating in a round' is only significantly and negatively related to round-length in models 0-1 and 1-1 (whilst it was negatively and significantly related to round-length in all models of

variables, our range of knowledge proxies. They are all negatively related to round-length in all models of both analyses. Also, the syndicates' and the 'lead' VCs' age is never significantly related to the round-length in any of the models; and the syndicates' and the 'lead' VCs' biotech expertise is most strongly related to round-length in both analyses, closely followed by their biotech-stage expertise. As such, the main difference between the two analyses regarding the theoretical variables is the fact that the 'lead' VCs' non-biotech and total experience are (marginally) significantly related to round-length in the first round analysis but not in the main analysis.

Overall, therefore, the key findings from the main analysis are mirrored in the first round analysis, based on a much smaller sample size and eliminating possible problems of non-independence between observations obtained from the same ventures. This suggests that our findings in the main analysis are robust across different samples - regarding both the negative relation between knowledge and round-length and the increasing strength of this relation with increasing specificity of the knowledge proxy used.

In addition, as outlined before, the first round analysis is interesting in that it looks only at situations where VCs have no 'insider' knowledge about the venture under consideration. We can therefore study the effect of the main theoretical variables of interest – the VCs' knowledge that was acquired during previous investments in *other* ventures - in its 'purest' form. We find that in first rounds all proxies for the VCs' (syndicates' or 'lead' VCs') knowledge have slightly larger standardized beta coefficients suggesting that the impact of VC experience is greater when there is more company-specific uncertainty present. Furthermore, in first rounds the 'lead' VCs' non-biotech and total experience are also significantly negatively related to round-length (whilst they are not in the analysis of all and/or later rounds). Finally, the overall explanatory power (adjusted R^2) of the models focussing on first rounds is slightly lower (2.8%-4.0%) than of those focussing on all rounds (3.4%-4.3%), but visibly higher than that of those models focussing on later rounds (1.6%-2.4%).

These findings might be interpreted as an indication that the ('lead') VCs' knowledge acquired by investing in ventures other than the one under consideration is relatively more important in first rounds than in later rounds,

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the main analysis). However, it is worth mentioning that the signs of the coefficients in the baseline model do not differ between the main analysis and the first round analysis.

where the VCs might have already developed some additional 'insider' knowledge about the venture under consideration.

G.V.2.b.ii. Analysis of pre-1998 rounds

As explained above, another issue with our main analysis concerns the DV, round-length, which, the reader will recall, is truncated due to the fact that for many ventures in our sample we don't know the length of the last round. To address this issue, we conduct an additional analysis using only those rounds occurring before 1998, i.e. 5 years before our sampling ends.[237] This is intended to ensure that each venture in our (sub-) sample had sufficient time to receive a new round of funding, therefore making it possible to determine the length of their last round (if started before 1998).[238]

The results of this analysis are summarized in Table G-5. As can be seen from this table the results for pre-1998 rounds (N=1,938) closely resemble those for all rounds (N=2,837) - with respect to both the overall model fit and the coefficients of the individual theoretical variables. Arguably the main difference between the two analyses concerns the 'lead' VCs' non-biotech and total experience, which are marginally significantly negatively related to round-length in the analysis of pre-1998 rounds but not in the main analysis of all rounds. Overall, this suggests that the findings of our main analysis are not unduly biased by the truncation of the dependent variable in the main analysis.[239]

*** INSERT TABLE G-5 HERE ***

[237] This is the time period corresponding to the average round-length plus 2.5 standard-deviations of all observations in our sample.

[238] Here, it should be mentioned again that, using the same variables as in our main analysis, we also conduct an additional Cox regression analysis of all rounds in our sample (N=2880), which results in findings that are qualitatively very similar to those of our main analysis, in that it shows no relation of either the syndicates' or 'lead' VCs' age and the ventures' hazard to experience another round, whilst this hazard increases for both the syndicates and the 'lead' VCs from the non-biotech experience, over the total experience, to the biotech and biotech-stage expertise. The main difference is that in the Cox regression models, the 'lead' VCs' total experience is marginally significantly related to the ventures' hazard of experiencing another round whilst it is not significantly related to the ventures' round-length in our main analysis.

[239] In this context, it should be mentioned though that we conduct additional analyses separating first and later pre-1998 rounds, which result in qualitatively very similar findings to those described in this section. Similarly, also unreported analyses of different time windows (e.g. pre-1996 and pre-1999 rounds) result in qualitatively similar results.

G.V.2.b.iii. Comparison of not/included first rounds

As mentioned previously, another issue concerning our main analysis, also related to the truncation of the dependent variable, concerns the fact that we cannot include ventures that have only received one round of funding.[240] This might in theory introduce some bias into the findings in the main analysis because we might only examine round-length for ventures that have been successful enough to receive at least two rounds of funding (or go public or be acquired). At the same time, however, it is equally possible that those ventures that have received only one round during our sampling period might either never receive a next round (and their investments just be liquidated) or that they might receive their next round any time after our sampling ends. To see whether there are any fundamental differences between those ventures that receive at least two rounds (and, therefore, are included in our main analysis) versus those that receive only one round (and, therefore, are not included in our main analysis), we compare the (mean) values of the variables used in the main analysis for the two groups with a simple t-test. We do this for both all first rounds in our sample and pre-1998 first rounds only. The results of both analyses are summarized in Table G-6, Panel A and B.

*** INSERT TABLE G-6 HERE ***

With view to Panel A and B in Table G-6, some observations are particularly noteworthy. To begin with the last row in Panel A, it is clear that the average round year of those observations included in the analysis is much lower (1993) than that of the rounds excluded from the analysis (1999). This clearly suggests that many excluded observations are more recent than those that were included, and the corresponding companies have had insufficient time to experience another round. This time-difference between the two groups might also explain some other significant differences between them.[241] Interestingly, however, the average deal size is not significantly different for those ventures included in the analysis and those not included (in fact, it seems even higher for the latter).

[240] With the exception of those ventures whose last round ends with an event such as an IPO or an acquisition, for which we have a specific date.

[241] For instance, the context-related control variables indicate a substantial 'cool-down' in the markets towards the end and/or after the high-tech Bubble. The finding might also mirror VCs' changing investment preferences indicated in the venture-related control variables.

However, most interesting to us are the differences between the two groups when it comes to the average knowledge of their syndicates and/or lead VCs'. With the exception of the VCs' age, all knowledge proxies are (sometimes highly) significantly *lower* in case of those observations not included in our main analysis than in case of those included.

Here, one might argue that this could be due to the fact that – as indicated in our exploratory analysis (see Chapter E.b) the average VCs' knowledge declines towards the end of our sampling period. However, Panel B, which examines only observations up to five years before our sampling ends, suggests an alternative explanation. Specifically, several of the significant differences (e.g. regarding context-, venture-, and VC-related control variables) between included and excluded observations found in Panel A disappear in Panel B. At the same time, in contrast to Panel A, Panel B shows, for the pre-1998 observations, that the average round amount of those observations not included in the analysis is smaller (although not significantly) than that of those observations included in the analysis. Furthermore, and particularly interesting to us, Panel B shows that significant differences in the knowledge proxies also exist in the pre-1998 sub-sample. In fact, if anything, the differences between the VCs' knowledge for those observations included in the analysis and those not included seem even bigger in the pre-1998 sample than in the total sample.

Together this could suggest that at least some of the (first round) observations included in our main analysis indeed have enjoyed better founding situations (measured by funding and relative experience of their investors) – and, therefore, might ultimately be more successful - than those (first round) observations not included in our analysis. Therefore, in the interpretation of the findings of our main analysis, it seems important to bear in mind that the companies might be representative of the more successful ventures rather than of all ventures.[242]

[242] At the same time, it should also be mentioned that of all 532 pre-1998 first rounds (corresponding to 532 ventures) in our overall sample, only about 10% (55) were not included in our analysis because they did not receive a second round before our sampling ended (which might be taken as a indication of their failure). This proportion of 'failed' ventures is in line with the overall failure rate in our sample. Therefore, it seems unlikely that the non-inclusion of those ventures leads to a substantial bias in our findings.

G.VI. Summary and discussion

In this section we discuss our results, first in light of our hypothesis and then in light of the limited existing literature on staging.

G.VI.1. Findings in the light of the hypothesis

For the discussion of our results in light of the Hypothesis, we focus on our main findings regarding the impact of VCs' knowledge on the round-length. However, we also briefly discuss some additional findings regarding the control variables.

Main findings

Summarizing the empirical analysis, our results provide support for the main parts of our Hypothesis 2, which predicts an empirical relationship between VCs' (syndicates' or 'lead' VCs') knowledge and round-length, and argues that this relationship should be more pronounced the better matched the VCs' knowledge is to the venture under consideration

We find, consistent with Hypothesis 2a, that the strength of the relationship between VCs' knowledge and round-length increases as we move from the most general measure of knowledge, VCs' age, over more specific measures of knowledge represented by VCs' non-biotech and total experience, to the most specific measures represented by VCs' biotech and biotech-stage expertise.

However, our findings provide *no* support for the last part of our Hypothesis 2b, which predicted that the relation between VCs' knowledge and round-length is more pronounced for the 'lead' VCs' knowledge than for the syndicates' average knowledge.

This is evident with a view to both the fit of models based on different theoretical variables (five different proxies for VC knowledge) and the coefficients of those theoretical variables.

Overall model fit

When examining the goodness-of-fit parameters of the models in our main analysis (that for all rounds), an overall trend is apparent: the predictive power of the models increases with the specificity of the theoretical variables chosen.

The inclusion of the VCs' age – be it in the form of the syndicates' or the 'lead' VCs' – provides no significant improvement over the baseline model. By contrast, the inclusion of the two most specific knowledge proxies (biotech and biotech-stage expertise) result in a highly significant change in the F-ratios and a corresponding increase in the values of the adjusted R^2 for both the syndicate and the 'lead' VC. Furthermore, in both cases, the inclusion of the proxy for either the biotech or the biotech-stage expertise results in the largest change in the F-ratios in any of the models.

The main difference between the models using the syndicates' knowledge versus those using 'lead' VCs' knowledge concerns the non-biotech and total experience, both of which result in a significant improvement over the baseline model for the syndicates' but not for the 'lead' VCs' knowledge. So, whilst the predictive power of the models using the proxies for the syndicates' knowledge seems slightly higher than for the models using the proxies for the 'lead' VCs' knowledge, the overall pattern of the changes in and the magnitudes of the model parameters are very similar whether one looks at the syndicates' or the 'lead' VCs' knowledge (this is particularly so when looking only at the sub-sample of first rounds).

With respect to the findings regarding the 'lead' VCs' versus the average syndicates' knowledge, it should also be mentioned that those findings might be partly influenced by the way in which we calculate these proxies.

Specifically, our variable 'lead VC knowledge' comprises both the knowledge of 'true' lead VCs (in syndicated deals) and of sole VCs (in unsyndicated deals). Thus - referring back to our previous Chapter F on syndication, where we showed that more knowledgeable VCs' tend *not* to syndicate – it seems likely that the 'true' knowledge of 'lead' VCs in syndicates is lower and the actual knowledge of sole VCs (which we do not analyse) is in fact higher than suggested by our choice of variable.

Similarly, our variable 'average syndicate knowledge' comprises both the average knowledge of VCs (in syndicated rounds) and the 'average' knowledge of sole VCs (in unsyndicated rounds, where the VC's average knowledge obviously is identical to his absolute knowledge). Thus – and again referring back to the previous Chapter F – it is likely that the 'true' average knowledge of syndicates is lower than suggested by our variable.

Therefore, we must caution the reader that in interpreting our findings on the impact of the 'lead' VCs' versus the syndicates' knowledge he must keep in mind the fact that both variables are based on average values combining the knowledge of syndicated and sole VCs. Our findings could have been different had we looked only at truly syndicated rounds.

Individual coefficients

In the same vein, when looking at the *coefficients of the theoretical variables* in our main analysis, we find that the magnitude of the (beta) coefficients increases from age over non-biotech and total experience to biotech and biotech-stage expertise. Furthermore, the coefficients for both biotech and biotech-stage expertise are even larger than those of the 'deal size', indicating the relative importance of the biotech/-stage knowledge in determining the round-length.

This pattern is also reflected in the significance levels of those coefficients. Specifically, the coefficients for the VCs' age are never significant. However, the coefficients for the VCs' non-biotech experience, and total experience are at least significant for the syndicates (although not significant for the 'lead' VCs); and the two most specific proxies for biotech/-stage expertise are even highly significant related to round-length, independent of whether one looks at the syndicates or the 'lead' VCs.

Therefore, at least in the main analysis of all rounds, more of our knowledge proxies have significant coefficients when looking at the syndicates than when looking at the 'lead' VCs, and the (beta) coefficients are constantly higher for the syndicate's knowledge than for the 'lead' VC's knowledge.

This suggests, somehow contrary to the argument above, that it is not the 'lead' VC who is mainly responsible for determining the deal structure, including the round-length. Instead, this could indicate that the VCs in the syndicate are revealed by our finding to make the relevant decisions *jointly*. However, referring back to our discussions of the previous section, we caution that these findings have to be interpreted keeping in mind the particular way in which we calculate the 'lead' VCs' and the syndicates' knowledge.

Overall, however, the pattern in the development of the size and significance of the coefficients is very similar, regardless of whether one examines the syndicate or the 'lead' VC knowledge: the relation between knowledge and round-length is more pronounced the better matched the knowledge proxy is with respect to the focal venture.

Equally important, we find all coefficients for our proposed knowledge proxies are negative. It should be recalled that we did not hypothesize the sign of the relation between knowledge and round-length because there were plausible arguments for positive and negative relationships. We repeat that argument for convenience here: on the one hand, more knowledgeable VCs may be more confident in their investment decisions and/or in their ability to manage investments, and therefore prefer to have longer rounds, spending less time and effort on staging; on the other hand, more knowledgeable VCs may also be aware of the fact that many problems, particularly in a high-risk sector such as biotechnology, are difficult if not impossible to predict. This might make them more inclined to have shorter rounds, with an opportunity to regularly and thoroughly check the progress of their investments, and to abandon them if need be – without incurring too high sunk costs.

Our findings can now be compared with these two alternative hypotheses, and they suggest that the second explanation is clearly the more likely: more knowledgeable VCs prefer shorter rounds, arguably because they are more aware of potential problems, want the opportunity to exercise tighter control over the venture, and to be able to abandon bad projects sooner rather than later.

Robustness of findings

Finally, it is important to note that our findings obtained from the main analysis of all rounds are robust across various sub-samples.

For instance, the additional analysis of first rounds only, where possible biases from non-independence between some observations are eliminated, shows very similar model parameters to those in our main analysis, some control variables become insignificant, but the theoretical variables remain (or become even more) significantly and negatively related to round-length; and this negative relation always is the more pronounced (i.e. the stronger and more significant) the more specific the examined knowledge proxy is with a view to the venture under consideration; and similarly also is to be observed in the analysis of later rounds only.

At the same time, the fact that in the analysis of first rounds only, several proxies for the 'lead' VCs' knowledge become significant whilst they have not been significant in the analysis of all rounds, further support the idea that the ('lead') VCs' knowledge developed by investing in ventures other than the one under consideration could be particularly important in first rounds when the VCs have not had a chance yet to develop 'insider' knowledge about the venture under consideration.

Finally, also the additional analysis of pre-1998 rounds only, which eliminates the problem of truncation in our dependent variable results in qualitatively similar results compared to our main analysis of all rounds.

In sum, our fundamental hypothesis is supported when looking at the individual models and/or when comparing the models that include the different theoretical variables. Controlling for various context-, venture-, finance-, and VC-related factors, we find that there is a negative relation between all examined proxies for the knowledge of VCs participating in a round and the round-length; and this relation is more pronounced - and more significant - for the more specific knowledge proxies.

Additional findings

Whilst our findings provide clear support for the main parts of our hypothesis, we are aware that the explanatory power of all of the empirical models is low, suggesting that neither our theoretical variables nor the control variables explain much of the variability of the round-length found in practice. Furthermore, our theoretical variables contribute less to this explanatory power than some of control variables employed. This suggests that other theories also have some credibility in explaining the data.

In this section, therefore, we briefly highlight some of the additional findings regarding these control variables

Starting with the *context-related controls*, the 'annual change in venture capital raised' is highly significantly and positively related to the round-length. Thus, a faster proportionate growth in venture capital funds increases the time between funding rounds. Since we control for deal size the effect of a faster rate of growth of funds raised on round-length seems not driven by the need of VCs to fund larger deals. This result suggests that VC capital constraints do not operate to reduce round-length below the project optimum. The dummy variable for deals in the 'boom years 1996-2000' is marginally significantly and negatively related to round-length. In other words, during the Bubble period round-length systematically declined for the typical venture. This could illustrate a 'feeding-frenzy', where 'money was chasing deals'; and it could also be a result of the VCs' desire for their ventures to reach IPO faster in a market with bourgeoning IPO valuations and the increasing likelihood of a collapse in valuations.

Turning to the *venture-related controls*, it is particularly interesting to observe that none of the variables that could be associated with higher risk ventures is significantly related to the round-length. The only exception in this context are 'first round investments', which however – contrary to what one might expect – are longer than later round investments, even when controlling for VCs' knowledge and investment size. One possible explanation for this is that first round investments may throw up more problems than ones in later rounds. VCs may therefore allow a longer time for issues to be resolved before disbursing additional funds. For example, if companies are more likely in early rounds to fail to meet targets (milestones), this may delay the subsequent disbursement of funds until issues are sorted out. Unfortunately though we have not been able to control for such milestone effects in this analysis.

The *deal size control* variable is highly significantly and positively related to round-length. This finding does not come unexpectedly - because, generally speaking, the larger the amount invested in a venture the longer it should 'last' before it needs the next cash-injection. However, it should also be noted that the relation between deal size and round-length obviously is moderated by the ventures' cash-burn rates, which we cannot control for in our data. This might also explain why the magnitude of the 'deal size' coefficient is comparatively small.

With a view to the *VC-related controls*, we find that the 'percentage of independent private equity partnerships' (i.e. 'true' VCs, or 'VCs in a 'narrow sense') investing in a deal is highly significantly and negatively related to the round-length. This could be a consequence of the 'true' VCs being more aware of the value of tight control via staging of investments than, say, bank-related or corporate VCs ('VCs in a wider sense'). Assuming that 'true' VCs are more experienced than those other types of VCs, this finding also seems in line with our general assertion that VCs' knowledge has an impact on the round-length.

Finally, and particularly interesting, we find that 'syndicated deals' are highly significantly longer than unsyndicated deals, even when controlling for the deal size (which, as we have seen, is much larger for syndicated versus unsyndicated deals).

This is particularly noteworthy in light of our discussions in the previous Chapter F on syndication. There, we have found that more knowledgeable VCs tend not to syndicate. Therefore, we argued that it seems possible that primarily ignorant VCs tend to syndicate with each other, resulting in a lower average knowledge of syndicates than of sole VCs.

Since our present chapter now shows a negative relation between VCs' knowledge and round-length and a positive relation between 'syndication' and round-length, this not only provides further support for the assertion that syndicates tend to involve 'ignorant' VCs but also shows that syndicated VCs have a different investment approach, at least as far as the staging of investments is concerned.

In this context it is also worth mentioning that in our additional analysis of first rounds we still find 'syndicated deals' to be significantly positively related to the round-length, but not the round amount. This suggests that – at least in first rounds – knowledge-related issues are more important determinants of round-length than finance-related issues; and the positive relations between syndication and round-length could be due to the fact that the average knowledge of syndicates indeed is lower than that of sole VCs – leading to longer rounds.

Thus, in conclusion, it seems that there are good reasons to believe that syndicates exercise less intense control over their investments via staging than sole VCs. This, one might further speculate, could also translate into a different (i.e. inferior) performance of syndicated deals versus unsyndicated deals. However, from our findings so far, we cannot determine whether this is actually the case. This is because we have not examined the actual performance of investments by syndicates versus sole VCs. At this stage, we merely mention that we shall return to this topic in our next chapter.

G.VI.2. Findings in the light of the literature

Our findings undoubtedly add to the extant theoretical and empirical literature on the staging of venture capital investments.

To illustrate this, in the following, we highlight exactly how our findings relate to this literature - first with a view to our main findings regarding VCs' knowledge, and then with a view to our additional findings regarding other factors related to round-length.

But, at this stage, the reader is also referred to our more general discussions in the 'synthesis' Chapter J.

Main findings

The major contribution of our study to the literature is that it is the first study to examine the empirical role of VCs' knowledge in their staging decisions.

A few authors have already pointed out that this issue deserves greater attention (e.g. Bergemann & Hege, 1998; Lerner, 1998; Schertler, 2000). But the empirical literature so far has failed to address the impact of VCs' knowledge on staging, instead focussing primarily on venture-related factors as possible determinants for VCs' staging strategies (e.g. Bergemann & Hege, 1998, 2003; Cuny & Talmor, 2003; Gompers, 1995; Kaplan & Strömberg, 2002, 2003; Neher, 1999; Wang & Zhou, 2004).

Thus, our main finding that there is a negative relation between VCs' knowledge and their choice of round-length provides new insights into an empirically un-researched issue.

Furthermore, our main findings also add to the literature by showing that not all types of VCs' knowledge have the same impact on VCs' staging behaviour. The relevance of VCs' knowledge increases with its specificity regarding the focal venture; and some proxies used for VCs' knowledge in the previous literature, such as VC's age, in fact have no significant empirical relation to the VCs' investment staging decision.

Moreover, our main findings also add to the existing literature by addressing another issue, namely the role of syndication in staging. This topic has been completely neglected in the literature on the staging of venture capital investments.

Here, we find that the relation between VCs' knowledge and round-length is no more pronounced with respect to 'lead' VCs' knowledge than with respect to the syndicates' average knowledge. Although this runs counter to our hypothesis, it is an interesting finding as it may suggest that important decisions in the syndicate, such as the staging of rounds, are not exclusively determined by the 'lead' VC (and his knowledge) but rather by the overall syndicate. This finding is also new to the literature on venture capital.

We note also that it is difficult to interpret our main findings in the light of the most commonly employed theoretical concept in the literature on staging, namely the principal-agent theory.

On the one hand, our finding that more knowledgeable VCs overall prefer shorter rounds could be understood as suggesting that perceived information asymmetries are not as relevant for the VCs' staging decision as suggested by previous research. This is because, if the VCs' perception of information asymmetries indeed was a key determinant for their staging decision, one might expect that those VCs with more knowledge (particularly with a view to ventures of the same type/stage as the of focal venture) should perceive less information asymmetry. This, in turn, should result in longer rounds because of the (administrative) costs of staging. Similarly, also our finding that first rounds last significantly longer than later rounds apparently contradicts the assumption that (perceived) information asymmetries are the main determinants of the round-length, because those information asymmetries should be largest in first rounds.

On the other hand, our finding that the VCs' knowledge is more strongly related to the length of first rounds than of later rounds could be understood as providing some support for the relevance of perceived information asymmetries for the staging decision as suggested in the previous literature. Those information asymmetries should be greatest in first rounds, making VCs' knowledge (information) particularly critical in those first rounds. But then again, we note that the average knowledge of VCs in first rounds is much smaller than that of VCs' in later rounds. Furthermore, it should also be mentioned that the VCs' knowledge as approximated by us – i.e. the knowledge that is mainly, and in first rounds always, gained from investing in ventures other than the focal venture - might only be of limited relevance to resolving any information asymmetries between VC and entrepreneur in a new focal venture. This is because, even if a VC has plenty of experience with the same type of venture as a particular focal venture, this experience might only be of limited value for assessing the quality and intentions of the management team in a new focal venture, which is largely an unknown.

However, whilst a VC's previous experience might only be of limited relevance for addressing venture-specific information asymmetries, it nevertheless should make him more aware of the general problems regarding the overall industry-specific uncertainties associated with a particular type of venture.

In this context, the reader is also referred back to the arguments by Kaplan and Strömberg (2002) that were reviewed in detail earlier in this chapter. These authors point out that most studies on agency and information problems share the difficulty that they do not distinguish between different types of uncertainty – although this would be likely to result in different theoretical predictions. It will be recalled that Kaplan and Strömberg (2002) suggest differentiating between *internal* uncertainty (e.g. regarding management quality, previous performance) and *external* uncertainty (e.g. regarding market size, competition, exit conditions). With view to those types of uncertainty, the authors argue that only the *internal uncertainty* gives rise to information asymmetries as suggested by a principal-agent perspective, because the relevant information is internal to the venture and therefore the VCs are likely to be less informed than the entrepreneurs. By contrast, *external uncertainty* is less likely to be associated with information asymmetries, because the relevant information is external to the ventures and VCs and entrepreneurs are equally (un-) informed. Based on this differentiation Kaplan and Strömberg's (2002) empirical study finds that the round-length is only significantly (negatively) related to the external risk but not to the internal risk; and the authors therefore suggest that the driving force for staging is not asymmetric information, but rather the option to abandon the project, which will be more valuable in volatile environments.

Thus, from this perspective, our finding of a negative relation between VCs' knowledge and round-length may not be due to more knowledgeable VCs experiencing less venture-specific information asymmetries but due to their greater awareness of industry-specific uncertainties, and the corresponding value of the timely abandoning of a project with poor prospects of success.

But we note again that it is impossible to draw any further conclusions regarding the applicability of the agency theory based on our study (see also the next session for more discussion on this issue).

Additional findings

Finally, looking at other knowledge-unrelated findings of our study, one finds that they partially support and partially contradict some of the limited previous research on staging.

To begin with, our study provides support for previous studies suggesting that the staging of deals is common in the venture capital industry. More than half of the ventures in our sample receive two or more rounds of funding (on average 2.9 rounds, with an average number of 2.9 VCs per round); and, on average, the ventures in our sample receive a new round of funding every 445 days (median: 313 days). This closely resembles the findings from previous studies. Gompers and Lerner (1999), for instance, find - in a random sample of 794 ventures from various industries – that the average number of rounds received per venture was about 2.7. Thus, our findings are not necessarily confined to our particular sample industry, biotechnology.

With a view to the control variables, however, our study provides mixed support for previous research.

As outlined above, most of the agency-based literature on staging predicts that the value of staging (the value of having shorter rounds) should increase with the risk and the information asymmetries associated with an investment (e.g. Bergemann & Hege, 1998, 2003; Cuny & Talmor, 2003; Gompers, 1995; Kaplan & Strömberg, 2002, 2003; Neher, 1999; Wang & Zhou, 2004). However, our findings regarding the control variables provide no support for this prediction. For instance, neither the ventures' age nor their development stage is significantly related to the round-length. By contrast, first round investments are significantly - but positively - related to round-length.[243] This latter finding seems particularly noteworthy since, according to agency perspective, the risks and information asymmetries should be highest for the VCs in first rounds, resulting in shorter rather than longer rounds.

However, whilst seemingly contradicting most of the theoretically oriented literature on staging, those findings are in line with the two empirical studies on staging reviewed above. Gompers (1995), for instance, finds – contrary to his expectations - no significant difference in the duration of early- or middle stage rounds, and no significant relation between venture age and round-length in the high-tech cohort of his sample. Similarly, Kaplan and Strömberg (2002) find that round-length is significantly, but – contrary to their (and our) expectations – positively related to first round investments.

These 'unexpected' findings (viewed from a principal-agent perspective) might be explicable by a combination of factors.

With a view to the non-significant relation between the ventures' age and round-length, for instance, Gompers (1995) suggest that 'venture age' might be less important for measuring information asymmetries, at least in the context of high-tech investments - because it might take some time before the progress, or failure, of high-tech projects actually becomes observable. This is likely to be the case in the biotech sector.

Kaplan and Strömberg (2002), furthermore, suggest that the positive relation between first rounds and round-length could indicate that the driving force for staging is not asymmetric information, but rather the option to abandon a project, which will be more valuable in volatile, uncertain, environments – as is undoubtedly the biotechnology industry.

At the same time, it is also important to mention that although first rounds are longer than later rounds, they involve much smaller deal sizes.[244] Thus, VCs might accept longer rounds (i.e. less control) because their actual financial risk is smaller in first rounds, and because it simply takes time - but not necessarily much money - for high-tech projects to deliver the first observable results and reach their first milestones. This interpretation of our findings would be in line

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[243] See Table G-3, Panels B and C: first rounds last, on average 533 days (median: 395 days) whilst later rounds last, on average, 416 days (median: 285 days).

[244] As Table G-3 shows, first rounds are substantially smaller (avg. $4.7Mio, med. $1.8Mio) than later rounds (avg. $5.8Mio, med. $2.7Mio).

with some existing formal models of staging, which predict that the optimal capital allocated and the funding horizon are increasing from one stage to the next (cf. Bergemann & Hege, 2003; Cuny & Talmor, 2003).[245]

Finally, our study could add yet another interesting explanation for the 'unexpected' findings regarding the length of first rounds to the literature, namely, VCs who invest in first rounds are simply too ignorant to realise the value of shorter rounds than those VCs investing in later rounds. As our study reveals, the knowledge of VCs investing in first rounds is substantially smaller than that of VCs investing in later rounds, consistently with this view of things.[246] This of course raises some doubt as to whether the first round VCs' willingness to accept longer rounds is actually an outcome of rational considerations, or whether it is a sign of insufficient knowledge and ability to appropriately deal with the particular risks of first round investments. This is certainly an interesting field for further research, for instance, on the subsequent performance of different ventures depending on the level and type of knowledge of their first round investors; and we will deal with this issue to some extent in our next chapter.

G.VI.3. Limitations and future research

Although our findings support our hypothesis overall, we are aware that several limitations in our research design prevent us from drawing far-reaching conclusions.

At this stage we will highlight some of those limitations that are specific to our examination of the hypothesis in the present chapter, also to direct future research in this particular area. But it should also be referred to our discussion of those limitations that are of relevance to our general approach, such as with view to the theoretical variables or the sampling, in the synthesis Chapter J.

Units of analysis

As already described in some detail above (see section on 'analytical approach'), one limitation of our (main) analysis could be seen in the *non-independence of observations*. Specifically, some VCs and some ventures enter our analysis several times, because the same VC participates in several rounds of the same

[245] Unfortunately we have not been able to control for such milestone effects in this analysis but this reiterated finding provides fertile grounds for future research.

[246] As a comparison of Panels B and C in Table G-3 shows, the average knowledge of both the 'lead' VCs and the syndicates in first rounds is considerably lower than in later rounds.

or different ventures and because the same venture receives several rounds involving the same or different VCs. Thus, the pooling of all observations (rounds) introduces a potentially bias into our results because of the existence of venture- or VC-specific specific factors that we cannot control for but affect the decision on round-length.

To address this issue, we conducted several additional analyses, which only used sub-samples that partly or completely (first rounds) eliminated potential biases resulting from non-independent observations of the same ventures. They resulted in findings very similar to those of our main analysis.

Therefore, we are confident that the extent of a potential bias in our findings is small, at worst. Nevertheless, we are aware that those additional analyses do not completely eliminate the problems of non-independence resulting from multiple entries by the same VCs in our analysis.[247] Furthermore, the additional analyses performed might introduce another source of potential bias, for instance, with respect to sample selection. Hence, future research might address this issue more accurately by performing a Panel data analysis on the data.[248]

Dependent variable

Another possible limitation of our study that has also already been outlined above (see section on 'analytical approach'), concerns the *truncation of the dependent variable*. Because we measure the round-length as the time between one round and the next, this leads to the exclusion of all last rounds (unless they have a specified end date such as an IPO or an acquisition). Furthermore, in our main analysis, we also have to exclude all ventures that have only received one (their first round) unless this round ends in an IPO or acquisition. This could

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[247] However, in this context, it should also be mentioned that unreported additional analyses that only looked at the last investments made by each VC in our sample (similar to the approach described in more detail in our previous Chapter on syndication) – and as such completely eliminated the problem of non-independence with a view to the VCs (each VC can only have one last investment!) - also resulted in findings similar to those of our main analysis

[248] At the same time, also this approach is not without its problems. Specifically, our data would result in a very unbalanced Panel, with many firms entering only with one single observation (round) and many other firms entering with many observations (rounds). Furthermore, the time-intervals between observations would be very uneven, because VCs do not make investments throughout the year but not in regular intervals. One way to address this latter aspect might be to 'standardize' the time-intervals between observations (investments), for instance, by using average values for the number of investments (and the level/type of knowledge) for each VC in a fixed period of time. However, this procedure also introduces problems since it throws away information.

potentially bias our findings, for instance, because we only examine those ventures successful enough to attract more than one round of funding.

To address this issue, we again conduct additional analyses that use subsamples of observations (e.g. rounds before 1998) and/or a different analytical method Cox regression (unreported), which result in findings very similar to our main analysis of all rounds. This makes us confident that those latter findings are not too unduly influenced by the truncation of the dependent variable.

Nevertheless, also in this case, we acknowledge that our additional analysis in this context not completely eliminate the possibility of biases, also with a view to sample selection. As such, future research might address this issue in more refined ways.

Yet another - and arguably more severe - possible limitation of our study concerns the *validity of our dependent variable*, i.e. the question of whether it actually measures what it intends to measure. Specifically, we *assume* that our dependent variable, round-length, approximates the level of control exercised by the VCs. Here, we follow the arguments by several other authors (e.g. Bergemann & Hege, 1998, 2003; Cuny & Talmor, 2003; Gompers, 1995; Kaplan & Strömberg, 2002, 2003). Thus, we are confident that, the round-length indeed might be a suitable proxy for the control exercised by the VCs, at least to some extent. However, we are aware that this might not necessarily be the case.

For instance, we do not know whether subsequent rounds involve the same VCs. This might be an important issue because more knowledgeable VCs might simply be interested in a fast turn-around of their investments. In other words, knowledgeable VCs might tend to make investments, which they hope to cash in with a large profit after a short period by either taking the venture public or selling their stake on to another VC in the next round. If this were the case, our variable 'round-length' would not serve as a good proxy for the level of control through the VC. Instead, it might rather serve as a proxy for good (i.e. well-performing) ventures - since fast-turn-around investments should mainly involve good ventures (whilst the 'lemons' should be more difficult to take public or to sell to another VC). However, we believe that this argument is not really convincing, since good ventures should be in a stronger negotiating position in the pre-investment stage; and it seems likely that a promising venture will aim for larger funds, lasting for a longer period of time.

So, to us it seems more plausible to assume that more knowledgeable VCs prefer shorter investment rounds because they want to have tighter control over their investments, and not because they want to cash in their investments faster. Nevertheless, future research might also use more direct measures of VCs level of monitoring and control. Furthermore, an interesting avenue for future research might also be to examine additional/alternative means of control such as with a view to the type of equity VCs take and/or the particular deal structures (e.g. Kaplan & Strömberg, 2002, 2003).

Control variables

Another obvious limitation of our study concerns the overall low *explanatory power* of our various models and theoretical variables, which certainly limits their relevance from a practical perspective.

For instance, the maximum value of the adjusted R^2 in our main analysis (all rounds) is only about 3.9%; and we obtain very similar values also in all additional, unreported analyses on sub-samples (e.g. on first rounds or on ventures which we had additional patent information).[249]

Furthermore, we acknowledge that if sample sizes are very large (as is the case in our study), almost any difference between models (or blocks of models) is likely to be reliable (statistically significant), even if it may not have much practical importance. Similarly, we also realise that the magnitude of the coefficients (and betas) of our theoretical variables is still small; and it is also obvious that our relatively large sample size makes obtaining significant coefficients more likely. Furthermore, the betas of the theoretical variables are even smaller than that of some control variables.[250]

Therefore, future research in this area is recommended to search for other and/or more relevant variables with possible relevance in this context. For this purpose, one approach might be to improve on the control variables included in our models. For instance, most of our context-related variables only consider annual changes – e.g. in the number of VCs and ventures, or in the venture capital raised. Although we have tried – without obtaining very different results -

[249] In this context, it should also be mentioned that, in further unreported analyses, which did not include outliers/influential cases in the solution of the original main analysis, we 'managed' to raise the (adjusted) R^2 to some degree. However, the actual improvement was rather limited (maximum adjusted $R^2 < 6\%$). Furthermore, a closer inspection of the outlier/influential cases provided no reason to believe that those cases were not part of the overall population. Therefore, we opted not to focus on / present those 'improved' results.

[250] In this context it should be especially referred to the 'dummy variable for first round investments' that shows by far the largest coefficient (and beta) of any of the examined variables in the main analysis.

other time lags for those variables, it might well be that a more fine-tuned measurement of these context-variables provides further insights.

In addition, there are likely to be many more factors of possible relevance in this context. For instance, one might also consider the impact of external events (e.g. 'announcement of the completion of the human genome project' or 'product problems/scandals in the pharmaceutical industry') as additional factors of potential relevance for VCs activity, including round-length. Additionally, future research may also include control variables for the change of VCs between rounds, the general investment policies of individual VCs, cash-burn rates of different (types of) ventures, different human or 'patent' capital of ventures (as suggested by Neher's (1999) model), and/or naturally occurring mile-stones in the ventures' development (as suggested by Bergemann & Hege's (2003) and Cuny & Talmor's (2003) models).

In sum, although our main intention was to examine the relation between VCs' knowledge and the round-length, and although we have shown that such a relation exists and is more pronounced the more specific the VCs' knowledge is with respect to the particular venture under consideration, we clearly have to interpret our results regarding the practical relevance of VCs' knowledge with some caution. The relation between VCs' knowledge and round-length is very small, and VCs' knowledge hardly accounts for the variability found in our data.

CHAPTER H: VCS' KNOWLEDGE & PERFORMANCE OF VENTURES

H.I. Introduction

In the previous two Chapters we have examined the relation between VCs' knowledge and two features of VCs' investment approach, syndication and staging. There, our findings suggested that VCs' knowledge indeed can make a difference in that more knowledgeable VCs tend not to syndicate and have shorter investment rounds.

However, one of the most interesting questions in research on venture capital concerns the relation between VCs' knowledge and performance of VCs' investments. This is what we shall deal with in this chapter.

For this purpose however, we have to specify not only what we mean by 'VCs' knowledge' - as we already did earlier in formulating our propositions (see Chapter D) - but also what we mean by 'performance of VCs' investments'. With view to the latter, one can distinguish two main strands in the literature. They take different approaches and are likely to result in different findings regarding both the 'performance of VCs' investments' and the relation between VCs' knowledge and the performance of VCs' investments.

Some studies adopt the 'VCs' perspective', by looking at the performance of VCs' portfolios overall (e.g. Dimov & Shepherd, 2004; Kaplan & Schoar, 2003; Ruhnka et al., 1992). The rationale behind this approach is that VCs are said to be mainly interested in the performance of their overall portfolios. But a good 'performance by VCs' will often be due to the 'spectacular' returns on a few investments that make up for many unprofitable or failed investments. Thus, from this perspective, there might be a relation between VCs' knowledge and the overall performance of their portfolios, but not necessarily of their individual investments (e.g. Gorman & Sahlman, 1989).

Other studies, by contrast, adopt the 'entrepreneurs' perspective', by looking at the performance of individual ventures (e.g. Audretsch & Lehman, 2002; Chang, 2004; Hochberg et al., 2004; Hsu, 2004). This approach is different from the previous one because entrepreneurs will be mainly interested in the successful development of their ventures; and they approach VCs – as a very expensive source of funding – not only because no other sources of funding are available to them but also because they expect value-added contributions by VCs. So, if there is some truth behind the common industry adage that 'it is far more important whose money you get than how much you get or how much you pay for it' (Bygrave & Timmons, 1992), there might be positive relation between VCs' knowledge and the performance of their individual investee ventures.

That these two approaches are likely to result in different findings regarding the performance of VCs' investments is evident from an early study by Venture Economics (1988). This study finds that the returns on individual investments in a VC portfolio vary widely. More than one-third of 383 investments made by 13 firms resulted in an absolute loss; and more than two thirds of the investments made by the same firms resulted in capital returns of less than double the original costs. Nevertheless, the returns on a few investments more than offset the disappointments: for example, 6.8% of the investments resulted in payoffs greater than ten times cost, yielding 49.4% of the end-value of the portfolio (or 61.4% of the profits).

At the same time, academics such as Gorman and Sahlman argue that 'failure is at the very least endemic to the venture capital process, an expected common place event; in some cases, the process itself may even promote failure'; and the same authors continue: 'the entrepreneur, motivated by a dream of building a company, is intent that the company survives, that the dream be kept alive. The venture capitalist, by contrast, is intent on preserving the value of his or her capital investment and maximizing the return on his or her scarce resource time' (Gorman & Sahlman, 1989: 241).

In a similar vein, Manigart and Sapienza (1999) note that VCs are not so much in the business of reducing risk but in that of enhancing value through increasing returns. When business activities are not developing as favorably as expected, the interests of the entrepreneur and the venture capitalist may diverge. Because VCs manage their investments on a portfolio basis, their true interest might not be in the survival of an individual portfolio company.

Thus, the above two approaches are clearly distinct and ideally one would pursue both simultaneously and make a comparison of the outcomes. However, in the analysis to follow, we adopt the second approach exclusively – the 'ventures' perspective – reserving the venture capitalists' perspective for future research.

From this decision follows our current research question:

What relation exists between VCs' knowledge and the performance of VC-backed ventures?

H.II. Literature review

In our general literature review above, we already looked at theoretical and empirical literature, some of which is also of relevance to the research question of this chapter. At this point, we therefore refer the reader back to Chapter C.

However, our guiding question for that above literature review was more general (i.e. 'what impact has VCs' knowledge on financing entrepreneurial high-tech ventures?') than that for the current chapter.

In the present chapter, we therefore concentrate on empirical studies that deal with both VCs' 'knowledge' and the performance of VC-backed ventures.

But before we turn to this empirical literature we briefly recap the main conclusions from the theory (for more details on this literature see Chapters C and D).

H.II.1. Theoretical literature

All the above-reviewed theoretical concepts provide some rationale for how VC-backing could be related to venture performance. Furthermore, from our review of this literature, we also concluded that these concepts could be interpreted as – implicitly or explicitly – emphasizing the importance of VCs' knowledge in this context.

The (*financial*) *intermediation/signalling perspective*, for instance, emphasizes the information asymmetries between, on the one hand, entrepreneurial ventures with no track record or reputation, and, on the other, investors in the firm. VCs – as intermediaries – signal the quality of the ventures they back to third party resource provider such as the financial markets. This ultimately could translate into better performance for those ventures (e.g. Barry et al., 1990; Chan, 1983; Hsu, 2004; Manigart & Sapienza, 1999; Megginson & Weiss, 1991; Sahlman, 1990; Stuart et al., 1999). However, it must be noted, most literature in this context *assumes* that VCs, as knowledgeable intermediaries, are indeed able to overcome information asymmetries and related problems. But this literature hardly looks in detail at VCs' actual knowledge.

The *principal-agent perspective* also focuses on information asymmetries, but on those between VCs (principals) and entrepreneurs (agents). In so doing it identifies possible causes of conflict and risk, as well as mechanisms to deal with them, such as contractual arrangements tailored towards the specific risks associated with those information asymmetries (e.g. Admati & Pfleiderer, 1994; Amit et al., 1998; Barry et al., 1990; Bruton et al., 2000; Gompers, 1995;

Gompers & Lerner, 1999; Gorman & Sahlman, 1989; Jensen & Meckling, 1976; Hellmann, 1998; Kaplan & Strömberg, 2001, 2002, 2003; Lerner, 1994, 1995; Ruhnka & Young, 1991; Sapienza et al., 1996, 2000; Sapienza & Gupta, 1994). Therefore, the principal-agent perspective can be understood as emphasizing the importance of VCs' information or knowledge - particularly in comparison to that of entrepreneurs - because this reduces (or: helps to appropriately deal with) the critical information asymmetries. However, overall, this theory ignores differences in VCs' knowledge. Instead, it implicitly assumes that all VCs are experts, capable of choosing the most appropriate investment approach (Hsu, 2003). Also as a consequence of this, there now is a growing body of literature that casts doubt about the universal applicability of this concept in the venture capital context (e.g. Busenitz et al., 1997, 2004; Cable & Shane, 1997; Casamatta, 2000; Forbes & Milliken, 1999; Hellmann & Puri, 2002; Barney & Hesterly, 1996; Inderest & Mueller, 2001; Repullo & Suarez, 1998; Sahlman, 1990; Sapienza & Korsgaard, 1996; Sapienza et al., 2000).

The *resource-based perspective*, by contrast with the previous two theories, explicitly emphasises the importance of intangible, or knowledge-based resources. From this perspective, valuable resources/knowledge should be those that help organizations, including VCs, to gain a competitive advantage over the company's competitors (e.g. Barney 1986, 1991, 1994; Conner, 1991; Dierickx & Cool, 1989; Grant, 1996; Nelson & Winter, 1982; Peteraf, 1993; Teece, et al., 1997). Furthermore, one strand of the resource-centred literature, that emphasising resource-dependence (Pfeffer & Salancik, 1978), can also help our understanding of how not only the VCs themselves but also their investee ventures benefit from their knowledge (e.g. Aldrich & Martinez, 2001; Busenitz et al., 2004; Bygrave, 1987; Fried et al., 1998; Locket & Wright, 1999). A limitation of the resource-/knowledge-based perspective is that it takes a rather static view of VCs' knowledge. In common with the previous two perspectives it fails to consider how resources, including knowledge, are developed in the first place (e.g. Foss et al., 1995; Teece et al., 1997).

The *organisational learning perspective*, finally – as we showed earlier (see Chapter D) - offers a useful theoretical angle to address the weaknesses of the main theoretical concepts discussed above by not only explicitly emphasizing the importance of organizational knowledge for organizational performance but also by explaining how this knowledge is acquired over time (e.g. 'learning by doing/investing'). However, to our knowledge, only Busenitz et al. (2004) explicitly refer to this literature and acknowledge its applicability to venture capital. They point out that:

> 'learning [...] should result in long-term positive performance implications [but] an *assumption* in much of the research on VCs is that their information improves a venture's performance.... VC information may be valuable to NVTs [new venture teams] managers because VCs bring a variety of experiences with them from earlier investments. A VC investor who has been involved with both successes and failures is *likely* to have gained some insights into how new ventures can be developed.... *Theoretically*, input from VCs on strategic issues should lead to decisions that are better than those that NVTs could have generated otherwise [...]. Thus, to the extent that VCs provide information to NVTs on strategic issues, we would *expect* that it would be related positively to improvements in venture performance' (Busenitz et al., 2004: 791-2; highlighting by us).

Bearing this in mind, we turn now to an examination of the relevant empirical literature to explore our research question.

H.II.2. Empirical literature

As outlined before (in Chapter C), within the empirical literature on venture capital, one can broadly distinguish between two perspectives: the *ex-ante* literature that looks at what VCs do and (sometimes also at how this is related to venture performance); and the *ex-post* literature that looks at how VC-backed ventures perform.

Whilst our focus in the general literature review was on the VC characteristics used in the existing literature to differentiate between VCs (and their knowledge; see also Table C-1), in the following sections, our focus will be on the different measures of performance of VC-backed ventures in this literature.

H.II.2.a) Ex-ante perspective

As explained in our general literature review, overall, the 'ex-ante literature' suggests that VCs have developed an investment approach quite distinct from that of more traditional investors.

However, only a few ex-ante studies take into account possible differences between VCs and even fewer studies differentiate between VCs on the basis of characteristics (VC 'differentiators') that might be understood possible proxies for VCs' knowledge. Moreover, hardly any studies relate differences between VCs and their knowledge to measures of performance of VC-backed ventures. Where they do relate them, ambiguous findings are reported.

Sapienza et al. (1996), for example, are interested in the relation between VCs' 'experience', their level of involvement in ventures, and VCs' *self-perceived value* *added*. To examine this relation, the authors conduct surveys of and interviews with over 220 VCs, differentiated on the basis of 'VC experience' and 'new venture experience.[251] The authors find mixed support for their hypotheses: VCs with greater 'VC experience' require less interaction with their ventures but do not add significantly more value than those VCs with less VC experience. By contrast, VCs with greater 'new venture experience' interact more frequently with their ventures, and they add significantly more value to their portfolio companies than those without such experience.

Also with focus on the VCs' post-investment involvement, Busenitz et al. (2004) examine the relation between the *ultimate (exit-) outcome* of ventures and the quality of the strategic advice they received from their VCs during their early development stages, which might be understood as an indirect proxy for VCs' knowledge.[252]/[253] For this purpose the authors conduct a survey of 183 US ventures receiving venture capital between 1987 and 1989, for which they determine, in 2000, the eventual outcome. Their analysis yields a non-significant result for the effects of strategic information on venture exits; and the authors acknowledge that their results fail to support a positive long-term influence of strategic information from VCs on venture exits. In this context, Busenitz et al. (2004) suggest an explanation for why their study failed to support the idea that VCs, on average, do add value by providing strategic information, which is interesting from the perspective of our project. They argue that even though their study used a large sample, non-significant findings do not prove the null hypothesis. It may be that *some* VCs do indeed add value: some VCs may possess keen insights and perhaps some unique business experiences that enable them to add value to at least some of the ventures in which they invest'.

With a view to IPO exits from investments, Gompers (1996) examines the relation between the *IPO underpricing* of VC-backed ventures and their VCs' age.

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[251] Sapienza et al. (1996) approximate VCs' 'VC experience' and 'new venture experience' by the number of years a VC has spent in the VC industry, and by the number of years a VC has with operating experience in the industry of a particular portfolio venture under consideration, respectively.

[252] Busenitz et al. (2004) differentiate between the following four exit-outcomes (in order of increasing desirability): going out of business, remaining private, merging with another company, or going public.

[253] Busenitz et al. (2004) measure 'the strategic advise given by VCs' by asking the ventures' top-management team to indicate on a Likert scale whether their VCs (1) gave 'sound business advice' (2) provided 'excellent financial advice', and (3) provided 'sound management advice'.

Based on a sample of 433 VC-backed IPOs, he finds evidence that younger VCs are more likely to bring ventures to the market (too) early, arguably in order to 'showcase' their successes to investors. Ventures, however, 'pay' for their VCs' 'grand-standing' as they experience larger under-pricing. Hence there is a possible relation between VCs' knowledge (assuming that VCs' age is an adequate proxy for this purpose) and venture performance. At the same time though, Gompers (1996) finds that young venture capital firms have been on the ventures' board of directors for a shorter period of time (at the time of IPO), hold smaller equity stakes in the ventures and time the IPO to precede or coincide with raising money for follow-on funds. So, it is difficult to say from Gompers' (1996) study whether, if and how VCs' knowledge is actually related to venture performance.

H.II.2.b) Ex-post perspective

As outlined above in our general literature review (Chapter C), the ex-post literature falls into three main categories: 1) studies that compare the performance of VC- vs. non-VC-backed ventures, 2) studies that look at the performance of ventures backed by VCs overall, and 3) studies that analyse the performance of ventures backed by different VCs.

All three strands of literature could provide insights into the relation between VCs' knowledge and venture performance.[254] However, only the third strand explicitly looks at differences between VCs (also) on the basis of VC characteristics that *might* be understood as proxies for VCs' knowledge. But also the ex-post literature that looks at the performance of ventures backed by different - and arguably differently 'knowledgeable' - VCs doesn't provide a clear answer to our research question ('What relation exists between VCs' knowledge and the performance of VC-backed ventures?').

For example, several studies suggest some positive relation between VCs' 'knowledge' and venture performance, but they also indicate the potential

[254] As outlined in our general literature review, the first two strands of ex post studies provide an ambiguous picture regarding the impact of VC-backing on venture performance. For instance, within the literature that compares the performance of VC- versus non-VC-backed ventures, some studies suggest that the former out-perform the latter; but some studies also suggest that this is not always the case. Similarly, the literature that only looks at the performance of VC-backed ventures overall, shows that some of those ventures perform extremely well, but the majority either fails completely or does not provide any return.

relevance of other moderating factors and/or of the specific proxies used for VCs' 'knowledge' and/or measures of venture performance.

Barry et al. (1990), for instance, examine the relation between the *underpricing of VC-backed IPOs* and three different proxies for VCs' 'quality' - the lead VCs' age, number of previous IPOs, and size/funds under management. Based on a sample of 210 VCs that invested in 433 ventures, the authors find a negative relation between underpricing and the lead VCs' age and number of previous IPOs, but not the VCs' size.[255]

Stein and Bygrave (1990), by contrast, compare the *returns to VC-backed IPOs* that involved 'top-20' VCs vs. those that involved 'non-top-20' VCs.[256] Based on a sample of 77 high-tech companies that were backed by 91 different VCs, the authors find that that ventures backed by a 'top 20' VC enjoyed higher returns at IPO. The authors note however that ventures backed by top-20 VCs commonly are backed by top underwriters, and the individual effects of the VCs and the underwriters could not be distinguished.

Stuart et al. (1999) examine the *time-to-IPO* and *market capitalization* of ventures depending on their *VCs'* commercial and technological prominence.[257] Based on a sample of 301 VC-backed biotechnology ventures founded between 1978 and 1991, the authors find a negative relation between VCs' commercial and technological prominence and ventures' time to IPO; but they only find a positive relation between the VCs' commercial prominence and ventures' market valuation at IPO, not one between the VCs' technological prominence and ventures' market value at IPO.

Lange et al. (2001) compare the *time-to-IPO, market capitalization,* and *returns over six months post IPO* of ventures backed by either 'top' or 'non-top' first

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[255] Barry et al. (1990) argue the results are consistent with the 'signalling' hypothesis that the quality of the VCs reduces investors' uncertainty, and lower uncertainty is associated with less under-pricing; and the authors explain the fact that the size (funds under management) of the venture's VCs is not significantly related to under-pricing of the IPO with the questionable quality of the data source used for this purpose.

[256] Stein and Bygrave (1990) define 'top-20' VCs based on the number of seats they held on the board of the sample ventures.

[257] Stuart et al. (1999) approximate VC's '*commercial prominence*' by their normalized degree score in the network of strategic alliances (deals), and the '*technological prominence*' in terms of a patent citation network (for more details see our general literature review, Chapter C).

round lead VCs.[258] Based on a sample of 162 VC backed Internet and software ventures that went public between 1998 and 1999, the authors find that ventures backed by top lead VCs take *longer* to IPO, have higher market capitalizations and higher returns over six months post IPO than ventures not backed by those VCs.[259]

Manigart et al. (2002) take a different approach to measuring venture performance by comparing the *survival rates* of ventures backed by independent/captive vs. government-owned VCs and old/established vs. young/not established VCs. Based on a sample of 565 Belgium ventures these authors find that ventures backed by the two oldest/most established government-owned VCs have a higher survival rate (a lower bankruptcy rate) compared to ventures backed by younger/less established government-owned VCs, and in some cases also a higher survival rate than ventures backed by private/captive VCs. At the same time, Manigart et al.'s (2002) study also points towards the importance of differences in the type/stage of ventures backed by those VCs.[260]

Gulati and Higgins (2003), analyse the relation between ventures' *IPO success* (net proceeds, pre-money/90-day/180-day market valuation) and the

[258] Lange et al. (2001) define 'top' first round lead VCs as those 16 VCs (out of 106 VCs in their sample) that have been involved in the greatest number of IPOs. At the same time, those 16 'top' VCs were the most frequent investors in the first rounds of the 162 sample ventures, being involved in 57 – or 35% - of the first rounds in the sample.

[259] But also the authors acknowledge problems of multicollinearity: ventures backed by top lead VCs have a *longer* time to IPO, higher revenues in the year prior to the IPO and more employees, and most of the ventures backed by top lead VCs are also brought to the market by top underwriters; and, as the authors note, it is impossible to separate these effects.

[260] Manigart et al. (2002) offer several possible explanations for their findings regarding differences in the survival rates of ventures backed by differently old/established VCs (without testing them though): since the two established government-owned VCs are amongst the oldest of all VCs in Belgium, it may be that there is a 'learning effect' where the management of those established government-owned VCs over the years may have acquired expertise and may be able to better fulfil its roles of selection, value adding and monitoring. Additionally/alternatively the two VCs may have a 'better' – i.e. less risky – deal flow (indeed, the two oldest government-owned VCs invest about equal proportions in late and early stage ventures, as do the private/captive VCs – whilst the younger government-owned VCs invest proportionally more in early stage ventures). This, in turn, might be due to their superior reputation and/or to the fact that those government-owned VCs require lower expected returns because they pursue additional, non-monetary goals as well. This might further have an impact on their strategy in that they are more willing to provide support to under-performing ventures, which might be liquidated as 'living dead' by other, non-government VCs.

prominence of their VCs.[261] Based on a sample of 858 VC backed US biotech ventures that were founded between 1961 and 1994, and of which 299 went ultimately public, the authors find a (marginally) significant positive relation between the prominence of a venture's VC and a its IPO success; but they also find that this relation is moderated by an interaction between VCs' prominence and the biotech equity market index – indicating that prominent VCs are particularly beneficial for the IPO success during 'cold' markets.

Chang (2004) examines the *time-to-IPO* of ventures backed by VCs with different previous IPO success rates and different previous numbers of investments (both in the computer and communications industries). Based on a sample of 90 Internet companies that were founded between 1994 and 2000, the author finds that the VCs' previous IPO success rate is negatively related to ventures' time to IPO, but the VCs' previous number of investments isn't. Furthermore, Chang (2004) also finds that other variables such as 'total amount of VC funding raised prior to the IPO' and 'startup age' are significantly negatively related to time-to-IPO.[262]

Hochberg et al. (2004) examine the relation between, on the one hand, *venture survival* or *time-to-IPO/-acquisition*, and, on the other hand, various measures for the lead VCs' experience.[263] These authors measure 'survival' from the first to the third investment round, *or* successful exit from one of those rounds in form of IPO or acquisition. Based on a large cross-sectional sample of almost 2,000 VCs that invested in more than 16,000 ventures between 1980 and 1999, the authors acknowledge mixed findings regarding the impact of the lead VCs' experience. Venture survival is negatively related to the lead VCs' age (at the first round), positively related to the lead VCs' previous number of investments rounds (in the first and second round), positively (first and second round) or

[261] Gulati and Higgins (2003) approximate VCs' 'prominence' by their total amount invested overall until the year prior to the venture's IPO.

[262] Specifically Chang (2004) finds that a venture backed by a VC with a previous IPO success rate of 30% had an IPO rate that was 2.12 times higher than that of a venture backed by a VC with an average IPO success rate of 10%. However, he also finds that other factors such as the venture's time of entry into the market and the reputation and number of strategic alliance partners had an - even bigger – impact on a venture's time to IPO.

[263] Hochberg et al. (2004) approximate the lead VCs' experience, in case of the survival analysis, by the their age, total amount invested, number of previous investment rounds, and number of previous portfolio ventures; and, in case of the time-to-IPO/-acquisition analysis, only by their cumulative amount invested.

negatively (third round) related to the lead VCs' cumulative investment, and negatively related to the number of ventures in the lead VCs' portfolio (at the first round). At the same time, the lead VCs' cumulative investment is significantly negatively related to successful exits from the investments (via IPO or acquisition), but also to time-to-IPO/-acquisition (suggesting that more experienced VCs successfully exit their investments faster).[264]

Hsu (2004), furthermore, examines the relation between, on the one hand, ventures' *cooperation-intensity*, their *probability of experiencing an IPO,* and their *time-to-IPO* and, on the other hand, their VCs' previous IPO track record.[265] Based on an analysis of about 380 VC-backed ventures from various high-tech industries that were founded between 1988 and 1999, he finds a significant positive relation between VCs' reputation and the probability of the ventures experiencing an IPO, and a significant negative relation between VCs' reputation the time-to-IPO of those ventures experiencing an IPO.

Finally, Tykvova and Walz (2005), investigate the relation between ventures' *post-IPO performance* (post-IPO-returns/volatility and underpricing) and their type of VC and the reputational rank of their lead VCs.[266] Based on an analysis of all IPOs on Germany's Neuer Markt, they find that ventures backed by independent VCs perform significantly better two years after IPO as compared to all other IPOs, and their share prices fluctuate less than those of their counterparts in the same period. By contrast, firms backed by public VCs record relative underperformance. However, the authors find no significant relation between different types of VCs and the level of post-IPO underpricing, and – to their own surprise – they even find a positive relation between VCs' reputation and underpricing.

[264] Hochberg et al. (2004) justify the use of the VCs' cumulative amount invested as the only proxy for VCs' knowledge for this part of their study by the fact that it had shown the largest economic effect in the previous sections of their study.

[265] Hsu (2004) measures the VCs' 'previous IPO success record' by a dummy variable indicating whether a VC's previous IPO record up to the time of funding the target startup placed it in the upper half of the sample; where the threshold value is 21 IPOs and the mean is 0.47.

[266] Tykvova and Walz (2005) approximate the VCs' 'type' by a dummy variable indicating whether the VC is independent or government-owned, and the VCs' 'reputational rank' on a scale (1-5) according to their size/funds under management and age.

H.II.3. Preliminary summary and conclusion

Summarizing the above literature in the light of our research question ('what relation exists between *VCs' knowledge* and *venture performance*?'), several conclusions can be drawn.

Overall, from both the theoretical and the empirical literature, it is *possible* that there is a relation between VCs' 'knowledge' and venture performance. But the empirical evidence proving this assertion is only limited at best.

There are several plausible theoretical explanations for how VCs' knowledge could be related not only to the performance of VCs' portfolios, but also to the performance of their individual investee ventures.

Similarly, also some of the findings in the empirical literature could lend support to the idea of a relation between a VCs' knowledge and his venture's performance. For instance, the literature on the performance of VC-backed ventures indicates that at least some VC-backed ventures perform extraordinarily well. Perhaps, ventures backed by the arguably more knowledgeable VCs outperform ventures backed by arguably less knowledgeable other investors. Also several studies that look at the performance of VC- vs. non-VC-backed ventures suggest that the former tend to outperform the latter.

However, some of the empirical literature also indicates that VC-backed ventures do not always outperform non-VC-backed ventures, and there are considerable differences in the performance of VC-backed ventures.

Therefore, we would follow other authors, such as Tykvova and Walz (2005), who conclude that studies investigating the effect of venture capital provide an ambiguous message: positive, neutral, and negative influences by venture capital financing can all be observed.

H.III. Hypotheses

The ambiguity in the findings of empirical research on the relation between VC 'knowledge' and venture performance may result from a multiplicity of factors. In the present context, two factors seem noteworthy. They concern the arguably inadequate proxies – or their deployment – in the literature, for the variables 'VC knowledge' and 'venture performance' respectively. Together these may contribute to obscuring the relation between VCs' knowledge and venture performance.

Therefore, in the following, we shall deliberately deal with these two aspects for the development of our own research hypothesis. But, in this context, the focus will be on the second aspect, venture performance, because the first aspect, VC knowledge, has already been dealt with in detail before (in Chapters C and D).

VCs' knowledge

As we have already pointed out in our general literature review (see Chapter C), there is only very limited research that has actually differentiated between VCs on the basis of characteristics that might be understood as proxies for VCs' knowledge, and this literature shows ambiguous findings regarding such VC characteristics and venture performance.

In this context, furthermore, we have also already highlighted the arguable shortcomings of the proxies for VCs' knowledge, and of the way in which those proxies have been employed in the existing literature (see Table C-1 and corresponding discussions), and we concluded that these factors potentially contributed to the ambiguous relationship between VC-backing/VC-'knowledge' and venture performance identified in the empirical literature.

Thus, given the deficiencies of knowledge proxies in the literature, the question of what might be a better proxy for VCs' knowledge on the venture level arises.

At this point the reader is referred back to our propositions (see: P1-2, and particularly P4, Chapter D) where we explored in detail a suitable proxy for VCs knowledge on the venture level, namely the number and type of VCs' previous investments.

To briefly recap, based on the literature on organizational learning ('learning by doing'), we proposed that, at the venture level, *the average knowledge of the most knowledgeable lead VC should be more influential for investment performance than the average knowledge of all syndicate VCs ever investing in the venture.*

Furthermore, we also argued that *both the average lead VCs' knowledge and the syndicate's average knowledge should be more influential for performance the better matched it is to the current investment opportunity.*

Finally, we argued that *the knowledge of the VCs in first rounds should be more strongly related to venture performance than the knowledge of the VCs in later rounds.*

Venture performance

The various measures of venture performance used by previous studies are themselves a possible source of ambiguity in the relation between VCs' knowledge and venture performance (Sapienza, 1992).

Arguably the most effective way to assess organizational performance is by using financial measures, such as revenues, profits, and/or returns to owners. These rely on the idea of value being determined in a competitive market with publicly available information on company financials and outcomes. However, in the context of VC-backed entrepreneurial ventures this is a questionable approach. As Chang (2004) notes, conventional measures, such as profits or sales, are not available for many entrepreneurial ventures. Moreover, since many technology-based ventures require huge upfront investments, there may be a long time lag before they can measure performance (Chang, 2004). Most of these ventures usually do not generate revenues - not to mention profits - for a long period of time; and, particularly in the early years of their development, negative cash-burn rates might even be an indication of 'healthy' growth and project progress - potentially resulting in intangible outputs such as insightful results from experiments or even patents, but not in tangible outputs that could be evaluated in financial terms.

An alternative approach, therefore, might be to look at the ultimate financial returns to the VCs from their investment in particular ventures. However, as Jääskeläinen et al., 2003 point out, obtaining the relevant in data is difficult as VCs keep their profits secret.[267]

Because of the difficulties involved in using traditional financial measure of venture performance, a number of studies suggest other measures such as data collected from VCs and/or entrepreneurs on the *perceived* investment performance, either in economic or non-economic terms (e.g. Fredriksen et al.,

[267] Furthermore, it must be mentioned that, in our data, we don't have the necessary information to follow this path. Specifically, in many cases, we don't know how much a VC has actually invested in (a particular round of) a particular venture. Instead we often only have the total amount invested by a syndicate of VCs in a round. Furthermore, in most cases, we don't know the change in the value of a venture between rounds. So, when a VC invests, say, in the first round of a venture, but sells his stake to other VCs in the next round, we don't have information to calculate the return of the investment to this VC. Similarly, we don't have information about the actual stake a VC holds when a venture goes public or gets acquired. As such, we don't know what his overall proceeds are from his investment(s) in this venture; and we cannot calculate the return to the VC's overall portfolio.

1997; MacMillan et al., 1989; Rosenstein et al., 1993; Sapienza, 1992). However, these approaches are limited because of their subjective nature.

Yet another non-financial approach to measure performance of VC-backed ventures is to look at their survival as a performance indicator (see e.g. Manigart et al., 2002; Hochberg et al., 2004). However, also this measure is not fully satisfactory. On the one hand, simple survival tells us little about the performance of ventures. For instance, it is well known that many VC-backed ventures are in fact what is sometimes called 'living dead' (Bourgeois & Eisenhardt, 1987; Ruhnka et al., 1992). That is, the ventures still exist but are often inactive. On the other hand, as an in-depth case study by Steier and Greenwood (1995) suggests, VCs might even be willing to give up viable ventures if they don't promise the expected high returns within the usually limited time-horizon.[268]

The majority of studies on the relation between VC-backing and venture performance, however, focus exclusively on ventures that ultimately go public, and measure their performance, for instance, by their time-to-IPO (e.g. Chang, 2004; Hochberg et al., 2004; Hsu, 2004; Lange et al., 2001; Stuart et al., 1999), IPO size (Megginson & Weiss, 1991), returns at/after IPO (Cherin & Hegert, 1988; Stein & Bygrave, 1990), or post-IPO share-price volatility/performance (Barry et al., 1990; Brophy & Verga, 1989; Florin, 2005).

There are good arguments in support for the primacy of IPO as a measure of performance success, particularly for the VCs.[269]

However, there are some quite severe problems associated with it, chief amongst them 'survivorship bias' (Manigart et al., 2002). The foregoing studies only include survivors, thus ignoring the non-randomness of the sample of survivors. For example, companies making it to an IPO are already a very select and successful group of companies. Similarly, also Busenitz et al. (2004) note that perhaps one of the reasons for the variation in past research findings is that many studies examining VC impact have a survival bias: as non-surviving companies disappear, samples tend to contain higher percentages of firms that

[268] This fact is also supported by our own case studies (Chapter I below); and also below.

[269] See our discussions in the general literature review on the 'exiting of deals', Chapter C; and also below.

go public. An exclusive focus on these ventures could well distort the impact of VC-backing in general, or VCs' knowledge in particular, on performance.[270]

As a consequence, Busenitz et al. (2004) suggest a related, but arguably better, approach by looking at the ventures' *probability of experiencing a particular outcome*.[271] Specifically, Busenitz et al. (2004) categorize the exits of VC-funded ventures into: (1) those that fail and go out of business ('out of business'), (2) those that neither earn or lose much money, but which somehow stay in business ('still private'), (3) those that are merged or acquired by another firm ('merged or acquired'), and (4) those that sell stock in an initial public offering ('IPO').

Of these outcomes, an IPO is widely considered the most desirable from the perspective of both the VC and the venture.[272]/[273]

A Venture Economics study (1988), for instance, finds that a $1 investment in a company that is floated provides an average cash return of $1.95 in excess of the initial investment, with an average holding period of 4.2-years. According to the same study, the second best alternative is an acquisition of the shares by another company, over a 3.7-year average holding period. Sahlman (1990) furthermore shows that almost all of the average returns of venture capital funds

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[270] Pointing into a similar direction, Gompers (1995) notes that in some studies the results may understate the proportion of liquidations. For instance, some of the acquisitions/mergers may be distressed firms that provide little more than physical assets to their acquirer. Similarly, a number of firms classified as private may have been liquidated, but it is not possible to locate any record of the event because firms without any debt would have no need to file for bankruptcy.

[271] At the same time though, it should be also be mentioned at this point, that to our knowledge no previous study has simultaneously used the ventures' probability of experiencing an IPO as a measure for venture performance and our above-suggested proxy for VCs' knowledge (i.e. the number/type of VCs' previous investments.

[272] This was also emphasized in several interviews conducted with both VCs and entrepreneurs during the case study part of our project.

[273] However, Gompers (1995) also notes that there are differences between firms from different industries. For instance, in transportation, medical/health, and *biotechnology* the proportion of firms that go public is quite high. Specifically, Gompers (1995) finds that of 18 biotech companies in his sample, 9 went public, 5 merged or were acquired, 2 were liquidated or went bankrupt, and 2 remained private. This, according to Gompers, may reflect either the relative success of companies in this industry or their need for large capital infusions, which an IPO provides. In electronic components, industrial products and other (services), the proportion of IPOs is quite low and many more firms remain private. This, one might argue, could also explain some of the ambiguity in the findings from extant studies that used the IPO as a measure of venture performance, but relied on very heterogeneous samples comprising ventures from very different industries.

were earned on portfolio companies that went public. This finding is confirmed by Bygrave and Timmons (1992), who find that the largest valuations and returns are often realized in IPOs, which are small fraction of venture capital investments. Several other authors – such as Bascha and Walz (2001), Darby and Zucker (2002), Dimov and Shepherd (2004), Giot and Schwienbacher (2004), Lerner (1994), and Schwienbacher (2002) - come to similar conclusions.

At the same time, IPO often is also considered the most desirable outcome from the perspective of the entrepreneurs. As Chang (2004) explains, for them, the IPO is an opportunity to exchange stock for cash and reap personal gains; and it is an important means for raising funds to ramp up operations. Thus, IPO connotes a performance milestone and indicates the firm is ready for further growth.

Whilst one might also argue that an acquisition or a merger could result in profit for the entrepreneur (and his investors), an IPO is likely to be the event with the largest, and cheapest funds, providing the vital resources for the venture to develop into profitability whilst (by contrast with a trade sale) simultaneously remaining independent. Dimov and Shepherd (2004), note that an IPO also offers the entrepreneurial company legitimacy with stakeholders, access to debt capital, and a mechanism by which entrepreneurs can reacquire control from investors.

In sum, there are good arguments *for using the probability of a VC-backed venture reaching an IPO as a proxy for the performance of this venture.*

Final Hypotheses

From the above reasoning and evidence follows our **main Hypothesis 3a**:

Other things equal, VC knowledge enhances the probability that a venture will reach an IPO; and this relationship is stronger:

i) the better matched is the VC's knowledge to the venture under consideration,

ii) for lead VCs' than for syndicates' average knowledge, and

iii) for first round VCs' than for later round VCs' knowledge.

For the reasons outlined above, we believe that the ventures' probability of going to IPO is the most suitable measure of venture performance for the purpose of our project. As such, Hypothesis 3a presents our main Hypothesis.

However, because of this VCs typically wish to take startups public as soon as possible to realize their profits and invest the proceeds in other startups (Chang, 2004). Therefore, much of the literature has chosen a different approach, by focusing only on those ventures that ultimately went public and measuring, for instance, their time-to-IPO (e.g. Chang, 2004; Hochberg et al., 2004; Hsu, 2004; Lange et al., 2001; Stuart et al., 1999).

Most of this literature suggests a negative relation between VCs' 'knowledge' (or VC characteristics that might also be understood as proxies for it) and the ventures' time-to-IPO. In other words, given that a venture will reach IPO, VC knowledge shortens the time it takes to get there.[274]

Therefore, to compare the findings from our project with those previous studies we will run parallel analyses of the relation between VCs' knowledge and the time-to-IPO of VC-backed ventures.

From the above follows our **additional Hypothesis 3b**:

Other things equal, more VC knowledge in the first round reduces a venture's time-to-IPO; and this relation is stronger:

i) the better matched is the VCs' knowledge to the venture under consideration, and

ii) for lead rather than syndicate-average VCs' knowledge

H.IV. Methodology

In the following, we describe our methodology for operationalising and testing Hypotheses 3a and 3b. This includes a description of the variables and their operationalization, the statistical methods, and the analytical approaches used.

At this stage it should also be referred to Table H-1 at the end of this section that provides an overview over our methodology regarding the variables and units of analysis used for our tests.

H.IV.1. Variables and their operationalization

Whilst the tests of Hypotheses 3a and 3b involve different dependent variables, they involve many identical theoretical and control variables. Specifically, the

[274] In the language of hazard rates (see below for details), the relationship changes sign: knowledge is now Hypothesised to increase the chances that a venture will reach IPO in the next instant, given that it has not done so to date.

theoretical and control variables used for examining Hypothesis 3b are a subset of those used for examining Hypothesis 3a.[275]

H.IV.1.a) Dependent variables

The dependent variable for the test of our main Hypothesis 3a is the 'venture's probability of an IPO'. We operationalise this variable by a dichotomous dummy that takes the value of 1 if a venture goes public, and the value of 0 otherwise.

The dependent variable in our additional Hypothesis 3b is 'the time-to-IPO'. As we will describe further below, we operationalise this variable by computing the ventures' IPO hazard rate.[276]

H.IV.1.b) Theoretical variables

The theoretical variables for the examination of Hypothesis 3a and 3b are six different proxies for VCs' knowledge:

1) VC age
2) VC non-biotech experience
3) VC total experience
4) VC biotech expertise
5) VC biotech-stage expertise
6) VC biotech-subsector expertise

These variables and their operationalization have already been described in detail above, and we therefore refer the reader to the propositions of Chapter D for details. However, to assist the reader, we recap now: The VCs' age is operationalised by the time (in years) between the VCs' foundation and the date of the particular investment under consideration; and in those cases where a VCs' foundation date is unknown, we use the date of the VCs' first investment (as given in the Venture Economics database). All other knowledge variables are

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[275] Specifically, Hypothesis 3a involves theoretical variables for a venture's first, later, and all rounds, and control variables for first and last rounds. However, Hypothesis 3b involves theoretical and control variables only for the first round of a venture.

[276] As outlined before, at the end of our sampling window, many ventures in our sample have not gone public yet, and are therefore still privately held. Since (some of) those ventures might go public after our sampling period ends, the dependent variable is right-censored for those ventures at the end of the sampling period (March 2003).

operationalised as the cumulative number of the VC's investments one year prior to an investment under consideration. Specifically,

a) non-biotech experience = cumulative number of non-biotech investments

b) general experience = cumulative number of investments (biotech and non-biotech)

c) biotech expertise = cumulative number of biotech investments

d) biotech stage expertise = cumulative number of biotech investments at the same stage as the investment under consideration

e) biotech sector expertise = cumulative number of investments in the same sub-sector as the investment under consideration

Then, we calculate the average values for each of these variables, separately for

i) the syndicate as a whole

ii) the individual (lead) VCs

These calculations are repeated for first, later, and finally all rounds of each venture (in *un*-syndicated rounds, obviously, the sole VC simultaneously is the lead VC, and his 'average' knowledge is in fact his absolute knowledge).

As will be described in more detail below (see section on 'analytical approach'), for Hypothesis 3a, we then examine the above variables in separate models. For example, when we examine the relation between a venture's probability of experiencing an IPO and, say, its VCs' biotech-stage expertise, we run *separate models* that include (on top of the baseline model variables) – for the venture's (various) lead VC(s) *or* for its syndicate(s) – the VCs' biotech-stage expertise averaged over all rounds, the first round, *or* the later rounds this venture had received.[277]

For Hypothesis 3b (time-to-IPO), we calculate and examine the same variables but for a venture's first round only. This saying, we examine the impact of the VCs' knowledge (separately for the syndicate and the lead VC), measured at the venture's first round, on the time-to-IPO of this venture, but we do not consider the impact of the knowledge of VCs investing in possible later rounds of the venture.

[277] Thus, in this example, we would run six different models: 1./2. the average knowledge of all syndicates/lead VCs invested in all rounds of the venture, 3./4. the average knowledge of the syndicate/lead VC invested in the first round of the venture, and 5./6. the average knowledge of all syndicates/lead VCs invested in later rounds of the venture.

H.IV.1.c) Control variables

Although our above hypotheses are based on the assumption of 'all other things equal', it is obvious that venture performance is a product of innumerable endogenous and exogenous factors; and, no single factor or a limited group of factors - such as VCs' knowledge - will fully explain the success or failure of ventures.

Shepherd et al. (2003), for instance, note that there are daunting obstacles to determining the extent to which VCs make good, accurate, or successful decisions because many unforeseen circumstances can impact new venture performance during the elapsed time from when a VC makes a decision to invest and when the outcome of that decision is known.

Therefore, we control for a number of venture- and context-related variables with potential impact on venture performance. They are described in the following for Hypothesis 3a. For Hypothesis 3b, we use a subset of those control variables that refer to the first rounds of our sample ventures (e.g. market conditions at the time of the first round) or to the ventures as such (e.g. country of origin).

Venture-related control variables

Venture capital received (overall and in first round): When being interested in the relation between VCs' knowledge and venture performance, arguably one of the most important variables to control for is the amount a venture has received from its VCs. This is because - by contrast with the non-financial contributions made by VCs - their financial contributions to a venture's development are incontrovertible. Almost by definition, most ventures are cash-constrained and need external funds. Therefore, the funds provided by VCs are likely to be positively related to these ventures' performance - either because larger investments 'make opportunities better' or because better opportunities attract larger investments. Gompers (1995) suggests that the total venture financing is expected to be higher for successful projects (e.g. for IPOs or acquisitions) than for failures; and, in his empirical study, he finds that total amount received was indeed greater for IPO ventures than for ventures that either went bankrupt or were acquired/merged.[278] Also Shane and Stuart (2002) find that the cumulative

[278] For instance, in Gompers' (1995) study, biotech ventures on average received a total of $8.5Mio. However, those that went public received an average of $12Mio, whilst those that got acquired or merged received $8Mio, and those that went bankrupt only received $7.7Mio. At the same time,

amount of venture capital funding had a strong positive effect on the rate of IPO. This might be, Chang (2004) argues, because the more funding a startup secures from venture capital firms, the higher its growth rate should be since it can hire and retain talented employees and secure other resources, likely to help startups to have IPOs more quickly. Therefore, and because we conduct some analyses only on first rounds, *we control for both the total amount of venture capital received by the venture overall (in $Mio) and the amount of venture capital received by the venture in the first round (in $Mio).*

Venture development stage at first round: Another arguably important variable to control for in the context of our project is the development stage of the venture.[279] This is because it is widely accepted that the earlier the development stage of an investment opportunity the more difficult it is to assess, and the more likely it is to fail. Whilst we assume that more knowledgeable VCs might be more capable of realistically evaluating the potential of an early-stage venture than ignorant VCs, we acknowledge that it will be difficult if not impossible for all VCs to make a reliable decision particularly with view to first round investments, where often no information about the venture, its management team, and/or its technology will be available. At the same time, Bottazzi et al. (2004) argue, that companies which receive venture finance at an early stage are likely to benefit to a greater extent from the involvement of the VC. Therefore, *we control for the development stage of a venture at the time of its first round by a dummy variable taking the value of 1 if the venture is in a start-up-, seed-, or early-stage at the time of its first round, and the value of 0 otherwise.*

Venture country US: Another venture-related factor that might moderate the relations we intend to analyze is the country in which an investment takes place. This is because countries might, or might not, provide what sometimes is called 'social capital' and/or supportive 'institutional frameworks' for entrepreneurial ventures to prosper. This might include, for instance, the overall level of expertise available to a venture in form of high quality scientists, managers,

however, there was no difference in the total funding for those ventures that were acquired and those that were liquidated compared to ventures that remained private.

[279] Here, it should be mentioned that similar arguments could be made with view to the age of the venture (e.g. Stuart et al., 1999). However, since both variables are correlated, we opt to control only for one of them. For this purpose, we believe, the stage is the more relevant variable. This is because, in many cases there will be a high correlation between the stage and the age of the venture, some ventures might make slower progress with their projects, thus remaining in a high-risk, early development stage even although their age would suggest a later stage.

and/or professional support services. Furthermore, also the maturity of the private equity markets varies between countries, and with it arguably the overall level of knowledge VCs might have. All this is likely to contribute to the quality and performance of VC-backed ventures located in different countries. It is generally accepted, the US is the country with the most developed entrepreneurial culture, the most mature VC-market, and also the most advanced biotechnology industry; and it is likely that whether or not a venture is located in the US might impact its probability of experiencing an IPO. Therefore, we *control for the venture's country of origin by a dummy variable that takes the value of 1 if the ventures comes from the US, and the value of 0 otherwise.*

Venture first round syndicated: From our previous discussions in Chapters D and F ('Propositions' and 'Syndication'), it is reasonable to assume that syndication – particularly with view to ventures' first rounds - is related to subsequent performance of the ventures.[280] However, the direction of this relation is difficult to predict. For example, if syndication reduces risk, this should increase the chances that the venture will reach IPO rather than an alternative outcome. Likewise, if syndication reduces capital constraints, this should make it more profitable or viable and therefore reduce the chances of failure (non-IPO). Finally, if syndication is motivated by First-mover advantage, we expect that the deal will be cheaper for the VC and/or he will control the venture more effectively, thus increasing the chances of its success. Thus ultimately the performance impact of syndication is the underlying rationale for syndication discussed above. In consequence, one might expect a positive relation between the decision to syndicate and the performance of the venture: syndicated deals are more likely to be successful. There is some support for this proposition in the literature. For example, Sorenson and Stuart (2001) find that the annual return to VCs is significantly higher for syndicated than for unsyndicated investments (35-39% vs. 15-20%). They also find that there is a significant positive relation between syndicate size (number of VCs in the syndicate) and the annual rate of return on the investment. Jääskeläinen et al. (2003) find a curvilinear (inverted-U-shaped) relationship between portfolio size and IPO success rate, and this relation is moderated by the VCs' syndication behaviour. The higher the

[280] First rounds are likely to be most relevant because first round ventures are particularly difficult to assess realistically because they have no track record; whilst, at the same time, first round ventures are particularly likely to benefit from the non-/financial contributions of their VCs.

proportion of syndicated investments in the portfolio the higher the 'optimum' portfolio size and the higher the number of IPOs from new investments.[281]

By contrast with these findings however, in our Chapter F on syndication further above, we found that there was a *negative* relation between the individual VCs' knowledge and the probability of syndication. This suggests that syndicates, on average, are in fact *less* knowledgeable than sole VCs; more knowledgeable VCs tend to go-it-alone, and ignorant VCs can only syndicate with similarly ignorant VCs. This would in turn suggest that syndication could be *negatively* related to venture performance. Similarly, following Brander et al.s' (2002) suggestion that if a sole VC syndicates if he is not convinced about the ventures' quality, this might also imply that syndication is negatively related to venture performance. Overall, however, too little is known to predict the actual relation between syndication and investment performance to make an exact prediction of the sign of this relation (cf. Wright & Lockett, 2003; Manigart et al., 2004). Therefore, *we control for whether a venture's first round was syndicated or not by a dummy variable that takes the value of 1 if the round is syndicated, and the value of 0 otherwise.*

Venture first round length: Building upon our previous Chapter G on 'staging' we believe, it is also interesting to control for the length of a venture's first round. This is because, as outlined before, staged capital infusions are said to be the most potent control mechanism a VC can employ, and, and as such, is likely that this also translates into venture performance (Gompers, 1995; Gompers & Lerner, 1999). Gompers (1995), for instance, notes that if monitoring is valuable for the VCs they should show tighter monitoring (shorter rounds) when investing

281 Jääskeläinen et al. (2003) provide three explanations - without testing them though - why syndication could be positively related to venture performance: 1) the syndication of investments may increase the quality of investments. Through syndication networks, VCs share information on the potential deals (Bygrave, 1987; Lerner, 1994). It allows VCs to become aware of ventures that are beyond their geographical reach (Sorenson & Stuart, 2001), thus increasing the amount of proposals received. Having a larger pool from which to pick investments may increase the quality of best proposals, thus resulting to better investments. 2) the shared decision-making of a syndicate is likely to further enhance the quality of investments (Brander et al., 2002; Lerner, 1994). If syndicate partners independently review a proposal and decide to invest if each partner approves the proposal, their decision is likely to be of better quality than one made by individual decision maker (Sah & Stiglitz, 1986; Wilson, 1968), thus resulting in better investments. 3) the syndication of investments increases the number of investor of a venture, thus potentially giving it an access to larger pool of resources. A syndicate with multiple VCs provide complementary skills and contacts that contribute to the assistance and governance of the venture (Brander et al., 2002; Lockett & Wright, 2001).

in ventures where information asymmetries are likely to be high.[282] On the other hand, we also found before that first rounds often differ from later rounds in that they involve smaller deal sizes. But whilst smaller deal sizes generally should lead to shorter round-lengths this might not be the case in first rounds, for instance, because the cash-burn rates of ventures' first rounds, particularly when they are at an early stage of their development, are lower than those of later round/stage ventures. Therefore, *we control for the length of the venture's first round (in days) between the beginning of the first round and the beginning of the next round.*

At this point, however, it should be mentioned that controlling for the round-length requires the round-length to be measurable. This, in turn, requires that a venture has received at least two rounds, so that we can calculate the time between the beginning of the first and the second round. But since many ventures in our sample have only received one round of funding, including this control variable into our main analysis would further reduce our sample size; and, more severely, it might bias our findings since we would only include those ventures in our analysis that have been 'so successful' that they received at least two rounds of founding. This might also impact what is in the focus of our interest, i.e. the relation between VCs' knowledge and venture performance. Therefore, we check the robustness of our findings obtained from the sample of ventures that received at least two rounds of funding by running extra analysis on samples that include all ventures, regardless of the number of rounds they had received.

Context-related control variables

If one is interested in the relation between VCs' knowledge and venture performance - and particularly if the latter is measured in terms of the ventures' probability of going public - one must certainly control for contextual factors - at

[282] Supporting this, Gompers (1995) finds evidence for his predictions regarding the relation between investment structure and investment outcome: the number of rounds is greater for the sample of IPO ventures than for either the entire sample or the sub-samples that go bankrupt or are acquired/merged. Furthermore, ventures that went public received more financing rounds than those that remain private, while ventures that were acquired or go bankrupt did not receive more rounds on average than those ventures that remain private. However, it is not clear whether Gompers controlled for the time until the event, i.e. it might be that ventures that went public received more rounds in a longer period of time, whilst bankrupt/acquired ventures went bankrupt/were acquired sooner. Furthermore, this is not the case for biotechnology (N=29) where the average (median) number of rounds overall, for IPOs, for bankruptcies, and for mergers/acquisitions is 3.69 (4), 3.56 (3), 4.00 (4), and 4.60 (4) respectively.

the time of the initial funding and/or of the ultimate exit of the venture. This is for several reasons.

To begin with, VCs are sometimes said to follow 'fads' and invest in sectors or types of ventures perceived to be 'hot' (cf. Valliere & Peterson, 2004). Since, at any point in time, there is only a limited number of existing ventures on which VCs can 'throw their money', it is plausible that the 'hotter' the markets, the more likely also low-quality ventures are to get funding. Gompers and Lerner (2000), for instance, show that the prices VCs pay when investing in portfolio companies increase as more money flows into the VC industry holding investment opportunities constant; and they interpret this pattern as evidence that competition for scarce investment opportunities drives up valuations. Hochberg et al. (2004) further argue that competition for deal flow also affects the quality of VCs' investments and thus performance. This is supported by Chang (2004), who finds, in a study on Internet ventures, that those ventures that entered the market early on (before the Bubble) had rate of going public more than 12 times higher than that of late entrants.

On the other hand, the contextual situation certainly is also important for the final outcome of ventures, and specifically for their probability of reaching an IPO. The public markets are known to be cyclical/volatile, with 'windows of opportunity' for IPOs rapidly opening and closing again (see Lerner, 1994, for the impact of this phenomenon in the biotech context). When the window is closed, even 'good' ventures might find it difficult/impossible of going public; but when the window is open, even 'bad' ventures might manage to do so. As a consequence, Gulati and Higgins (2003) point out that the impact of VC-backing on (post-) IPO performance should not be the same at all times: the signal VC backing sends to external investors at IPO might be altered by market up- or downturns. This is because for outside resource holders such as public investors, uncertainty associated with a venture can arise not only due to characteristics of the venture itself but also from exogenous sources. Here, one critical aspect of uncertainty for investors should be how favourable or unfavourable the market is for equity offerings. During cold markets, external investors might perceive the risk of investing in unworthy ventures to be less salient; and they might tend to rely more on the signal of the prominent VCs' decision making than during hot markets - when VCs might be overly optimistic and less diligent in their own investment decisions. Chang (2004) therefore recommends that, if one is to examine the effects of venture capital financing on the IPO event, one needs to control for environmental factors that may also influence the incidence of IPOs such as the general IPO market environment; and one can expect the probability of going to IPO is greater as the IPO market becomes more bullish. Similarly, also Florin (2005) argues that 'what really matters are not necessarily the characteristics of the industry but rather how 'hot' the industry sector is in the market for IPOs.

In sum, the contextual situation, at the time of both venture foundation and potential venture exit, is likely to impact the actual performance of ventures in terms of their probability of going public. Therefore, we control for several variables that are likely to capture the situation in the private equity as well as the public financial markets:

- The *Dow Jones Industrial Index*
- The *number of venture-capital backed IPOs by biotech ventures*
- The *total amount of venture capital raised*
- The *number VCs providing venture capital*
- The *number of biotech ventures receiving venture capital*

With view to the above variables, however, it is plausible to assume that the 'hotness' of the markets finds its expression not so much in the absolute value of certain indicator variables but rather in the changes in the above control variables. Therefore, *we control the annual percentage change in the year of the investment in a venture compared to the previous year.*[283]

Furthermore, it should be mentioned again that, in our examination of Hypothesis 3a, we control for the above variables at the time of a venture's first round and for the time of a venture's last round or IPO. In the examination of our additional Hypothesis 3b, by contrast, we control for the above variables only at the time for a venture's first round because - due to the censoring of the dependent variable – for many ventures we cannot determine the time of the last round or IPO.

[283] Here, it should be mentioned that we use the DJI instead of arguably more appropriate indices such as the NASDAQ or the NASDAQ Biotech Index because the latter are only available since a time after our sampling period starts. As such, using those indices would have reduced our sample size considerably. However, it should also be mentioned that the pattern of development in the DJI during the sampling period closely resembles that of the other two mentioned indices.

H.IV.2. Statistical methods and analytical approaches

The different dependent variables in Hypotheses 3a and 3b necessitate different statistical methods and analytical approaches, which we describe in the following.

H.IV.2.a) Hypothesis 3a

H.IV.2.a.i. Statistical method

The dependent variable in Hypothesis 3a, 'the venture's probability of an IPO', represents a dichotomous variable, i.e. whether or not a venture ultimately goes public. Here, logistic regression is the appropriate analytical technique. We have described the general procedure for logistic regression in Chapter F, to which the reader is referred for details.

H.IV.2.a.ii. Analytical approach

This section outlines our approach for analysing Hypothesis 3a, and its three sub-hypotheses (i-iii). For an overview it should be referred to Table H-1 further below.

To begin with, one general problem with our examination of venture performance in Hypothesis 3a concerns the *censoring of observations*. Specifically, for many ventures in the sample it is impossible to determine whether or not they ultimately go public. This is because a considerable proportion has been founded only a few years before sampling ends (in March 2003). Therefore, the majority of those comparatively young companies are still privately held at the end of the sampling period. Some of those ventures might have gone public soon after our sampling has ended, some might go public in the future, and some others might never make it to an IPO. In the language of statistics, our dependent variable is *right-censored*. There are various ways of dealing with this issue, but we adopt here a simple approach considering only those ventures that are old enough at the end of the sampling period to have had a realistic chance to go public.[284]

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[284] The most celebrated alternative is a two-stage estimation procedure using the so-called Heckman correction method. In this method the probability of missing data is first estimated on the whole sample. Then a Mills ratio, representing the hazard of a missing observation conditional on characteristics observable for *all* firms, is added as an additional regressor in the second stage estimation of the probability of success on the subsample for which the outcome is known. However,

Yet determining the appropriate cut-off point (age) for the ventures to be included is difficult; and scholars facing similar problems have suggested different approaches to dealing with the issue. Gompers (1995), for instance assumes those ventures that haven't received a new round of funding during the 4.5 years before his sampling ends to remain private. Jääskeläinen et al. (2003), by contrast, record the exit date either as the date of an IPO or as the date one year after the last observed investment round (This corresponds to the median interval between investment rounds in his sample). Hsu (2004) includes all ventures in his sample and just controls for their funding year. Hochberg et al. (2004) include ventures that had received their first round of funding only 4 years before the end of their sampling period. Finally, Busenitz et al. (2004) suggest that one should allow for up to 10 years for ventures to change their status, for instance, from privately held to public.[285]

Our approach follows Busenitz et al. (2004). This is, in our test of Hypothesis 3a, we include only those ventures, which have been founded at least 10 years before the end of the sampling period, i.e. before 1994.

That this is a reasonable approach is evident from Figure H-1 below, which illustrates three aspects for each year of our sampling period:

- the cumulative percentage of all ventures that were founded up until this year and that ultimately went public by the end of the sampling period (green line with numbers, left-hand scale)
- the percentage of those ventures that were founded in the particular year and that ultimately went public by the end of the sampling period (red line, left-hand scale)
- the total number of ventures founded in a particular year (dashed line, right hand scale)

As this Figure illustrates, of all ventures founded up until 1993, 49% went ultimately public; and of those ventures founded in 1993 alone, about 45% went

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the method is not without its difficulties: the specification of the selection equation at the first stage is critical in avoiding additional bias at the second stage.

[285] The authors note that, in their study, several VCs indicated that their goal was to exit their portfolio ventures within 6 years. However, because market swings delayed public stock offerings for many of them, the status of some ventures was not resolved within 6 years. But after 10 years, VCs will face pressure from their own limited partner investors to liquidate investment funds, which will give limited partners the option of either using their money for another purpose or for reinvesting in the next fund (Busenitz et al., 2004).

ultimately public (percentage value not shown in Figure H-1). But by 1994 these Figures decrease to 47% for all ventures founded up until this year and 27% for those ventures founded in this year alone. Finally, at the end of our sampling period in 2003 those Figures reach a low of 25% for all ventures founded up until the last year of our sampling period and 0% for those ventures founded in this year alone.

In other words, the effect of the right censoring in our data seems to become particularly evident after 1993. Chances are that some of those ventures founded from 1994 onwards will go public after our sampling period ends, but it is impossible to predict what proportion of those ventures will ultimately make it to an IPO. This is particularly so, because, from the mid 1990s onwards the overall situation in the biotech industry apparently changes dramatically (as can be seen from the drastic increase in the number of ventures founded from 1994 onwards). Choosing 1993 as the cut-off for our sampling period is therefore justifiable - although, as is evident from Figure H-1, this approach means we exclude from our analysis the large number of ventures founded in the second half of the 1990s.

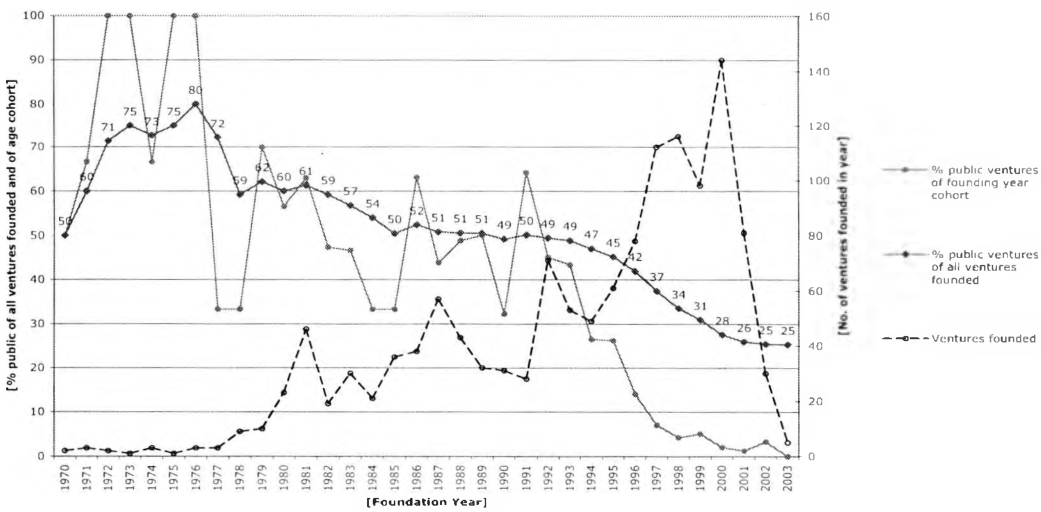

Figure H-1: Cumulative % of all ventures and % of ventures in age cohort going to IPO during the sample period.

It should be emphasized that limiting our sample to those ventures founded before 1994 is not the same as limiting our sample to those that went public before 1994. Instead, we include all ventures (whether they went public or not) that were founded before 1994 in our analysis, but we follow their outcome until March 2003. As a consequence, our analysis still includes the majority of IPOs that have occurred overall during our sampling period (269 out of 321), and we are only losing those (52 or about 16%) IPOs that involved ventures founded after 1993.

Next we turn to our analytical approach with respect to the three sub-hypotheses (i-iii) of hypotheses 3a.

In sub-Hypothesis 3a i our intention is to examine and compare the relation between VCs' knowledge and venture performance for different knowledge proxies. As outlined before, some of our knowledge proxies are (highly) correlated. This creates problems for estimation including the significance of individual variables (which may fall dramatically even though the overall fit of the model is high), the stability of estimates of individual coefficients and even (in the extreme) a problem of getting any estimates at all. Initial estimates of the coefficients of these variables – when included simultaneously - proved to be quite unstable. Therefore, we run six parallel analyses, one for each of the theoretical variables, using the same units of analysis and only those observations for which we have information on all variables included in the analysis. This allows us to compare and contrast both the overall model parameters and the individual coefficients for each theoretical variable.

In sub-Hypothesis 3a ii our intention is to compare the impact of the average knowledge of all 'lead' VCs versus that of the syndicates ever invested in a venture on venture performance, again using all six proxies for VCs' knowledge. Therefore, we conduct separate analyses for the 'lead' VCs' and the syndicates' knowledge.

In sub-Hypothesis 3a iii, finally, our intention is to compare the relation between the average knowledge of 'lead' VCs/syndicates in first rounds versus that of 'lead' VCs/syndicates in later rounds. To test this Hypothesis, we again run separate analyses for first rounds and later rounds.

However, because not all ventures in our sample have received more than one round, testing and comparing the relation between VCs' knowledge and venture performance with view to first and later rounds obviously reduces our sample to the number of ventures that have received at least two rounds of funding compared to the number of ventures, regardless of how many rounds they have received. Furthermore, this might also introduce some bias into our findings because we only include ventures that were as 'successful' that they attracted at least two rounds of funding.

Therefore, to test the robustness of the results, we analyse the above described models twice: first, using the reduced 'core sample' of those ventures that have received at least 2 rounds (N=310), and then using the 'full sample' of ventures regardless of how many rounds they have received (N=406).

H.IV.2.b) Hypothesis 3b

H.IV.2.b.i. Statistical method

In our analysis of Hypothesis 3b, the independent variable is the 'time-to-IPO of those ventures that ultimately go public', depending on the knowledge of their VCs in their first round, and controlling for a number of factors that are also likely to influence the ventures' outcome.

But for the same reasons outlined in the previous section on Hypothesis 3a, this independent variable is right-censored - ventures that have not gone public by the end of our sampling window, have no time-to-IPO available. Neglecting this right-censoring – for instance, by running a multiple regression on the full sample to examine the time it takes them of going public depending on their VCs' knowledge - clearly would introduce a significant bias, because it would leave unconsidered all the other ventures for which we do/can not observe whether they ultimately experience an IPO. To avoid this bias, we could again – as already done for examining Hypothesis 3a - exclusively focus on those ventures, which either have already experienced an IPO or for which we can be almost certain that they will not experience an IPO anymore. This approach would again severely limit our sample size.

However, contrary to Hypothesis 3a, where the dependent variable was dichotomous, in Hypothesis 3b, the dependent variable is the continuous time it takes for an IPO event to happen. In this situation, as Tabachnick and Fidell (2001) point out, survival (or: failure) analysis is the most appropriate choice.

The goal of this technique is to predict survival time (or, more generally, the time for an event to occur) by a set of covariates. Survival analysis is similar to logistic regression in that it uses a log-linear rather than a linear model, which tends to be more forgiving in terms of assumptions. However, survival analysis is different from logistic regression in that it accommodates censored data and analyses the time between events rather than predicting the occurrence of events (Tabachnick & Fidell, 2001). Thus, survival analysis is concerned with the probability that the event will end in the 'next period' given that it has lasted as long as it has; or, more exactly, survival analysis asks: given that the spell (duration variable) has lasted until time t, what is the probability that it will end in the next small interval of time?'. The latter is known as the *hazard rate* (Greene, 2003).

There are several procedures to estimate hazard functions, of which the semi-parametric *Cox proportional hazards model* (*CPH*) is the most popular.[286] The CPH model estimates the influence of the explanatory variables on the hazard of an IPO event without specifying a parametric form for the time of investment. Instead, it ranks IPO events in terms of their temporal sequence. The dependent variable in the hazard model is a hazard rate that denotes (in our case) the chances that a firm will go public in each time period given that it has not done so to date.

More specifically, this model presumes that hazard rates can be represented as log-linear functions of the covariates. If $h(t; Z,X(t))$ is the hazard function for an individual with time-invariant covariates vector Z and time-varying covariates X(t), the proportional hazard model specifies this hazard as the probability that the observed IPO event should have taken place, conditional on the hazards of all startup firms at risk. This formulation leads to the following specification of the probability (L_i) for the *i*th firm:

$$L_i(t) = h_0(t)\exp(\mu_i Z_i + \beta_i X(t)) / h_0(t)[\sum_{j \in R_t} \exp(\mu_i Z_i + \beta_i X(t))]$$

where $ho(t)$ is the baseline hazard rate at time t; j is an index for startup firms at risk at time t (R_t being the risk set); Z_i are independent variables for individual firm i that are constant over time; $X_i(t)$ are the time-varying covariates for firm i; and μ and β are coefficients to be estimated.

This model contains two implicit assumptions. First, it assumes a multiplicative relationship between the underlying hazard rates and the log-linear function of the covariates (the proportionality assumption). Second, it assumes that the effect of the covariates on the hazard function is log-linear. It is these two assumptions that allow the model to leave the baseline hazard unspecified.[287] This generality is achieved by assuming the baseline hazard rate is the same for all firms in the risk set. From this assumption, $ho(t)$ in the above equation cancels out. We can rewrite the probability function as:

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[286] For more details on these models and their underlying assumptions, see: Allison (1995), Cox and Oakes (1984), Kalbfleisch and Prentice (1980), and Yamaguchi (1991).

[287] Since the proportional hazard model does not specify the baseline hazard, there is no bias incurred by mis-specifying the stochastic process of the underlying hazard rate; and the method is quite robust in its accommodation of non-proportional hazards.

$$L_i(t) = \exp(\mu_i Z_i + \beta_t X(t)) [\sum_{j \varepsilon R_i} \exp(\mu_i Z_i + \beta_t X(t))]$$

The rewritten probability function is equivalent to allowing only the conditional probabilities to contribute to the statistical inference. Multiplying these probabilities together for each of the distinct time spells allows the partial probability function to be maximized. No information on the precise time of entry is required, providing a partial, rather than full, maximum probability estimate. Thus, partial probability estimation involves an efficiency loss because the exact investment time is not considered. Nevertheless, the estimates are consistent and asymptotically normally distributed; and one can interpret the t values as asymptotically close to the full maximum probability estimates.

This model has already been employed by some researchers in studies closely related to our own (Busenitz et al., 2004; Chang, 2004; Hsu, 2004). Chang (2004), for instance, estimates a hazard model of IPO events for startup companies. In line with this previous research, we also use a Cox proportional hazard-rate model to examine our hypothesis regarding the relation between VCs' knowledge and ventures' 'hazard' of experiencing an IPO. Specifically, we will use this method in a sequential way, where differences between models that do and do not include a certain 'treatment' variable (on top of a baseline model) can be compared.

In this context, it should be mentioned that SPSS (the program we use to estimate the Cox regression model) doesn't provide a measure for the strength of association in Cox regression models. However, following Tabachnik and Fidell (2001), one can calculate a 'R^2' for the models (see also Allison, 1995). For this purpose, one first calculates a G^2, a likelihood-ratio chi-square statistic, as

$$G^2 = [(-2LL \textit{ for smaller model}) - (-2LL \textit{ for larger model})]$$

Then the R^2 is given as

$$R^2 = 1 - e^{(-G^2/n)}$$

We report this 'R^2' for the estimates of our various models below[288].

Turning now to the *assumptions* underlying the Cox regression models regarding the characteristics of the examined data, they are limited.

[288] It should be borne in mind however, that this parameter does not have quite the same interpretation as the R-squared of the OLS regression. As Tabachnik and Fidell (2001) point out, the 'R^2' of the CPH model is not the proportion of variance in survival that is explained by the covariates, but merely represents *relative association* between survival and the covariates tested.

For instance, as Tabachnick and Fidell (2001) note, a sample size of 60 is needed if 5 or fewer parameters for covariates are to be estimated; but larger sample sizes are needed with more covariates. As we shall see below, this should present no problem with respect to our sample-size and the number of parameters we intend to examine. At the same time, Tabachnick and Fidell (2001) point out that in the Cox regression multivariate normality, linearity, and homoscedasticity among covariates, although not required, often enhance the power of the analysis to form a useful linear equation of predictors. It is therefore useful to assess the distribution of each covariate – as well as the presence of potential outliers - by statistical or graphical methods prior to analysis. As such, we will test those assumptions and report the results where relevant. In addition, as Tabachnick and Fidell (2001) note, survival analysis with covariates is sensitive to extremely high correlations among covariates. As in multiple regression, multicollinearity is signalled, for instance, by failure of a tolerance test in the analysis. This, theoretically, could constitute a problem for our study because we examine several theoretical variables that are indeed highly correlated. However, as mentioned above, these variables are in fact examined in parallel analyses rather than in the same model, thus avoiding the problem altogether.

A final problem for our study, however, could result from the fact that, survival analysis assumes that the same things that affect survival at the beginning of the study affect survival at the end of the study and that other conditions have not changed. To circumvent this, we control for several (often time-varying) factors, which we believe could have an impact on the hazard function estimated.

H.IV.2.b.ii. Analytical approach

The general analytical approach for examining Hypothesis 3b is identical to that described above for Hypothesis 3a in that we test our theoretical variables - the six proxies for VCs' knowledge, each for the lead VCs and the whole syndicate – in separate models.

However, the analytical approaches for examining Hypothesis 3b differ from that for Hypothesis 3a in two aspects (for an overview over our analytical approach it should be again referred to Table H-1 further below).

The first aspect concerns the analysis of the relation between VCs' knowledge and venture performance with view to different rounds. Whilst we run, in Hypothesis 3a, additional analyses to examine possible differences in this relation when looking at the knowledge of the VCs in first rounds only vs. the knowledge of the VCs in later rounds, in the context of Hypothesis 3b, we only look at the knowledge of the VCs in first rounds.[289]

The second aspect concerns the sampling period. As outlined before, the right-censoring of our dependent variables means that for the examination of Hypothesis 3a we have to restrict our sample to those ventures that have been founded before 1994 (i.e. at least 10 years before our sampling period ends in March 2003).

By contrast, for the examination of Hypothesis 3b, the right-censoring of the dependent variable does not involve any restrictions on the sampling period, because the employed analytical method, i.e. the Cox hazard rate model, explicitly accommodates for this aspect.

However, to make the findings from our two hypotheses comparable at least to some extent, we examine Hypothesis 3b not only for the full sample comprising all ventures, but also for the sample comprising only those ventures founded before 1994.

H.IV.2.c) Overview over the analytical approaches

Table H-1 provides an overview over the units of analysis and variables for our examinations of Hypotheses 3a and 3b.

[289] Consequently, from our examination of Hypothesis 3b, we can, if at all, only make conclusions regarding the relation between the knowledge of a venture's first round VCs (and the market/contextual situation at the time of a venture's first round) and its 'time-to-IPO'.

Table H-1: Overview over units of analysis and variables examined in Hypotheses 3a/b

[(✓) indicates that a variable is examined in Hypothesis 3a but not 3b]

Hypothesis [dependent variable]	**3a** [probability of experiencing an IPO]					
					3b [time-to-IPO]	
Units of analysis	**All rounds**		**Later rounds**[290]		**first rounds**	
	Lead VCs	**Syndi-cates**	**Lead VCs**	**Syndi-cates**	**Lead VC**	**Syndi-cate**
Theoretical variables:						
VC age	✓	✓	✓	✓	✓	✓
VC non-biotech experience	✓	✓	✓	✓	✓	✓
VC total experience	✓	✓	✓	✓	✓	✓
VC biotech expertise	✓	✓	✓	✓	✓	✓
VC biotech-stage expertise	✓	✓	✓	✓	✓	✓
VC biotech-sector expertise	✓	✓	✓	✓	✓	✓
Controls (venture):						
All rounds $Mio received	✓	✓	✓	✓	(✓)	(✓)
first round $Mio received	✓	✓	✓	✓	✓	✓
first round early stage (y/n)	✓	✓	✓	✓	✓	✓
Venture from US (y/n)	✓	✓	✓	✓	✓	✓
first round syndicated (y/n)	✓	✓	✓	✓	(✓)	(✓)
first round length	✓	✓	✓	✓	(✓)	(✓)
Controls (context):						
% changes in first round yr.						
Dow Jones Industrial Index	✓	✓	✓	✓	✓	✓
IPOs of biotech ventures	✓	✓	✓	✓	✓	✓
Venture capital raised	✓	✓	✓	✓	✓	✓
No of active VCs	✓	✓	✓	✓	✓	✓
Ventures receiving vc.	✓	✓	✓	✓	✓	✓
% changes in last round yr.						
Dow Jones Industrial Index	✓	✓	✓	✓	(✓)	(✓)
IPOs of biotech ventures	✓	✓	✓	✓	(✓)	(✓)
Venture capital raised	✓	✓	✓	✓	(✓)	(✓)
Active VCs	✓	✓	✓	✓	(✓)	(✓)
Ventures receiving vc.	✓	✓	✓	✓	(✓)	(✓)

As described before, for Hypotheses 3a the models based on first rounds only will be examined twice: first using the 'core sample' of ventures that have received at least two rounds, and then using the 'full sample' of ventures regardless of how many rounds they have received (this is not shown in Table H-1).

Furthermore, for Hypothesis 3b, the models will also be examined twice: first using all ventures founded before 2003, and then using only those ventures founded before 1994.

[290] As outlined further above, the examination of Hypothesis 3a with view to the knowledge of VCs in later rounds only involves a sub-sample of the ventures used for the other examinations of Hypothesis 3a (namely, only those ventures that have received at least 2 rounds)

H.V. Results

This section describes the results of our analyses of both Hypotheses 3a and 3b – where the former is in the focus of our interest, whilst the latter mainly serves to relate our findings to those of previous studies.

H.V.1. Descriptive statistics

In the following, we provide an overview over the summary statistics and correlations.

Summary statistics

Table H-2 shows the summary statistics for the variables used for examining Hypothesis 3a that is based on the 'core sample' of ventures founded before 1994. With view to this sample, Table H-2 further differentiates between all ventures (columns 1-5), those ventures that did not go public until March 2003 (columns 6-8), and those ventures that went public any time before March 2003 (columns 9-11). Furthermore, it also shows the results of a t-test of the mean values for the non-public and the public ventures (columns 12-13). In addition, the last five columns of Table H-2 show the descriptive statistics of the sample used for examining Hypothesis 3b that is based on the 'full sample' of ventures founded until March 2003.

***INSERT TABLE H-2 HERE ***

A number of observations are noteworthy in Table H-2.

We begin with a focus on the 'core sample', and here with a focus on the differences between the non-public vs. the public ventures (columns 12-13).

Here, it should be noted with view to the theoretical variables (lines 1-36) that the VCs' (if not specified further, 'VCs' refer to all VCs/syndicates and lead VCs) average age, non-biotech, and total-experience never differ significantly for the non-public and the public ventures. The VCs' average biotech-subsector expertise, by contrast, is always higher for the public than for the non-public ventures. Similarly, also the VCs' general biotech expertise and the VCs' biotech-stage expertise are almost always (with one exception each) higher for the public than for the non-public ventures.

But also with view to the control variables (lines 37-52) a number of observations seem noteworthy. For instance, the amounts received by the ventures, either in their first rounds only or until their last round/IPO (lines 37-

38), do not seem to differ for the public vs. the non-public ventures. The two types of ventures differ though in that the public ventures receive their first round of funding earlier (with an average age of 2.13 years) than the non-public ventures (with an average age of 3.77 years) (line 55). Furthermore, they also differ in that public ventures are clearly more frequent in the US than outside the US (line 39). Finally also the average values for the (annual changes in the) context-related control variables seem noteworthy. Here, several variables referring to the context at the time of first rounds seem to contradict the idea that 'hotter market conditions' lead to investments in ventures with a poorer prospect. However the variables referring to the context at the time of the last round/IPO could support the idea that 'hotter markets' enhance ventures' chances of going public, particularly if the 'window of opportunity opens widely (line 49).

Turning now to a comparison of the 'core sample' and the 'full sample', it is evident that the former (column 5) is less than half the size of the latter (column 18). In other words, between 1994 and March 2003, about 1,000 additional biotech ventures received venture capital for the first time.

When looking at the mean values of the variables in the two samples several aspects are also noteworthy (columns 1 and 14). For instance, with view to the different theoretical variables (lines 1-36) the two samples differ surprisingly little. Whilst there are some variations between the 'core' and the 'full sample', the average knowledge of the VCs has apparently not changed much – although the VCs in the full sample had 10 more years to build up their knowledge. In several cases the average knowledge of the VCs in the 'full sample' even is in fact lower than that of the VCs in the 'core sample'. The most plausible explanation for this is that, from 1994 to 2003, many new and inexperienced VCs entered the market and pushed down the average experience of the VCs who already were in business in the 'core sample'. This assertion is also supported by the fact that the average age of the VCs (as one of our proxies for VCs' knowledge) is almost unchanged between the 'core' and the 'full sample' – which could be due to ever more young, inexperienced VCs entering the arena and/or ever more old, experienced VCs leaving in the time period covered by core sample (until 1993) to the time period covered by the full sample (until 2003). Another interesting observation is the fact that the average amount received by ventures in their first round (line 37) is much higher in the 'full sample' ($4.86Mio) than in the 'core sample' ($3.05Mio) – whilst the total amount received by ventures until the time of their last round or IPO (line 38) has only marginally increased. It is also interesting that the age of the ventures receiving first rounds (line 55) shows a decrease from the 'core sample' (3.00 years) to the 'full sample' (2.61 years). Together this could indicate that, on average, VCs over the past 10 years became more willing to invest larger sums in riskier ventures. At the same time, the average length of first round investments (line 42) sends ambiguous signals. This variable decreases from the 'core sample' to the 'full sample' by about 3 months. This could either indicate that VCs invest more money in first rounds but keep the investments at a tighter leash, or it could indicate that VCs invest more money more often – supporting the idea of an increasing 'feeding frenzy' during the late 1990s. However, since we don't know for certain whether the ventures' cash-burn-rates/funding-requirements have changed during that period, we cannot draw any conclusions in this context. Finally, it should be noted that the proportion of US investments (line 39) drops visibly from the 'core sample' (.84) to the 'full sample' (.63), reflecting the increasing internationalization of the VC industry over the past 10 years.

Correlations

Table H-3 shows the correlations of the variables in the 'core sample' of ventures founded before 1994.

*** INSERT TABLE H-3 HERE ***

From this Table is immediately obvious that by far the highest correlations exist between our theoretical variables (lines/columns 1-36), justifying our approach of examining the effects of these variables in parallel models. With view to the theoretical variables, another interesting observation concerns the fact that VCs' age (our additional theoretical variable) obviously is much less correlated with the other (main) theoretical variables than the latter are correlated with each other.

This suggests that age may well be measuring something else than investment experience. With a view to the main theoretical variables, the correlations also indicate that there are two blocks of variables: on the one hand, non-biotech and total experience, and, on the other hand, biotech, biotech-stage, and biotech-subsector expertise.

Another observation from Table H-3 concerns the high correlations between the context-related control variables both at the time of the first rounds and at the time of the last rounds/IPOs. However, tests for multicollinearity suggest no significant problems arising from this fact.[291] Therefore, for Hypothesis 3a, we simultaneously included both sets of context-related control variables in our analysis.

H.V.2. Regression results

In the following we present the results from the logistic regression models for Hypothesis 3a and the Cox hazard rate models for Hypothesis 3b.

H.V.2.a) Hypothesis 3a – 'Probability of an IPO'

We begin with Hypothesis 3a (iii), which predicted the knowledge of VCs in first rounds to be more strongly related with venture performance than in later rounds. Whilst the average VC experience may be less in the first round, the impact of this knowledge should be critical in the early rounds of a venture's existence to enable him to see through the fog of uncertainty and asymmetric information with which the venture presents the VC at that first round.

Examining this empirically, however, requires of course that ventures have received at least two rounds of funding.[292] But as mentioned above, focussing only on such ventures both reduces the sample size and may bias the findings – for example, ventures that have received two or more rounds of funding may be 'more successful' than those receiving only one. Therefore, in the following, whilst we focus on the findings from our analysis of those ventures that have received two or more rounds of funding ('core sample') (see Table H-4) we also check the robustness of the findings by running additional analyses that include all ventures, regardless of how many rounds of funding received ('full sample'). The latter analysis is briefly summarized in the last paragraph of the current section (see also Table H-5).[293]

Based on the structure of our Hypothesis 3a (i-iii), we present the findings following the sequence of Panels in Table H-4:

*** INSERT TABLE H-4, PANEL A, HERE ***

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[291] Furthermore, in unreported analyses where only individual context-related control variables were included, we ended up with essentially the same findings.

[292] This is also true of one of the control variables, namely the ventures' first round length.

[293] It should further be mentioned that whilst our main interest is on proxies for VCs'/syndicates' *average* knowledge, in additional unreported analyses we also examine VCs'/syndicates' *cumulative* knowledge (but in first rounds only), and obtain qualitatively similar results.

With a view to the baseline model shown in Table H-4 Panel A, neither the *amount received in the first round* nor the *overall amount received* by ventures (columns 1 and 2) are significantly related to the ventures' probability of an IPO. By contrast, if a venture received its *first round at an early stage* in its development (start-up-/seed-/early-stage; column 3) its probability of going public is significantly higher.[294] Thus, the *amount* of VC funding is (surprisingly) irrelevant to success but the timing of it (whether received at an early stage or later) is important.

Whether the investment was done in the US also matters: the variable *US ventures* (column 4) is significantly positive indicating that US based ventures funded by VCs are more likely to go to IPO than their non-US peers.[295]

The variable *syndication of first round* (column 5) is always negatively related to the ventures' probability of going public, but significantly only in the full baseline model (column 9).

A longer time to the second round of funding (given the occurrence of the first) represented by a larger value of the variable *first round length* (column 6) has a negative impact on the probability of its going public.

None of the *contextual control variables for the time of the ventures' first round* (column 7) is significantly related to their probability of an IPO.

However, some of the *contextual control variables for the time of the ventures' last round/IPO* are significantly and positively related to the ventures' probability of experiencing an IPO. Specifically, the more bullish the markets (DJI), the more IPOs of biotech ventures occur, and the more biotech ventures receive venture capital in a given year compared to the previous year the more likely ventures go public in that year – although the DJI is no longer significant in the full baseline model.

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[294] There are a number of possible explanations for this finding but one attractive interpretation seems to be that in a highly competitive market (as high tech is) venture capital venture capital provided at an early stage in the company's history offers a First Mover advantage to the recipient. There are several examples that can be adduced in support of this interpretation. Another is simply the theory of mistakes and learning (Jovanovic, 1982; Cressy, 2004b). These theories argue that entering business is a learning experiment in which costly mistakes are made. The larger the initial resources the greater the probability of surviving the initial period when mistakes and learning are critical.

[295] This finding should be interpreted with caution since the vast majority of ventures, about 84%, in our sample come from the U.S..

Finally, it should be noted that the model chi-square of the full baseline model suggests a highly significant improvement over the constant-only model but the overall explanatory power of the model is 13% (R_{CS}^2) or 17% (R_N^2). And it should also be noted that the single largest contribution to the explanatory power of the baseline model comes from the context-related control variables for the time of the ventures' last round/IPO, followed at a distance by the length of the ventures' first round. In other words, so far it seems that the biggest driver of success of a venture is what is going on in the economy or subsector rather than the factors associated with the company or the VC. However, we have yet to introduce the role of VC experience into the equation.

*** INSERT TABLE H-4, PANEL B, HERE ***

Building on the baseline model, Panel B in Table H-4 provides an overview over the relation between VCs' knowledge (averaged over *all rounds*) and the venture's probability of going public; and Panels B-I and B-II further differentiate between all VCs/syndicates investing in the venture (Panel B-I) and the lead VCs' only (Panel B-II).

Starting with Panel B-I, there is a significant and positive relation between VCs'/syndicates' knowledge in total and the ventures' probability of going public only for the biotech-subsector expertise (column 6). The other knowledge proxies play no role in performance. By contrast, as Panel B-II shows, there is a significant and positive relation between the lead VCs' biotech, biotech-stage, and biotech-subsector expertise and the ventures' probability of going public. Moreover, this relation is stronger for the last two knowledge proxies, which are better matched to the venture under consideration. We note that neither the syndicates'/lead VCs' age, their non-biotech experience or their total experience is significant in this context.[296] Additional evidence for the superiority of precisely matched experience in current investment performance is reiterated in the Hosmer and Lemeshow tests presented in the table. These show that the observed data are not different from the predicted data in the models using biotech/specific knowledge proxies, whilst they are different in the models using the more general/unspecific knowledge proxies. Finally, biotech/specific knowledge proxies enhance the explanatory power of the model over the

[296] This trend is also reflected in the block chi-squares, which are only significant for all biotech/specific knowledge proxies but the syndicates' biotech expertise.

baseline that now explains 15% (R_{CS}^2) and 19% (R_N^2) of the variance in IPO performance respectively.[297]

*** INSERT TABLE H-4, PANEL C, HERE ***

Panel C focuses exclusively on the knowledge of *first-round* syndicates (C-I) and lead VCs (C-II). Contrary to the above analysis across all rounds, the first round syndicates' biotech-stage expertise (C-I, column 5) is significantly and positively related to the venture's probability of going to IPO. The first round lead VCs' biotech expertise (C-II, column 4) however, drops out. As such, with view to both the syndicates' and the lead VCs in first rounds, only the two most specific proxies for their knowledge – biotech-stage and biotech-sub-sector expertise – are positively and significantly related to the ventures' probability of going public; and both proxies show a similar strength of relation to the dependent variable. At the same time, it might be noted that the Hosmer and Lemeshow test suggests that the observed data are not significantly different from the predicted data in all models except the last one that uses the lead VCs' biotech-sub-sector expertise. Finally, biotech/specific knowledge proxies add marginally to the explanatory power over the baseline model, with maximum values for the R_{CS}^2 and the R_N^2 of 14% and 18%. However, it should be recalled that the average knowledge of VCs in first round is substantially smaller than that of the VCs in later rounds.

*** INSERT TABLE H-4, PANEL D, HERE ***

Panel D, finally, looks at the average knowledge of *later rounds* syndicates (D-I) and lead VCs' (D-II). Compared to the knowledge of the first round syndicates'/lead VCs' (Panel C), when looking at the average knowledge of later round syndicates'/lead VCs', the average biotech expertise (columns 4, in D-I and D-II) is significantly and positively related to the ventures' probability of going public. All three more specific proxies for later round syndicates'/lead VCs' knowledge – biotech-, biotech-stage, and biotech-sub-sector expertise - are again significantly and positively related to the dependent variable - whilst the three less specific proxies for the syndicates'/lead VCs' knowledge – age, non-biotech experience, and total experience – remain insignificant. This is despite the fact that Hosmer and Lemeshow test shows a significant deviation of the

[297] These Figures for R-square may seem small until one realises that some of the models presented in the literature have R-squareds of around 5%, much smaller than our models.

observed data to the predicted data only in case of the later round lead VCs' biotech and biotech-stage expertise but not in case of any of the other knowledge proxies. The explanatory power, of the 'best' models in Panel D is slightly higher than that of the baseline model, with maximum values for the R_{CS}^2 and the R_N^2 now rising to 16% and 21% respectively.

When comparing the findings in Panel C and D (with view to our Hypothesis 3a (iii)), it is difficult to determine which, if any, kind of knowledge is more important, i.e. knowledge of the *first round* syndicates versus lead VCs or that of the *later* rounds syndicates versus lead VCs. When looking at the log-probability and the block chi-squares, one might argue that there is a slightly stronger explanatory power of the models looking at the first round syndicates'/lead VCs' knowledge. However, when looking at the size and significance of the coefficients for the individual knowledge proxies, one might argue that the later rounds syndicates/lead VCs' knowledge shows a stronger relation to the ventures' probability of going public. This assertion is also supported by the fact that the syndicates'/lead VCs' biotech expertise is significantly related to the dependent variable in case of the later round knowledge analysis but not in case of the first round knowledge analysis. Furthermore, of all models examined in Panels A-D, the average biotech-sub-sector expertise of the lead VCs in later rounds shows the strongest relation to the ventures' probability of experiencing an IPO.

Therefore, *overall, there might be a slightly stronger relation between the later rounds syndicates'/lead VCs' average knowledge and the ventures' probability of going public than between the knowledge the first rounds syndicates'/lead VCs' average knowledge and the ventures' probability of going public.*

*** INSERT TABLE H-5 HERE ***

Finally, without going into detail, the reader is referred to Table H-5, which, by contrast with the previous Table H-4, uses the *full sample of ventures founded before 1994, regardless of how many rounds of venture capital each has received* (N=approx. 400).

As mentioned before, the analysis shown in Table H-5 serves mainly as a robustness check for the findings of Table H-4 obtained from the smaller sample of ventures receiving at least two rounds of funding (N = approx. 300). Although, as outlined above, the smaller sample might in principle introduce bias, the findings regarding the theoretical variables are in fact quite similar in Tables H-4 and H-5.

Specifically, when looking at all ventures regardless of the number of rounds received, the average knowledge of all syndicates/lead VCs is significantly and positively related to all three specific knowledge proxies – biotech, biotech-stage, and biotech-sub-sector expertise – but not to the more general knowledge proxies – age, non-biotech experience, and total experience. So, when comparing Table H-4 Panel B and Table H-5 Panel A with view to the *syndicate knowledge versus the lead VCs knowledge* (when both averaged over all rounds), the main difference is that in the larger sample (Table H-5) the syndicates' average biotech and biotech-stage expertise (columns 4 and 5) is significantly and positively related to the ventures' probability of going to IPO, whereas there is no significant relation in the smaller sample (Table H-4). Similarly, when comparing the average knowledge of first round syndicates/lead VCs in Table H-4 (Panel C) and Table H-5 (Panel B), the results are quite close. The main difference here is that in the larger sample (Table H-5, column 4) the first round syndicates' average biotech expertise is positively and significantly related to the ventures' probability of going public, but not so in case of the smaller sample.

Overall, however the findings obtained from the larger sample seem to mirror closely those of the smaller sample. This is also reflected in explanatory powers of the models using the different samples, where - depending on the knowledge proxies used – the values for the R_{CS}^2 range from 12% to 16% for the smaller sample and from 13% to 15% for the larger sample; and the values for the R_N^2 range from 17% to 21% for the smaller sample and from 17% to 20% for the larger sample.

H.V.2.b) Hypothesis 3b – 'Time to IPO'

In the following, we briefly report the results for our additional Hypothesis 3b, which examines the determinants of a venture's time-to-IPO. As mentioned before this Hypothesis is not our primary focus of interest but is aimed at relating our findings – particularly those regarding the theoretical variables - to the literature. This literature has predominantly examined the determinants of ventures' time-to-IPO.[298]/[299]

[298] Hypothesis 3b is not the primary focus of interest because, as explained before, we feel that the ventures' 'probability of experiencing an IPO' (see Hypothesis 3a) is a more suitable proxy for venture performance than the ventures' 'time-to-IPO', which is arguably biased because it focuses on those ventures only that ultimately go public.

As also already explained above, one of the advantages of the Cox regression models is that they – by contrast with logistic regression models - accommodate right-censoring of data. As a consequence, and by contrast with the analysis of Hypothesis 3a, in the analysis of Hypothesis 3b we can use the full sample of ventures founded before the end of the sampling period (March 2003). Panel A in Table H-6 refers to this full sample. However, to relate our findings for Hypothesis 3b to those of Hypothesis 3a, we run additional analyses using the same sample as for Hypothesis 3a, i.e. those ventures that have been founded before 1994 (see Table H-6, Panel B for the results of this analysis).

With respect to the interpretation of Table H-6, it should be noted that because we coded the 'IPO event' as '1' and the 'no IPO event' (censored observation) as '0', exponentiated beta coefficients ('odds ratios') smaller/greater than 1 indicate longer/shorter time to IPO; or, in other words, a smaller odds ratio indicates a smaller probability (reduced hazard) of experiencing an IPO in the next time period, whilst a larger odds ratio indicates a greater probability (increased hazard) of experiencing an IPO in the next time period for the ventures that are 'at risk' of experiencing an IPO.

In the following, we describe the findings illustrated in Table H-6 Panels A-I-III based on the full sample of ventures founded before March 2003.

*** INSERT TABLE H-6, PANELS A-I-III, HERE ***

Starting with the control variables in the baseline model (Panel A-I), column 1 suggests that the ventures' '*first round amount*' is not significantly related to time-to-IPO (although it is significantly related to a shorter time-to-IPO in all subsequent models). The opposite is true for the dummy variable indicating whether a venture has received its ' *first round at an early stage*' (start-up-/seed-/early-stage') (column 2). Taken alone, this variable is highly significantly related to a shorter time-to-IPO, but in all subsequent models that include additional variables the relation to the dependent disappears. The dummy variable for '*US ventures*' (column 3), by contrast, is highly significantly related to a shorter time-to-IPO throughout all models; and it is the single most important variable of all the variables examined. More ambiguous are the findings for the *context-related control variables at the time of the ventures' first*

[299] At the same time it should also be mentioned again that our examination of Hypothesis 3b differs from that of Hypothesis 3a in that we only examine theoretical variables – and control for contextual variables – that are related to the ventures' *first rounds*.

round (column 4): the changes compared to the previous year in both the 'Dow Jones Industrial Index' and the 'number of biotech ventures receiving venture capital' are significantly related to a shorter time-to-IPO; the annual change in both the 'number of IPOs by biotech ventures' and the 'total venture capital raised' are not significantly related to time-to-IPO; and a higher annual growth in the number of VCs providing venture capital increases time-to-IPO, perhaps as competition between VCs intensifies. Those results for the context-related control variables in the baseline model, furthermore, do not change in any of the other models that also include the theoretical variables. With view to the overall model parameters, it should be noted that the explanatory power even of the full baseline model is rather limited with a 'R^2' of about 4.1%.

Turning now to Panel A-II in Table H-6 that illustrates the findings for the different proxies for the knowledge of the first round *syndicates*, only one of those theoretical variables, the syndicates' 'biotech-sub-sector expertise' is significantly related to a shorter time-to-IPO. But the addition of this variable to the baseline model only marginally increases the 'R^2' to about 4.4%. Almost identical results are obtained when looking at the knowledge of the *lead VCs* in first rounds only (Panel A-III).

Finally, as mentioned before, we also run the above-described analysis on the same – smaller - sample already used for the examination of Hypothesis 3a, i.e. on those ventures founded before 1994.[300] The results of this analysis are illustrated in Table H-6 Panels B-I-III.

*** INSERT TABLE H-6, PANELS B-I-III, HERE ***

Looking at the baseline model for the smaller sample in Panel B-I and comparing it with that for the larger sample in Panel A-I, one finds that the main difference lies in the context-related control variables, of which none is significantly related to the time-to-IPO in the smaller sample.

Additional differences between the control variables in the smaller and the larger sample become evident when looking at the models that also include the theoretical variables (Panels B-II and B-III).

By contrast with the larger sample, the 'amount received by a venture in the first round' is never significantly related to the ventures time-to-IPO in the smaller

[300] However, because our sample now again includes all ventures founded before 1994, regardless of how many rounds of funding they have received, it is closest to the sample we have used for our additional examination in the context of Hypothesis 3a (Table H-5).

sample, whilst the dummy variable indicating that the ventures' ' first round took place in an start-up-/seed-/early-stage' is significantly related to a shorter round-length in most of the models in the smaller sample (but wasn't significantly related in the larger sample).

With view to the theoretical variables (Panels B-II and B-III), finally, the smaller sample shows more, and more significant relations between the proxies for both the syndicates' and the lead VCs' knowledge in first rounds and time-to-IPO than the larger sample.

Specifically, in the smaller sample not only is the syndicates' biotech-sub-sector expertise significantly related to a shorter time-to-IPO but also their biotech- and biotech-stage expertise (Panel B-II); and also the lead VCs' biotech-stage expertise now is significantly related to a shorter time-to-IPO - in addition to their biotech-sub-sector expertise already significant in the larger sample.[301] With view to the overall model parameters, finally, it seems that the explanatory power of the models based on the smaller sample is marginally greater (max. 'R^2' ca. 6.4%) than that of the models based on the larger sample (max. 'R^2' ca. 4.5%).

H.VI. Summary and discussion

In this section we summarize and discuss our findings, first in the light of the hypotheses and then in the light of the existing literature. Furthermore, at the end of this section, we also highlight several limitations of our study to be addressed in future research.

For this purpose, we focus on the findings from our main analyses, since the findings from our various additional analyses were qualitatively very similar.

H.VI.1. Findings in the light of the hypotheses

Hypotheses 3a

Summarizing the above findings, we find *support for the main part of Hypothesis 3a*: there is a positive and significant relation between VCs' knowledge and a venture's probability of reaching an IPO (when VCs' knowledge is averaged over all rounds received by the venture).

[301] It should also be mentioned that those results mirror closely the results we obtained in our examination of Hypothesis 3a (Table H-4, Panel B), where found the same pattern in the relation between the first rounds syndicates'/lead VCs' knowledge and the ventures' probability of experiencing an IPO.

We also find support for two of the three specifications (i)-(iii) of Hypothesis 3a:

Importantly, we find *support for part (i) of Hypothesis 3a*: the positive relation between VCs' knowledge and a venture's probability of going public is more pronounced the better matched is the VCs' knowledge to the venture under consideration. More specifically, there is only a significant relation between VCs' specific biotech expertise and venture performance, but not for VCs' age, non-biotech, or total experience.

We find also *support for part (ii) of Hypothesis 3a*: the relation between the VCs' knowledge and a venture's probability of going public is more pronounced for the average lead VCs' knowledge than for the average syndicates' knowledge.[302]

However, we find *no support for part (iii) of Hypothesis 3a*: the relation between the VCs' knowledge and the ventures' probability of going public is not more pronounced for first rounds. If anything, the knowledge of VCs – both syndicates and lead VCs – seems marginally more related to ventures' performance when looking at later rounds than when looking at first rounds.

This could be an indication that VCs not only use their knowledge to 'pick' winning ventures (for this purpose their knowledge in first rounds might be particularly important) but also to 'build' winning ventures over time.

Here it is also noteworthy that we find a stronger relation between the lead VCs' knowledge and venture performance than between the syndicates' knowledge and venture performance (see H3ii above) only when looking at the average knowledge of the lead VCs and syndicates in all rounds and in later rounds of the ventures.[303]

[302] This can be seen when comparing, within each Panel (B-D), the coefficients for the knowledge proxies and the overall model parameters in the columns with identical numbers (e.g. columns 6 in Panel B-I and B-II). For instance, when looking at the *average knowledge of* VCs *in all rounds* (Panel B) a comparison of the corresponding proxies in Panel B-I and B-II shows that more of the proxies for the lead VCs' knowledge are significantly related to the ventures' probability of going public than of the proxies for the syndicates' knowledge. Also, the overall model parameters suggest a slightly greater explanatory power for the lead VCs' knowledge proxies than for the syndicates' knowledge proxies.

[303] Specifically, a comparison of the corresponding models in Panel D-I and D-II shows that for both the syndicates and the lead VCs the same knowledge proxies are significantly related to the ventures' probability of experiencing an IPO. However, if anything, the size and significance levels of most coefficients for the knowledge proxies as well the overall model parameters might suggest a slightly stronger explanatory power of those models using the lead VCs' knowledge than of those using the syndicates' knowledge.

However, when we only look at the relation between the knowledge of VCs in *first rounds* and venture performance, we don't find indications for a stronger relation between the first-round lead VCs' knowledge and venture performance than between the first round syndicates' knowledge and venture performance. If anything, we find the opposite. The average knowledge of first round syndicates seems marginally stronger related to venture performance than the knowledge of the first round lead VCs.[304]

Thus, contrary to our prediction, syndicate knowledge is more important than lead VC knowledge in predicting whether a venture will go to IPO when that knowledge is measured at a venture's first round.

On the other hand, when looking at the average knowledge of the VCs in later rounds there is little difference in the importance of syndicates' rather than lead VCs' knowledge in IPO performance.

This could suggest that, particularly in first rounds, syndicate members, in addition to contributing to the financing of the deal, contribute knowledge over and above that of the lead VC when engaging with other VCs in the venture's first round.

At this point, however, it should also be mentioned again that the average knowledge of VCs in first rounds is considerably smaller than that of the VCs in later rounds.

Finally, it should be noted that although we find overall support for our hypotheses 3a, we are aware that our models have only a limited predictive power. Specifically, even the 'best' models can explain not more than about 20% of the variability in the ventures' likelihood to experience an IPO, and even the 'best' theoretical variables only contribute very little to the predictive power of our models over and above the control variables in the baseline model.

In this context, it should also be noted that we find that the 'lion's share' of the explanatory power of the models is taken by context-related control variables in the equations estimated, namely the annual changes in the number of venture-capital backed biotech IPOs overall, and in the number of biotech ventures receiving venture capital.

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[304] A comparison of Panels C-I and C-II shows that, when only looking at first rounds, for both the syndicates and the lead VCs the same knowledge proxies are significantly related to the ventures' probability of experiencing an IPO. However, this time, the 'advantage' is rather on the syndicates' side, where the coefficients of the knowledge proxies are marginally larger and more significant, as are the overall model parameters.

This suggests that macro factors, such as the opening of the 'window of opportunity' in the financial markets and the perceived 'hotness' of the biotech sector have a stronger influence on the likelihood of biotech ventures experiencing an IPO than has their VCs' knowledge.

Hypotheses 3b

Summarizing our findings regarding the time-to-IPO for the full sample of ventures founded before 2003 we find that *for the main part Hypothesis 3b is supported* by the data: VCs' knowledge is generally positively related to the ventures' hazard of an IPO or equivalently is negatively related to the venture's time-to-IPO.

Furthermore, we also find *support for part (i) of Hypothesis 3b*: the above relationships are significant only for one of the two very specific proxies for VCs' knowledge, namely biotech-sub-sector expertise.

But we find *no support for part (ii) of Hypothesis 3*: there seems to be no difference in the impact of lead VCs' knowledge over syndicate knowledge in reducing time-to-IPO.

We also find incidentally, but importantly, that, whilst the amount of first round and total funding has no impact on the probability of an IPO (H3a), VC first-round funding reduces the time-to-IPO of biotech ventures that are already destined for success (H3b).

The fact that VC involvement matters in reaching an IPO but funding does not suggests that the VC is adding value not only by pecuniary means but by providing access to resources which, if received early on in a ventures' life leads to success.

Furthermore, we note that when comparing the findings of the larger sample of all ventures founded before March 2003 to those from the smaller sample of ventures founded before 1994 that, in the latter sample more of the *theoretical* variables and *none* of the context-related control variables are significantly related to time-to-IPO.

One plausible explanation for this could be that in the larger sample – which comprises many investments made during the boom years in the late 1990s – the VCs' experience became a less important determinant of venture performance than the financial and private equity markets.

Finally, it should also be noted that although we find overall support for our hypotheses 3b, we are aware that our models have only a limited predictive power. Specifically, even the 'best' models can explain not more than about 5% of the variability in the ventures' time-to-IPO, and even the 'best' theoretical variables only contribute very little to the predictive power of our models over and above the control variables in the baseline model.

H.VI.2. Findings in the light of the literature

In this section we look at our above-described findings in the light of the existing literature in the area.

Hypotheses 3a

Comparing our findings regarding Hypothesis 3a to those in the literature is problematic because most studies are based on different proxies for VCs' knowledge and/or different measures for venture performance from the ones used in this thesis.

For instance, Busenitz et al. (2004) examine the relation between the entrepreneurs' assessment of the strategic advice they had received from their VCs and the ultimate outcome of the ventures, with an IPO being the most desirable outcome. Based on this approach, Busenitz et al. don't find the expected positive relation.

However, for the reasons outlined before (Chapter C), it seems likely that the entrepreneurs' assessment of the strategic advice given by the VCs is not a suitable proxy for VCs' actual knowledge, making it difficult to relate the our findings to those obtained by Busenitz et al. (2004). And indeed, the authors acknowledge themselves that one of the reasons for their unexpected findings could be the fact that they don't really measure VCs' knowledge. As the authors put it: 'it may be that *some* VCs do indeed add value: some VCs may possess keen insights and perhaps some unique business experiences that enable them to add value to at least some of the ventures in which they invest' (Busenitz et al., 2004: 802).

Another study that uses a similar proxy for VCs' knowledge, but a different proxy for venture performance, is that by Hochberg et al. (2004). These authors examine the relation between VCs' knowledge and venture survival (from one round to the next). For this purpose, they approximate (the lead) VCs' knowledge also by the number of previous investment rounds. Based on this, they find that venture survival is positively related to the lead VC's knowledge.

Whilst this might be seen in line with our finding, it should be noted that Hochberg et al. don't differentiate between different types of VC knowledge (i.e.

between investments in different types/industries of ventures). Thus, their knowledge proxy is closest to our proxy for VCs' total experience, for which we find no significant relation to our measure of performance, namely, the probability of experiencing an IPO.

In contrast, Hsu's (2004) study uses a slightly different proxy for VCs' knowledge, but the same measure for venture performance as our study. He examines the relation between VCs' previous IPO track record (measured by the cumulative number of IPOs achieved to date) and the probability of a current portfolio venture of experiencing an IPO.[305] In his analysis, he finds that VCs' IPO track record enhances their ventures' probability of experiencing an IPO.

Thus, one might argue again that these findings are in line with our own. But it should be noted again, that – for the reasons discussed in Chapter C - a VC's previous IPO track record is not necessarily a satisfactory proxy for his actual experience. Furthermore, the way it is calculated, ignoring the industries in which the VC's experience is gained, seems closest to our proxy for a VC's total experience for which we find no significant relation to the ventures' probability of an IPO.

Hypotheses 3b

Comparing our findings regarding Hypothesis 3b to those in the literature is again difficult because most previous studies were based on different proxies for VCs' knowledge and/or different measures for venture performance.

Nevertheless, with a view to the limited previous studies relating to our project, it seems that our findings are consistent with some of these studies, but inconsistent with others.[306]

For example, our finding that VCs knowledge reduces the time to IPO is in line with Stuart et al. (1999), who – using one of the best proxies for VCs' knowledge in the literature - find a negative relation between the VCs commercial and

[305] Hsu (2004) measures the VCs' 'previous IPO success record' by a dummy variable indicating whether a VC's previous IPO record up to the time of funding the target startup placed it in the upper half of the sample; where the threshold value is 21 IPOs and the mean is 0.47. We would argue that his measure is less satisfactory than ours because one can learn from mistakes as well as successes.

[306] It should be only referred to the limited number of previous studies that seem similar to our project in that they look at the relation between VC characteristics that might be understood as proxies for VCs' knowledge and the time-to-IPO of the ventures they back (for more details on those studies and their proxies for VCs knowledge see Chapter C, and particularly Table C-1)

technological 'prominence' and the time-to-IPO of the biotech ventures they back.

Similarly, our findings find an echo in Hsu (2004), who examines the relation between a ventures' time-to-IPO and their VCs' previous IPO track record. He finds a significant negative relation between a VC's reputation and the time-to-IPO of those ventures experiencing an IPO. But, as mentioned in the previous section and as discussed in detail in Chapter C, we note again that a VC's previous IPO track record is not necessarily a satisfactory proxy for a his actual experience. Furthermore, the way it is calculated, ignoring the industries in which the VC's experience is gained, seems closest to our proxy for VCs' total experience for which we find no significant relation to the ventures' probability of an IPO.

By contrast, our findings would seem to contradict those of Lange et al. (2001) who examine the performance of ventures in the Internet and software sectors, and who find that the presence of a 'top' lead VC at the venture's first round was associated with a longer time-to-IPO. One explanation for this might be that Lange et al.'s (2001) study was based on a questionable proxy for identifying 'top' lead VCs, namely the number of IPOs those VCs have been involved in.

Some of our findings are also consistent with and supplement those of Chang (2004) who worked with a sample of Internet ventures and their VCs. He found no relation between the VCs Internet-industry knowledge (approximated by the VCs' previous number of investments in Internet ventures, and averaged for all VCs in syndicates) and the ventures' time-to-IPO. This mirrors our findings regarding the non-significant relation between the average biotech expertise of first-round syndicates and time-to-IPO (see Table H-6, Panel A). However, our more fine-grained proxy of the syndicates' biotech-sub-sector expertise shows a significant relation to time-to-IPO. It would therefore be interesting to see whether similar results also obtain in Chang's (2004) sample when using more fine-grained proxies for VCs' knowledge (in this case, in specific Internet-subsectors).

Finally, it is noteworthy that our study finds no support for Gompers' (1996) thesis that younger VCs tend to bring their ventures to market too early, thus leading to 'expensive' underpricing of those ventures' IPOs. Our study, whilst we are unable to test for underpricing, in fact shows no relation whatsoever between a VCs' age and their investee companies' time-to-IPO.

Implications

The above-described findings of our study have several implications for research in this area.

As discussed in the general literature review of Chapter C and the specific literature review of the present chapter, existing empirical research provides contradictory findings on the relation between a VC's or a syndicate's 'knowledge' and venture performance. This, we argued, might be due to the fact that much of the literature on venture capital has used inadequate proxies for VCs' knowledge and/or incorrect ways of using those proxies. Furthermore, the majority of studies focus exclusively on those ventures that ultimately go public, attempting to explain the factors affecting their time to IPO.

In the present study, to address the deficiencies in knowledge measures used in the literature we developed and tested a broader range of proxies for VC knowledge, ranging from the most general to the most specific. We also employed less biased measures of venture performance. In this thesis we address this issue, but we also examine the factors determining whether a business gets to IPO or not.

Our empirical analysis shows that knowledge does indeed play a role in venture performance and that there are indeed significant differences in the relation between VCs' knowledge and venture performance, depending on the proxy used. Thus our study goes some way, we believe, in evaluating the use of different knowledge proxies. Importantly, we have shown that some of the proxies used in the literature (e.g. VCs' age or total experience) have, when other relevant factors are controlled for, no significant relation to venture performance at all. Last but not least, in our empirical analysis the correlation of knowledge with performance was found to be strongest for knowledge proxies most closely matched to the particular venture under consideration. This finding is new to the literature and one of the major achievements of this part of our thesis.

We also found, incidentally as it were to our main interest, the rather astonishing result that the total amount of funds injected over a business' life before IPO has no influence whatever on that outcome. Our finding is also in contrast to Gompers (1995) who reported that the total injection of VC funds was higher for those ventures that went to IPO than those that didn't. Thus, at the margin, we find that more or less money has no influence on a venture's chances of success (IPO). This suggests the absence of binding capital constraints on a business, since we should surely expect that businesses starved of funds would find more money would increase their chances of success (Evans & Jovanovic, 1989). It is also consistent with the experience of the Bubble period of the mid to late 90s when money for new ventures appears to have flowed very freely indeed.

Our results also have important implications for the validity of existing theories. For instance, our finding that those knowledge proxies most related to a VCs' reputation (e.g. VC age and total experience) bear no empirical relation to venture performance suggests that VC reputation-focussed intermediation or signalling models may be incorrect. Our findings also provide additional insights into the key-resources or core-competences of VCs, thus shedding light on existing resource-/knowledge-based theories. Experience in general is now *not* to be regarded as the key resource; only that experience germane to current investment opportunities counts in company performance.

However, whilst we believe that our findings have a number of implications for the existing literature, it is also important to be aware of the limitations of our study, which might be addressed by future research in the area.

H.VI.3. Limitations and future research

At this stage, we shall highlight some limitations specific to the tests of Hypotheses 3a and 3b. However, we also address those limitations that affect all of our hypotheses below in Chapter J.

Sample

One of the limitations in our study certainly is that we cannot observe, and consequently not analyse, venture performance - in terms of their likelihood of experiencing an IPO - for a large number of ventures founded after 1993.

It is likely that those ventures founded during the boom years in the 1990s differ from the ones founded earlier. For example, their investors may have been less critical in their investment decisions. However, it may also be the case that some of these investors built up relevant experience and expertise before the 'hype' years, so that as the Bubble developed they were less prone to simply 'follow the herd'. Either way, it is possible that the performance of the ventures in our sample is different from - or is related to different factors - than those ventures we cannot analyse. As a consequence, we cannot claim full representativeness of our sample for all biotech ventures in existence today.

It would therefore be interesting for future research to follow the performance of those ventures founded during the past ten years, and compare their findings to those of our study.

Dependent variable

The previous section points towards another limitation of our study, namely the measure we use to analyse venture performance as our independent variable in the context of our main Hypothesis 3a. Whilst we believe that this measure is less biased than the measures used by much previous research, we acknowledge that it is not without its problems.

Arguably the most critical of these, this measure doesn't allow us to analyse the performance of many ventures simply because they are not old enough to have had a realistic chance of going public. This is the problem of censored data. Furthermore, the IPO measure is also based on the assumption that other venture outcomes, such as a merger or acquisition, which we do not consider in our analysis, are to be seen as inferior to an IPO. Whilst both the literature and our own conversations with practitioners indicate that this is a reasonable assumption, we acknowledge that particularly in times of 'cold' markets a merger/acquisition might also be a desirable outcome from the perspective of both the VCs and the entrepreneurs.

In this context, it should also be mentioned that we do not examine the actual (financial) performance of the IPOs; and it might well be that IPOs backed by different VCs and/or IPOs taking place in different market conditions have very different returns to both the ventures and their investors. At the same time, we also acknowledge that a venture's 'ultimate' outcome – be it an IPO or a merger/acquisition - cannot possibly provide a complete picture of its actual performance. For instance, it is thinkable that the founders of a very successful and profitable venture simply decide to stay private because they don't want to lose control. At the same time, we are aware that the ventures' probability of going public is certainly strongly influenced by external factors, such as the general market conditions. This saying, our measure is unlikely to truly reflect the ventures' inherent performance particularly in their early development.

As a consequence, future research might employ additional/alternative measures of venture performance - such as the timely achievement of project milestones, the successful application for potentially valuable patents, or the establishment of high-profile collaborations - and examine how those more fine-grained measures relate to our more aggregate measure of a venture's probability of experiencing an IPO.

Finally, it should be reiterated that we examine the performance of individual ventures. This does not allow far-reaching conclusions regarding the performance of VCs because (most) VCs have a portfolio of ventures (Bygrave &

Timmons, 1992); it may well be – and indeed often is the case - that whilst most ventures in a VC's portfolio under-perform, a few ventures might achieve such spectacular returns that the portfolio overall (i.e. the VC) performs very well. Whilst there are good reasons to believe that, in general, an IPO event should be the most desirable outcome from the VCs' perspective, and also Hochberg et al.s' (2004) study indicates that there might be a relation between individual ventures' performance and VCs' overall portfolios, without further information regarding the IPO proceeds that go to the VCs it is impossible to say whether a venture's IPO is actually a success for its VCs; and it might well be the case that some VCs make large profits from exiting a venture before its IPO; for instance, by selling their shares to other VCs in a new round or selling them to other corporations.

Therefore, it would certainly be interesting for future research to also examine the actual performance of the VCs depending on their knowledge.

Control variables

As already outlined above, it is evident that venture performance – and particularly when measured as the ventures' probability of going public - is certainly a product of innumerable factors.

Given both the nature of the data and the time available to us, we could only control for some of the most obvious factors. For instance, we controlled for some of the context-related factors at the time of the ventures' last round/IPO (H3a) and first round (H3a and H3b). Our analyses show that some of those contextual factors indeed are related to venture performance.

But, as is evident from the comparatively low predictive power of models, there are likely to be many more influencing factors that we did not control for. For instance, it is plausible to assume that the specific scientific area or technology a venture is engaged in might experience certain 'hypes'. Furthermore, it might also be that different scientific areas / technologies are associated with different 'risks' and 'gestation periods' (but also different possible pay-offs), possibly leading to differences in their performance when measured by the probability of experiencing an IPO and their time-to-IPO. Finally, there might also be further, venture-specific aspects that could be related to a venture's performance such as the experience and the reputation of its management team or its alliance/corporation partners.

As such, future research should certainly consider a variety of additional venture- and context-related control variables.

Causality

Finally, our study takes a 'black box' or 'ex-post' approach in examining the relation between VC knowledge and venture performance. Therefore, as mentioned above, our study must leave the question regarding the causality of the identified positive relation unanswered.

At best, our finding that the knowledge of later round syndicates/lead VCs is more strongly related to venture performance than that of first rounds could be interpreted as VCs using their knowledge not only for 'picking' but also for 'building' winning ventures.

But without additional information about the VCs' actual type and quality of post-investment involvement in the ventures, no additional conclusions are possible; and, as a consequence, we are still not able to answer the question of whether more knowledgeable VCs just 'invest more smartly' or whether they actually provide 'smart money' that adds value to ventures.

This certainly is one of the most interesting questions for future research.

However, because this question cannot be answered by a database approach, the following chapter reports on two case studies that take an ex-ante perspective on the relation between VCs and their investee ventures.

This may shed additional light on this question, and also on other factors of relevance to the performance of VC-backed ventures.

CHAPTER I: CASE-STUDIES - URGENT & CARDIOGENIX

This pair of cases was written with the financial support of the European Case Study Writing programme of the Gate2Growth Academic Network in Entrepreneurship, Innovation and Finance (G2G). The cases were reviewed and accepted by G2G, and they are in the process of being published. Due to the sensitive nature of the information contained in the cases, persons and companies were anonymized.

I.I. Introduction

Our general literature review (see Chapter C) was guided by the question 'what impact does VCs' knowledge have on the VCs' investment approach and the performance of the VCs' investments?' Based on this we found that several theories developed outside the venture capital area could provide reasons for why VC knowledge could be of importance in this context. But we also found that the empirical research on venture capital arrived at ambiguous conclusions regarding the relevance of VCs' knowledge. This, we argued, could be because most literature has differentiated between VCs on the basis of inappropriate knowledge proxies.

Consequently, we proposed more suitable proxies for VCs' knowledge than have been used by the literature. Applying these proxies, in the previous three chapters, we showed that VCs' knowledge does make a difference with respect to both the investment approach and the performance of VCs' investments.

However, our findings also suggested that VCs' knowledge only accounts for a small proportion of the variance in VCs' investment approaches and the performance of VCs' investments; and context-related factors – such as (changes in) the financial/private equity markets - seem to play an important role, too.

This is in line with previous research, which shows that markets can be erratic, and that - at least at times – also VCs suffer from 'irrational exuberance'. This was particularly evident with view to the late 90s 'high-tech Bubble'.

In this context, the role of Internet-related ventures has already attracted some research (Shiller, 1998). However, to our knowledge, no detailed research exists on the events in the biotech industry ventures during that period.

At the same time, in our research so far, due to the nature of our data, we have had to take a large sample approach, allowing us only to come to general conclusions, but providing no detailed insights into *how* (differences in) VCs' knowledge actually translate(s) into their investment approach and/or the performance of their investments.

Furthermore, context-related variables were not the main focus of our interest in the previous chapters. Their function was that of control rather than theoretical variables in the statistical analysis conducted. We did not examine the interrelations between the context related variables and VCs' knowledge.

Moreover, whilst it is comparatively easy to operationalise finance-related contextual factors - such as changes in the financial/private equity markets - this is much more difficult with view to other contextual factors, such as technological or scientific developments in the relevant industry. These factors were thus ignored in the previous chapters.

In the present chapter therefore, we take a closer look at 'what is really going on' at the firm level during the period of analysis. We do this by examining the case of two specific biotech ventures starting during the period of the high-tech Bubble and seeing how VCs' knowledge translates into their investment approach and ultimately into their economic performance. We are able to explore how this also depends on the general context in which they operate.

For this purpose, our research question can be broadly stated as:

How - at the company level and in detail - does VCs' experience influence the development of early stage biotech ventures, and what impact do other factors – such as the state of the financial markets and the ventures' industry – have on that development?

I.II. Research design

With view to the above research question, it should be emphasized again that limited venture-capital specific theory exists in this area, and that the role of VC knowledge in company development is relatively unchartered territory. As a consequence, our research has to be understood as rather exploratory. Its intention is not to confirm existing theories or to test specific hypotheses, but to obtain a 'richer picture' of the relationship between VCs and their investee ventures, and of contextual factors influencing this relationship and its outcome, including the developments in the ventures' industry and in the financial markets.

Following the example of a small number of previous researchers in the venture capital area (e.g. Fried & Hisrich, 1995; Steier & Greenwood, 1995), we utilize a case study design for our research (cf. Eisenhardt, 1989). Here, our emphasis is on eliciting the experiences of key actors and examining material documenting key events and activities. This might ultimately lead to the development of more specific hypotheses that could be tested in future research on larger, and possibly more representative samples. Thus, our approach might be seen as a (first) step within a 'grounded theory' methodology (cf. Glaser 1998; Glaser & Strauss, 1967).[307]

In order to understand the relationship between VCs and entrepreneurs in the context of our cases, the study employs multiple data collection methods and sources: relevant background literature (e.g. governmental and industry reports), interviews, site visits, and archival materials.[308]

Most of our work on the case studies took place between February and August 2004. We began with a study of the relevant background literature on the industry, gathered information specific to the ventures and their VCs, conducted the interviews, and examined the archival data along with the academic literature (in an iterative process). Finally we combined our insights by writing up the cases and drawing conclusions from them. These insights are summarized in the summary and conclusion section to this chapter.

Selecting participants is an important part of case study research. Whilst some researchers follow a deliberate theoretical sampling plan (see Eisenhardt, 1989, for details), others arbitrarily select participants through contacts established in business (Larson, 1992). We opted for the latter approach, conducting our case studies on two ventures to which we had a personal relationship. We did this for several reasons.

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[307] As Dick (2005) explains, 'grounded theory' begins with a research situation. Within that situation, the task is to understand what is happening, and how the players manage their roles. This commonly involves interviews and sighting of archival data. Literature is mainly accessed as it becomes relevant; it is not given a position of privilege when compared to the data but treated as data. Constant/iterative comparison of the information obtained is at the heart of the process. Thus, what most differentiates grounded theory from much other research is that it is explicitly emergent. It does not test a hypothesis. It sets out to find what theory accounts for the research situation as it is. The theory is 'emergent' - discovered in the data, and when it has begun to emerge one compares data to theory. The aim is to understand the research situation, and to discover the theory implicit in the data. Then, the two main criteria for judging the adequacy of the emerging theory are 1) that it fits the situation, and 2) that it works, i.e. helps the people in the situation to make sense of their experience.

[308] A site visit was only possible in case of one venture, UrGenT, since the other venture, CardioGenix, was already closed down at the time of our case study.

Firstly, we knew that obtaining information on privately held companies would be difficult particularly when dealing with the financial aspects of the business. Furthermore, start-up ventures and VCs are known to operate in a highly dynamic environment and to suffer from severe time constraints, making it difficult to allocate time to academic researchers. Thus, we – rightly – assumed that having a personal relationship to relevant key people would facilitate our access to important information. Indeed, we got access to very sensitive information, even in a time that was characterized by substantial problems for the two ventures and high personal risk for their founders (i.e. legal/liability issues during the insolvency process).

But another, equally important, aspect for the selection of these two ventures was that we knew that the two ventures offered a very promising setting for our research in that they were at the same time very similar in many aspects, but quite different in others, particularly with view to their experiences with VCs.[309]

Regarding the interviews it turned out that our good personal relationship with the founders of both ventures indeed enabled us to conduct the interviews with key persons of the ventures and their VCs. To plan those interviews we identified, in collaboration with the founders of the ventures, suitable interview partners. These were contacted to assess their willingness to contribute to the case study and their availability to do so. Table I-1 provides an overview over the interview-partners and number of interviews conducted for our case studies.

Table I-1: Interview partner and number of interviews for case studies [numbers: no. of interviews; numbers in brackets: (additional) telephone-interviews]

Interview partner	**'UrGenT'**	**'CardioGenix'**
Founder	2/(2)	2/(3)
Co-founder/management-team	1/(1)	1
Lead VC round 1	1	(1)
Lead VC round 2	(1)	(1)
VC (executive of incubator) of seed round	1/(1)	
Total	**8/(10)**	

As is evident from Table I-1, it was not possible to conduct face-to-face interviews with all VCs involved in our two ventures because of their time-constraints. Nevertheless, we managed to conduct at least one telephone interview with all relevant VCs. To make interviews as efficient as possible, we mailed an outline of our project as well as key questions to all interview partners

[309] See also Table I-2 in the summary section of this chapter that provides an overview over the main dis-/similarlities between the two ventures.

about two weeks in advance so that they had time to prepare. Face-to-face interviews lasted on average 45 minutes each (shorter with the VCs, but up to 2.5 hrs. with the founders). Telephone interviews lasted an average of 30 minutes. During the interviews, which were semi-structured, we took notes. Due to the sensitive and confidential information, none of our interview partners agreed to tape recordings. In a number of instances we followed up or clarified certain issues in shorter telephone conversations (not listed in Table I-1).[310]

In addition to the interviews, we also surveyed a large amount of archival data on both ventures, which was mainly provided by the founders of the ventures, but also by the VCs. The archival data used for the case studies included:

- Business plans/investment proposals
- Due diligence reports by the VCs
- Summaries of agreements between the ventures and VCs
- Operating files, including monthly reports by the ventures
- Financial statements (quarterly) by the ventures
- Notes from the meetings of the ventures' boards of directors
- Press clippings regarding both the ventures and the VCs

During and at the end of the sampling period, we crosschecked the information provided by the interview partners with each other, with the archival data, and also with the information provided by VE.[311] Overall, however, our crosschecks did not reveal any substantial inconsistencies in the information provided by any of our sources.

Before we actually turn to the two cases, the reader should be referred to Appendix I, which provides background information on the developments in the (biotech/venture capital) sectors before and during the high-tech-boom - in Germany (the country of origin of the ventures) but also, given the global nature of venture capital activity, in the US and in Europe. This also provides further insights into the representativeness of our cases.

[310] Our interviews were 'semi-structured' in that we used a brief 'questionnaire' to ensure that we covered all relevant aspects. At the same time though we planned for sufficient time (ca. 50%) for our interview partners to provide their own insights and assessments.

[311] With respect to the latter we found that one round listed by VE as a separate (4th) round for UrGenT in fact only was a investment by one VC in the third round for which VE reported the wrong date. We therefore corrected the date for the analysis of the three research hypotheses.

I.III. Case studies

I.III.1. Case A: UrGenT

I.III.1.a) Origin

In October 1996, two seasoned Biology professors met in a seminar room of their institute, part of the Rhineland life-science cluster that had been declared an award-winning region in the German BioRegio competition a year before.

Knowing each other for more than 20 years, the two scientists had much in common. Both were at the peak of their academic careers, both had published extensively in all the major journals in their area, and both were comfortably integrated in the international scientific community. In short, they had achieved everything scientists could dream of - almost.

Compared to many of their U.S. colleagues there was one thing missing on their CVs: founding their own company. And this was exactly the reason why they were now meeting. Having been involved in their institute's participation in the BioRegio competition, they reckoned that now was the right time to take advantage of both the support-programmes and infrastructure to be provided by the government.

However, their ideas were very vague, at best. They definitely wanted to set up a company, but they didn't want to run it themselves. Moreover, with a background in basic research, they weren't really sure about suitable commercial areas for their venture to operate in. So, they decided to go back and search for capable people and promising ideas for commercialisation.

As senior professors, with a great network of contacts, it didn't take them long to identify a group of five other scientists (two professors and three post-doctoral research fellows: Maria, Paul, and Peter) eager to participate in the project. None of them had any commercial experience, but amongst them, they covered a wide range of scientific expertise, mainly in the areas of functional genomics.

In December 1996, this group met for the first time. Each person presented its research capabilities and – based on publicly available pharmaceutical market research - made suggestions for areas to 'turn their expertise into money'. The main outcome of this meeting was the identification of several urogenital diseases as the most promising target market for their venture. This was for several reasons.

The number of patients suffering from those diseases was constantly rising. According to some industry reports, the field was to become a multi-billion dollar market in the near future. Already now it ranked high in terms of sales. However, there was a clear disparity between sales figures and current drug development efforts. The diseases caused considerable discomfort to those affected, but they were not lethal. Furthermore, the treatment costs per patient were comparatively low. This had left many pharmaceutical companies rather uninterested in the area, resulting in relatively low competition.

At the same time, despite its large market size, only about 1-2% of all current pharmaceutical R&D activities were focussed on this field, and generic products dominated the market. This lack of innovation resulted in anaemic sales growth. With a cumulative annual growth of only 3% in recent years, the area was far below the industry average of 9%. Furthermore, because of the limited research efforts by established companies, most available drugs dealt with the symptoms rather than the causes of the diseases. The underlying molecular/genetic mechanism remained largely unknown. Together, this offered considerable upside potential for a venture focussing on basic molecular/genetic research in the area.

Based on those projections, the group drafted a mission statement outlining the activities of their envisaged company, UrGenT, and characterising it as a 'typical' biotech venture working in the area of 'functional genomics':

> '[...] UrGenT is a biotech company focussing on the genetic and molecular mechanisms underlying several urogenital diseases. Capitalizing on our in-depth knowledge in the areas of functional genomics and molecular biology, we compare the genetic profile of patients suffering from those diseases with those of healthy individuals. This enables us to identify the genetic causes of those diseases. Furthermore, it provides the basis for developing and examining compounds that interact either directly with the relevant genes or with their transcription products. This, in turn, is the basis for developing drugs targeted at the diseases. For this purpose we intend to collaborate with pharmaceutical partners [...].'

UrGenT's subsequent development was very rapid. Soon, a basic organizational structure was set up. The four professors in the team decided that they would not become involved in the day-to-day business of the venture. As the scientific advisory board, they intended to contribute advice, contacts and credibility to the company run by the three junior co-founders. Thus, Peter was announced CEO (chief executive officer), Maria CSO (chief scientific officer), and Paul CDO (chief development officer).

As Peter later recalled: 'we hadn't any professional experience outside the lab. But this didn't really matter to us. It was the very characteristic of all biotech ventures in Germany in those days, and our focus initially would be on R&D anyway'.

I.III.1.b) Seed round

Indeed, at that time, it wasn't too difficult to set up a high-tech venture and to get external support for it, particularly with the backing of some well-connected professors. Furthermore, UrGenT got some early support from an Angel investor, who was willing to put some of his private funds into the venture and who also introduced the team to some lawyers, patent attorneys and accountants.

So, soon after its incorporation in June 1997, UrGenT moved into a newly built biotech incubator, set up and sponsored by a private-public partnership. Being amongst the incubator's first tenants, UrGenT got even more than the initially required space for a rent much below market rates.

This incubator not only provided cheap laboratory space. It also invested some €100.000 into the venture and further helped it to successfully apply for additional government funds. So, by the time of its inception, UrGenT had already received about €1m in seed funding.

In addition, UrGenT also got some valuable non-monetary support from the incubator. For instance, the incubator's personnel, mainly scientist themselves, helped designing a research strategy. Based on their good connections to the local research institutions, they also helped searching for additional scientific staff. Moreover, the incubator regularly organized seminars for its, at that time, five portfolio companies. Run by external industry experts, those seminars dealt with a range of managerial, financial, and legal issues that the participants perceived to be very helpful to get to grips with their new, commercially oriented environment.

So equipped, UrGenT progressed very smoothly through the seed phase. The venture soon had more than a dozen employees working parallel on three different research projects. Moreover, thanks to its well-connected scientific advisory board, UrGenT managed to set up several joint research projects, even with some renowned scientific institutions in the U.S. Thus, over the next 1.5 years, the company was able to consequently pursue its initial goal, which was developing a more in-depth knowledge of the genetic and molecular underpinnings of its targeted diseases.

I.III.1.c) First financing round

In December 1999 most of the seed funds were used up, and UrGenT started preparing for its first financing round. This was the time when the high-tech boom was at its peak, worldwide as well as in Germany. Furthermore, the Human Genome Project had announced that it would not be long before the whole human genome would be decoded, offering unprecedented opportunities for the development of new drugs for and treatments of many diseases. UrGenT – as a functional genomics company – clearly was well positioned to participate in the forecasted boom.

As a consequence, Peter remembered: 'investors were queuing up, they offered more money than we did expect, and we had no choice but conducting a beauty parade'. Based on 'the investor's reputation and personal sympathy' as the main criteria, UrGenT finally choose – as lead investor - a well-known foreign firm with a long track record in biotech, and two other VCs, both also possessing good reputations, which were recommended by the lead VC who had already syndicated with one of them before.

Although there was an opportunity to get considerable larger funds, UrGenT's team felt that there was 'no real need to give away too much equity'. The markets seemed to be more than willing to provide further funding at any time. As a consequence, it was decided to 'let them invest only €5m' for the time being. This money was expected to last until the first candidates reached their proof-of-concept. Then, the management expected to attract further funding, at even more favourable terms, either from VCs or from potential pharmaceutical partners.

Indeed, this strategy initially appeared to work well, as did the choice of investors. As Peter recalled: 'the lead-investor contributed considerably to our professionalisation, especially with respect to managerial and financial issues'. For instance, the lead VCs established formal reporting structures and procedures allowing for a regular monitoring of the financials as well as of project progress. Furthermore, he organized the supervisory board. This board comprised five seats, one held by the lead VC, one by another VC, one by UrGenT's Angel investor, one by the MD of its incubator, and one – the chairman – by an executive of a major pharmaceutical company brought in by the lead VC. In addition, the lead VC also got involved 'hands-on' in some other aspects, such as with respect to market/competitor analysis, public relations, negotiating contracts with new staff, and patent issues. Finally, acknowledging the obvious deficiencies of UrGenT's management team regarding financial issues, the lead

VC suggested bringing in a CFO to support Peter, the CEO. The team agreed, and from the lead VC's vast network a suitable person was soon identified: Niko, an investment banker who seemed to fit very well into the team by his age and personality.

UrGenT's original management team perceived all these activities by its lead VC as highly beneficial. As Peter remembered, 'there was no doubt, the lead VC was really supportive; plus, we had this mutual understanding that everything should be done to achieve an IPO within three years'. Indeed, from the markets in 2000, it seemed more than likely that a successful IPO could be achieved in a short period of time. As a consequence, there was a frequent (often daily) and open communication between the management team and the lead VC.

Over the next year UrGenT made considerable progress with its initial strategy. It further build up its understanding of the molecular and genetic mechanisms underlying the targeted diseases. Furthermore, it identified several interesting genes, and filed patents for them. In addition, it generated a collection of tissue probes and medical histories from several thousand patients suffering from its targeted diseases. This provided a source of genetic information second to none in the area.

Together, in late 2000, this enabled UrGenT to close its first joint venture deal with an established foreign biotech company. In line with its strategy, this deal specified that UrGenT would identify possible drug targets (i.e. gene sequences) for which its partner then would screen compounds and develop drugs. This deal had a total volume of about €20m to be disbursed to UrGenT in several stages over the next years, depending on the achievement of certain milestones.

Mainly encouraged by this deal, but also because of the drastic downswing in the markets and the expected consolidation in the biotech sector, UrGenT's management team and investors consented that the company would have to develop 'critical mass' very soon.

Yet, because of the high-tech boom, laboratory space was hard to find in the region. Therefore, it seemed a good opportunity when the company was offered a long-term lease for a new building. Although the rates were high, the building seemed perfect for UrGenT's expansion strategy. So, the team accepted the offer and the company moved into its new base by December 2001.

I.III.1.d) Second financing round

To realise its expansion strategy, it was evident, UrGenT soon would have to go through another financing round. Initially, the prospects of this round being closed rapidly seemed excellent. The company had made further progress with its various research projects, filed several additional patent applications, and managed to attract some further high-calibre scientists (bringing its total staff to about 30). But most notably, it was in negotiations for another co-operation, this time with a top-tier pharmaceutical company and substantially bigger than UrGenT's first co-operation with the biotech firm. So, everything seemed to be working according to plan, and even without any of its projects beyond early stages, UrGenT was mentioned by an industry journal as 'one of the three most successful German biotech companies' at the time. Consequently, UrGenT's old investors indicated that they wanted to keep their shares – simultaneously claiming that their investment policy would prohibit them from increasing their share significantly. Thus, additional investors had to be brought on board.

But finding new investors now turned out to be more arduous than two years earlier. With the burst of the 'high-tech Bubble' in late 2000 the market sentiment had plummeted also for biotech companies. In addition, with the completion of the Human Genome Project, it had become evident that decoding the genome was only a first small step to actually understanding it. But also the Clinton/Blair decision regarding the limited 'reach-through' of gene-patents (as opposed to drug-patents) had a negative impact on the attractiveness of companies like UrGenT. Most investors now were very cautious with respect to companies owning patents but no late stage candidates.

Therefore, organizing a 'beauty parade' clearly wasn't an option anymore, and two VC firms UrGenT would have been most fond of because of their excellent reputation were not interested, because they were 'too busy bringing their existing portfolio through this difficult time'. Nevertheless, based on its progress so far, UrGenT convinced several 'second-choice' investors to start negotiating a sizable investment.

However, also actually closing a deal with existing and new investors turned out to be more troublesome than in the first financing round. There were several issues for which the negotiations were less smooth than in the first round. The new investors came up with a much lower valuation of the company than the old investors, emphasizing that it had no products even close to clinical development. On the other hand, the old investors insisted on their shares to be preferred over those of the new investors. Furthermore, all investors required more influence, for instance, in form of more rigorous reporting and regular management appraisal. In addition, the investors consented that a trade-sale of the company should be considered a possible exit option. This ran counter to the founders' belief that a trade-sale almost certainly would mean a break-up of their venture as big pharma was more likely to be interested in individual projects rather than in whole companies. Finally, the investors also indicated that they wanted to see UrGenT's value to increase significantly until the end of the round. As the new lead VC put it: 'we are no altruists!' This was when Peter became aware for the first time that the 'investors weren't really interested in the long-term sustainability of the company, but much rather in their short-term exit-opportunities'.

But in the end each party involved in the negotiations realized that they would benefit from closing a deal. UrGenT, on the one hand, clearly was in need of additional money, not just for its expansion strategy but also to cover the expenses for its new building and staff. The first round investors, on the other hand, felt that they wouldn't be able to exit their investment profitably in its current development stage and under the current market conditions. The new investors, finally, had to find investment opportunities for the funds drawn from their investors during the boom period – and UrGenT clearly was one of the most 'mature' opportunities in the German life-science sector in those days. Moreover, all parties put great hopes in the negotiations between UrGenT and the pharmaceutical company expected to be successfully completed by the end of the year. This deal would have served both the management team - which would have an important source of long-term funding for its activities, independent of investors' and markets' sentiments - and the investors - who expected the company's value to rise significantly once 'validated' through a deal with a global player in the industry.

So, in January 2002, after some tough negotiations, UrGenT received more than €15m in this second round. The funds came from a syndicate of one German lead investor accompanied by another German VC, one U.S. equity firm, and two of UrGenT's investors from the first round, who also had been working with the new investors in previous projects. The new investors had a reasonably good reputation but none had as much life-science experience as UrGenT's first lead VC.

With the newly received funds, UrGenT dramatically expanded its staff to almost 60 within less than six months. It continued all its initial projects and the negotiations with the pharmaceutical partner. So, again everything seemed to be on track.

Yet, after a couple of months, the new lead investors begun to 'show their muscles'. During the first meeting of the new supervisory board, the lead investor challenged Peter's ability to manage the now enlarged company as CEO, and suggested that Niko, the CFO brought in in the first round, should take over. They justified this by the fact that the markets had deteriorated so much that it would need a more business-minded person to guide the company through these difficult times.

As Peter recalled the situation: 'it didn't come as a real surprise. With the new size of the company, I didn't really feel too comfortable. Managing our expansion would have been a significant challenge even to someone more experienced than me. So, it wasn't so much the fact that the VCs wanted to get someone new. It was more the way in which they tried. To say they lacked diplomacy would be a polite way of putting it. But it seemed even more odd to me that *Niko* should take over. Obviously, he had a better grasp of the figures. But he had no idea about the science. I felt that this substitution wouldn't really improve the company's position much'.

The other co-founders largely shared Peter's perception. They agreed that it might be useful to have someone more experienced managing the company, but he should also know the industry. Therefore, they suggested that the chairman of the board (the senior pharmaceutical executive brought in by the first lead VC) should take over from Peter. However, this was something the investors were unwilling to accept. As Peter suspected: 'they wanted someone experienced, but not too experienced since this might have meant a loss of influence over the company for them. From their perspective, Niko must have been the best choice. He understood their language, but he was junior enough to be told things'.

Anyway, there was a deadlock situation. Peter was so offended by the investors' behaviour – and by the fact that Niko appeared to be a 'Trojan Horse' - that he left the company almost instantaneously. But there was no new CEO available immediately. Therefore, as a compromise, it was decided that Niko should function as interim CEO - until someone acceptable to all parties would be found.

It took some time for the dust to settle, but the investors were experienced enough to sufficiently 'incentivise' the remaining management team – by increasing its share-options - to continue cooperating. As a consequence, for the next couple of months, the company run relatively smoothly, pursuing its original strategy focussing on research in the area of functional genomics and trying to identify promising targets for drug candidates to be developed with its partners.

Yet, the situation completely changed when the big pharmaceutical company suddenly withdrew from the negotiation table by August 2002. It explained this totally unexpected move by its 'top management decision to exclusively concentrate on defeating a take-over bid by a pharmaceutical rival'. But, whether this was the real reason was never confirmed. Some in UrGenT's management suspected that their 'VCs' rather over-ambitious interferences in the negotiations might have stretched the pharmaceutical company's patience too much, particularly in a market situation that put considerable pressure on (the value of) biotech ventures'.

Whatever the real reasons, the failure to close this deal presented the starting point for a dramatic development. Most notably, UrGenT's investors now asked for significant changes in its strategy. Specifically, they wanted to see a stronger focus on in-house development of compounds (drug candidates) – instead of the initial focus on targets to be out-licensed to pharmaceutical partner for further development. For UrGenT, this meant moving up the value chain from basic research to development and clinical testing. At the same time, this meant that some of UrGenT's core capabilities would become obsolete, as would those scientists responsible for those capabilities.

Those suggestions had serious consequences even before they could be implemented. The new strategy found support not only by UrGenT's investors but also by Niko, the CFO and interim CEO. Maria (the CSO) and Paul (the CDO) as well as the majority of the scientific advisory board, however, reckoned that this wouldn't make much sense since UrGenT's strength was in target identification.

Initially, this controversy took place on a professional level. But it didn't take long for the first personal clashes to occur between the two parties, too. The differences finally escalated, in October 2002, whilst Maria was down with flu. Then, Niko - confident to have the investors' backing but without consulting Maria first – announced to the staff that redundancies were to be expected particularly among the researchers. Paul informed Maria who instantaneously returned from her sickbed. Not only did she feel completely overrun, also the scientific staff demanded to know what it had to expect from the future.

As a consequence, a joint emergency meeting of both the supervisory and the scientific advisory board was called in. This meeting, as it turned out, established the second major cornerstone in UrGenT's development. In preparation of the meeting, the chairman of the supervisory board (i.e. the pharmaceutical executive brought in by the VCs in the previous round) send a letter to the participants, in which he made some interesting suggestions. He explained his ideas as follows:

> 'Over the past years, we have developed not only an unique understanding of the genetic and molecular mechanisms underlying our diseases but we have also identified a number of possible targets to treat those diseases. However, so far, we haven't put much effort in developing corresponding candidates or even drugs. Instead, we have relied on partners to eventually deal with this. Accordingly, we haven't build up some relevant capabilities; and it now might take us too long to do so. So, we have to capitalize on what we have got.
>
> In this context, my suggestion: We shouldn't waste time trying to develop drugs from the scratch. What we should do instead is 'retargeting'. This is, we should use our knowledge of the mechanisms underlying our diseases to identify existing drugs that target similar pathways but were approved and patented for other diseases. So, if we identify suitable existing drugs approved for applications in other fields, we can file for second-use patents protecting application for one of our urogenital diseases. An additional advantage is that the regulatory hurdles are much lower for drugs already approved, allowing us to bring retargeted drugs to the market much faster and cheaper than most competitors could do.
>
> At the same time, we shouldn't give up completely our basic research. New targets will provide the basis for testing and retargeting existing drugs. Furthermore, once the interaction between our targets and a retargeted drug is validated, we are well positioned to develop novel compounds based on the same principle. This will yield second-generation drugs that are optimized and have a composition matter claim patent. Initially, we might achieve this in collaboration with companies that have capacities in medicinal chemistry. But in the mid-term, we should be able to build up own capacities for optimizing chemical leads, as well as developing and testing them.
>
> The retargeting approach has already been used successfully by several companies, but only opportunistically and frequently with drugs already available from the companies. In our field, we would be the only company to establish strategy based on systematic drug retargeting, Together, this will put UrGenT into a unique position in the market, which in turn, should soon be manifest by a significant increase in its value.'

This suggestion was intriguing to all parties. On the one hand, the 'finance people' (the investors and Niko) could hope for a quick development of drug-candidates into clinical stages, likely to increase the company's valuation considerably even within the current round. On the other hand, the 'science people', including Maria, could hope for UrGenT continuing at least some of its basic research and building up its corresponding capabilities, albeit to a lesser extent than had originally been planned.

Overall, however, the finance fraction had come out stronger from the situation. The investors finally succeeded in making Niko the actual CEO – 'because there was no other suitable candidate to be found on the market'. In addition, it was decided that the company in general and the research department in particular should become 'leaner', cutting down the staff of 65 to about 50. This should serve to reduce the cash burn-rate enabling it to last until early 2005 when the markets were hoped to have recovered. From a financial perspective this made sense, even taking into account the fact that more than half of UrGenT's expensive laboratory space would lie unused, with no potential sub-tenants in sight.

Since mainly scientists were affected by the redundancies, Maria - as the CSO - was given the ungrateful task to select several of her colleagues and to inform them about their redundancy. She recalled the situation as almost traumatic: 'there stood my old mates in my office, some shouting at me and some even crying – because they knew how difficult it would be in the current situation to find a new job that would feed their families'.

Maria still wasn't convinced about the board's decision. She feared that UrGenT, by firing its scientists, could loose its most valuable assets. Not long ago she had been laughing about some other biotech companies that 'had forgotten how to do even the simplest research-related things'. Furthermore, wasn't it the scientists who had built up the company's strong portfolio of several dozen patents?

But Maria had no choice. Hardly having 'survived' the recent confrontations herself, she knew that 'the others would have liked to cut the company's research function even further; and they were now watching the research departments activities and expenses closely'. Therefore, to keep at least the majority of her people and the most relevant capabilities, certain concessions - and cuts - had to be accepted. At the same time, she promised to herself 'to do everything to avoid such a situation ever happening again'.

Thinking back to the first financing round when the team had decided to accept only a fraction of the funds offered by investors, Maria concluded: 'the one thing I have really learned from all this is: whenever you can get money take as much as possible; you'll never know when there will be another chance'.

It took a while before the situation had calmed down again. But then everyone begun to realise that there wasn't much time left. Specifically, with the current cash UrGenT was expected to survive for not even two years, and the investors made it pretty clear that there were no more cash infusions to be expected unless the company should bring at least one retargeted drug into clinical testing. So, the shared perception that this was the last chance for the company made the management team co-operate again and focus all remaining resources on the new strategy. Still not fully convinced about the long-term viability of the retargeting approach, Maria even agreed to spend a significant fraction of the remaining funds on the development of a database tracking millions drugs and compounds potentially suitable for retargeting.

At least initially the new strategy seemed to pay off. UrGenT managed to close a cooperation deal with a mid-sized pharmaceutical company that would be able to manufacture and market the retargeted drugs eventually identified and validated by UrGenT. Indeed, it didn't take long to identify two existing drugs that were approved for medical indications different from those UrGenT was working on, and that promised to be suitable candidates for retargeting. Furthermore, even surpassing the chairman's expectations, UrGenT achieved the proof-of-principle for one of those candidates within less than six months. Thus, pre-clinical testing could commence by June 2003.

Overall, therefore, all members of the management team - including Maria - were confident that they had finally overcome the most difficult period in their company's history. Their optimism was further fuelled by the investors' indication that significant further funding already by mid 2004 would be no problem, as soon as the human proof-of-concept for the candidate was established in the clinical stage.

Thus, the goal was clear. The lead candidate had to make it into – and through – the clinical stage. As a consequence, even when it showed some 'irritating' results in the pre-clinical tests these weren't given too much weight, and in October 2003 it was decided to move ahead into the clinic. The clinical trials were designed to take 10 months and a general board meeting was scheduled for August 2004, to announce the results and to discuss the further proceeding.

However, a week before the meeting, Maria got the results of the clinical stage I trials. They were disastrous! The candidate showed no effects whatsoever in patients!

Maria had little doubt about the implications of those results for the company. Pushed by its financial strategy and the investors' stipulation to only invest further into a company with a human proof-of-concept, UrGenT had 'put all its eggs into one basket'. It had taken the retargeting route to shortcut its initial research-based multi-product approach, and to bring at least one product into clinical development. Everyone knew that most projects fail at this stage, even when the ground is prepared very carefully. This is just the hand of 'nature' in all natural science projects. However, although preliminary results had already indicated possible problems, everyone wanted to 'appease' the investors - at the expense of conducting additional pre-tests. At the same time, there now was no successor for the failed lead candidate anywhere near to clinical stage. It would take at least a year to develop another candidate thus far, much longer than the current cash would last. Yet, whether the investors were willing to prolong UrGenT's lifeline was questionable, at best. After all, they 'were no altruists'.[312]

I.III.2. Case B: CardioGenix

I.III.2.a) Origin

In May 1998, Michael, a young medical doctor read about a coached business plan competition that was initiated by his university and the state government - to foster the commercialisation of life science research in the Rhineland region.

Michael always wanted to become a professor of medicine, and he considered himself 'a science nerd with neither interest nor knowledge in business'. Indeed, during his PhD, he had made some exiting discoveries that he now intended to examine further.

Without going into too much detail, Michael's research concerned a number of life-threatening 'cardio-vascular' conditions that appeared to be based on similar genetic and molecular mechanisms. Yet, the drugs available to treat those conditions were very expensive. Even worse, they were rather inefficient. Less than 30% of the patients treated with existing drugs responded - more or less - positively. This presumably was because they had the right 'genetic profile' for the available drugs. The majority of the patients, in contrast, had different genetic profiles rendering the available treatments either entirely ineffective or even resulting in severe side effects.

[312] As it turned, out a few months after the completion of our case study, UrGenT's VCs' indeed were unwilling to provide any further funds. At the same time, because the market sentiment still had not improved, it was impossible to find any new investors. As a consequence, UrGenT ran out of money and had to file for bankruptcy. Its few tangible assets were auctioned, but the VCs are still trying to recoupe some of their investments by selling the venture's patents.

In this context, Michaels's research had revealed – in vitro - that a certain biochemical agent could serve as a key-component for new, more effective drugs against at least one of those conditions, and likely also against several others. Even more fascinating, it seemed that the agent could easily be customized towards an individual patient's genetic profile. This, in turn, could make the drugs based on the agent even more effective, efficient, and safe. Whilst Michael had already established a basic 'proof-of-principle' for this technology, much remained to be done from a scientific perspective. For instance, the underlying genetic and molecular pathways and interactions were far from being fully understood. Similarly, with view to the customization of the drugs, it also was not yet clear how great the genetic variation of patient population actually was.

Yet, to Michael, this wasn't a problem. On the contrary, to him, the many open questions offered a great opportunity for his future career in research. Thus, even when his former supervisor recommended filing a patent for his discoveries, he couldn't really be bothered about it. From an academic perspective, a patent was worth little compared to a publication in a top-tier science journal.

However, Michael wasn't totally unaware of what was going on outside his lab. He knew that in those days it wasn't easy - even for high-flying scientists - to get any position in Germany, not even as a poorly-paid post-doctoral fellow. Some of his colleagues were searching for jobs already for several months; and many had moved to the States. Yet, with two small children, this wasn't really an option for him.

Therefore, Michael reckoned, it might be useful to acquire additional qualifications. For this purpose, the business plan competition seemed tempting. It wouldn't require him to give up on his research projects, but just to take a new, commercial, perspective on them. At the same time, there would be a coach providing 'one-to-one teaching'. Clearly, this was more attractive than taking a business course at some training institution. When Michael mentioned these thoughts to two of his colleagues, they concluded that participating in the business plan competition wouldn't do any harm.

Thus, in June 1998, the three doctors applied for the competition and soon were assigned their 'personal coach', Sean. Sean seemed the ideal person for this job. Not only had he an academic background in the life sciences himself but he also had a PhD in entrepreneurship.

Soon after, the group of four started working on the idea in some more detail. However, initially, developing the business plan was more an 'exiting game'; and none of the team members seriously considered actually realising it. The medical doctors enjoyed getting an understanding of business issues, and Sean enjoyed watching 'entrepreneurship in practice', as opposed to what he had done in his PhD. Yet, with their meetings becoming more regular and intense, the team members developed not just mutual respect and trust but a genuine friendship.

At the same time, having done some market research, they also became more aware of the actual commercial potential of their idea. Indeed, the drugs developed on the basis of Michael's technology could eventually target a high, unmet medical need in a rapidly expanding market, with saturation not to be expected within the foreseeable future. This was even more so in case the drugs were actually customized towards individual patients' genetic profiles. It was the time when the first significant progress of the Human Genome Project began to stimulate the scientific community's interest; and several industry reports promised unprecedented changes in the pharmaceutical industry to occur. As Sean read in a publication by Ernst and Young (1998):

> 'Away from the glare of the media, pharmacogenomics was the hot new concept in biotech. The bet is that genomics and bioinformatics can be used to develop drugs with exquisite specificity for subpopulations of patients, as well as turning diagnostics from a relatively uninteresting low-margin commodity business into one that justifies stand-alone companies with high margins'.

Indeed, Genentech's cancer-drug Herceptin had already proven that it was possible to obtain high margins ($19.000 per treatment) for drugs customized to the genetic profiles of patient sub-populations. It was too early to make final predictions, but the overall market size for customized treatment in the cardio-vascular field certainly would be in the billions.

At the same time, the team's research also revealed that the significant treatment costs per patient for the targeted diseases had already attracted some potential competition. A couple of biotech companies were already working on similar – but arguably inferior - approaches in the US. But, as yet, there was no established competition. Furthermore, even if competitors were to be successful, their eventual products were expected to be complementary rather than mutually exclusive to those developed on the basis of Michael's technology. Finally, the 'cake seemed large enough to feed several companies'.

Based on this research, it didn't take long for Sean to come up with some preliminary projections for their venture. It did seem possible to achieve revenue streams of €500.000 in 2005 and of €225m in 2012, and to capture a market share of about 5% within 10 years in Germany alone. Those prospects suddenly made the idea much more 'tangible' for the team, and they noticeably fuelled its enthusiasm for the project. Consequently, in December 1998, the team had finalised the business plan, which described the company-to-be as follows:

> CardioGenix is a bio-pharmaceutical company developing drugs against several cardio-vascular conditions. It is based on a highly innovative, proprietary technology that provides clear advantages for patients and health care providers. Our technology provides the means to produce not only highly effective 'off-the-shelf' drugs but also 'customized' drugs, individualized towards a patient's genetic profile. Customization makes our drugs even more effective, efficient, safe and economical than most other drugs on the market. Furthermore, our technology allows us not only to develop drugs in-house, but also to produce and market them ourselves. This puts us into a unique position in the pharmaceutical value chain and provides exceptional opportunities to our investors.

With the final business plan in their hands, the initial team-members cautiously began wondering whether they should actually try realising their idea. In this context, a crucial cornerstone was reached when, in March 1999, the team was awarded an honorary prize in the business plan competition. The positive feedback from a wider audience was a new experience particularly for those team members, who were 'used to work in a rather closed academic environment'. In parallel, there was the increasing publicity regarding the 'Human Genome Project', which was expected to be completed soon and to provide the scientific basis for a new area of customized medicine.

Together, this finally convinced three of the team members, amongst them Michael and Sean, that the project could be worth a try. In June 1999, they began searching for both seed funding and suitable lab space. However, this turned out to be quite laborious. In Germany, there were a number of governmental programs to provide financial support for entrepreneurial-minded scientists. But application procedures were time-consuming and involved an 'incredible amount of paperwork'. Furthermore, the Internet-boom was in full blossom. Consequently, high-tech start-up ventures were coming to the market 'on an hourly basis', and affordable space was hard to come by.

I.III.2.b) Seed round

By December 1999 the team had collected sufficient money from 'family and friends' to incorporate their venture. Soon after its inception CardioGenix further managed to secure some tiny but comparatively cheap office space – but no proper laboratory - in a local biotech incubator.[313] This incubator also provided some seed funding which was soon topped up by governmental funds to about €300.000.

But neither the new space nor the initial funds were sufficient to properly start with the technical work on the project. Accordingly, it was decided that the two medical co-founders would remain in their former institutes until further funds and space would become available. This had several advantages. First, it provided an ongoing income at least for two team-members. Furthermore, it allowed them – in their 'spare-time' – to use their institutes' equipment for some initial work on CardioGenix' projects. Finally, the ongoing work-relationships with the institutes could be 'sold' externally as 'academic co-operation', providing important credibility for the fledgling venture.

At the same time, both funds and space available allowed at least Sean, now CardioGenix' CEO, to work full-time for the company and even to hire an assistant. This was crucial to sort out several issues. One of them was the filing of a patent-application to protect the venture's core-technology. Another, equally important issue was the more detailed specification of the business model and strategy from the original business plan. Sean realised, 'whilst the initial business plan had been good enough for the competition, it certainly wouldn't stand the scrutiny of investors; and there was no use in approaching investors with a 'half-cooked' business plan.

However, in this context, CardioGenix' key promise simultaneously was its key challenge. As already indicated in the original business plan, the venture's unique technology offered two main options for its business model and development strategy, which would require a very different level of resourcing.

On the one hand, CardioGenix' technology could be used for developing 'one-size-fits-all/off-the-shelf drugs' with the potential to become blockbusters or even a 'block-buster-product-Suite' (a number of products based on similar technology). However, this approach would confine CardioGenix to become a 'typical biotech company'. It would be merely engaged in early research activities, trying to develop drug candidates, which then had to be sold or licensed out to 'big pharma'. This was because only large-scale pharmaceutical companies would have the necessary means and capabilities to develop those candidates further, to organize and conduct the relevant large-scale clinical

[313] This was the same incubator where also UrGenT, the venture from the previous case, had its origin.

testing, to manage the approval process, to manufacture the actual drugs, and to market them. Thus, even if CardioGenix received some early income - e.g. in form of up-front fees, mile-stone payments, or royalties etc. - this approach would make the company dependent on licensing partners for a long time, and it would leave it with only a fraction of the overall revenues generated in the value chain. Yet, at least in the short run, this approach would also be the cheapest one.

On the other hand, CardioGenix' technology could also be used for developing customized drugs, individually tailored towards a patient's genetic profile. As Sean realised, 'this approach was both very attractive and very challenging at the same time'. It offered the opportunity for CardioGenix to become a fully-fledged bio-pharmaceutical company, a promising and challenging new business model. At least in theory, a pharmacogenetic approach would allow for developing more effective/efficient drugs with fewer side effects. It would be particularly interesting with respect to those diseases that were life-threatening and for which no efficient cures were yet available. In those cases, the treatment costs per patient are usually very high, whilst the legal and regulatory hurdles are rather low. Those drugs presented a 'last chance' and - because of their individualization - would not have to be tested in large clinical trials. The higher costs associated with customization could be compensated by economies of scope. CardioGenix could (or would have to) participate in a wider spectrum of the value chain than traditional biotech companies. For instance, it wouldn't only have to focus on the early R&D. Instead, since producing individualized medicine means producing on a small scale, CardioGenix could also have its own manufacturing facilities. Furthermore, CardioGenix could even deliver and market its products, cutting out the profit-eating involvement of 'big pharma'.

At the same time, however, this approach clearly presented some serious challenges. To begin with, there was the question of the technological feasibility. Although Michael's research had achieved its 'proof-of-principle', it wasn't certain whether it would also work in living organisms, let alone human patients. Pharmacogenetics in general would apply only where differing drug response is due entirely or mainly to genetic variation. But the actual variation in the relevant patients' genetic profiles wasn't fully known. In addition, many of the legal aspects regarding the genetic profiling of patients were not sorted yet. Similarly, regulatory and approval aspects presented considerable risks. The in-house production of customized biologic drugs, even on a small scale, required expensive GMP ('good manufacturing practice') facilities and qualified staff. This was a particularly risky bet since the facilities would have to be in place even before a drug eventually was approved. This was because the bio-pharmaceutical approval process covers the production facilities as well as the drugs themselves. If production were changed, then new clinical trials would have to be conducted to prove that the new plant would be able to accurately produce the complex biological molecules. Even worse, if the drug development failed, the investment in highly company-specific facilities would be almost lost. On top of this, the approach necessitated close co-operation with GPs and hospitals to identify suitable patients, to analyse their genetic profiles and to deliver the customized drugs to patients. At the same time, it required careful planning of the logistics and good contacts within the industry. Thus, overall, this approach required much more financial resources than a typical biotech venture needed, whilst it was simultaneously associated with even more uncertainties.

So, what was the most appropriate business model and strategy? Should CardioGenix go for the whole thing, or just for parts of it? Could the logistics be worked out? Would GPs and hospitals be willing to co-operate? What activities should be kept in-house? What was the most valuable and what was the most risky part of the business? Who might be a good partner to work with? Who could provide the relevant contacts? These were difficult to answer questions in general, but even more so for a young team without the relevant contacts and experience in the pharmaceutical industry.

In this context, also the incubator couldn't really help, despite its best intentions. Its main support came in form of the seminars organized on issues of general relevance for its tenants and in form of a significant database with valuable contacts for external networking. But the incubator had very limited manpower to serve all the needs of its 15 portfolio ventures, most of which were rather 'typical' biotech start-ups, with neither the intention of nor the possibility to become a bio-pharmaceutical company like CardioGenix. Furthermore, most of the incubator's employees were scientists themselves without much business/corporate development experience, particularly with respect to (bio-) pharmaceutical companies. As a consequence, CardioGenix wouldn't get answers to its questions regarding the business model.

Nevertheless, Sean knew that CardioGenix would have to get its first proper financing very soon. This was not only because it needed funds to actually get off the ground and avoid loosing too much time to potential competitors. It was also because there were clear indications of a change in investors' sentiment. It was September 2000 and, over the last months, the performance of several high-tech/Internet ventures had disappointed investors' expectations, particularly those of the less experienced German investors. Many ventures had failed to keep their promises, and not just a few went out of business completely. The resulting losses made investors much more wary than they had been only a couple of months before. At the same time, also the investors' investment preferences began to change. In general, they now preferred more mature to 'virtual' start-ups.

So, to get started with the fund raising, Sean and his team finally opted for the 'bio-pharmaceutical model'. This model not only seemed most promising to them but it was also assumed to be more attractive for potential investors. Despite its many uncertainties, this strategy had the advantage of being relatively unique, and it could lead to CardioGenix becoming a fully-fledged drugs-company within a relatively short period of time, creating significant wealth for its shareholders.

With the support of its incubator, the team started approaching potential investors, initially asking for about €5-6m. This amount was at the lower end of what had been given to many early-stage biotech ventures only a couple of months before. But Sean reckoned it would be wiser to start cautiously, especially because he was hoping for some extra, non-monetary contribution from the investors in form of constructive input to the development of the business model.

With this hope in mind, Sean contacted several foreign investors, known for their track record as 'builders' of life science companies. Indeed, it turned out that some of them were actually interested in CardioGenix' innovative technology, and some also indicated that – based on their own expertise and their network of contacts – it shouldn't be impossible to get CardioGenix' rather challenging business model running. Thus, it came to pre-negotiations and closing a deal seemed possible.

However, in November 2000, the negotiations came to an abrupt halt. The European Patent Office (EPO) claimed that in CardioGenix' application for the patent covering its core technology an arguably relevant article from a group of U.S. researchers had not been considered, potentially making the patent application invalid.

Although the team was convinced that this article wouldn't have any impact on the patentability of CardioGenix' technology, the investors refused to continue with the negotiations unless the IP issue was sorted. The team, therefore, immediately applied for fast-approval of its application. But, in those days, the EPO had to deal with so many patent applications that the whole process consumed a lot of time, very valuable time as it soon turned out. It was late 2000 and the window of opportunity on the markets was closing visibly.

CardioGenix managed to establish another academic co-operation with a well-known scientific institute, and it made some progress with its projects. However, with the IP issue still not being solved by the end of the year, the potential investors finally withdrew from the negotiation table, leaving CardioGenix still without a better-specified business model and with cash lasting only for a couple of months.

As a consequence, by the end of the year, one of the employees had to be made redundant, and even Sean was paid only the bare minimum. Furthermore, whilst he would have liked to pay for external advice on the most suitable business model, this wasn't an affordable option. Instead, he even had to cut down his networking activities to a local level.

As Sean recalled the situation: 'This time was really bad for all of us. We had put all our hopes and energy into this project; and we were convinced that we could make it work. But there was always was this money issue, and without a final decision by the EPO it seemed impossible to get any serious funding. Actually, without the support of our old institutes [those the two medical co-founders were still working in] and without our friends we never would have made it through this period'.

I.III.2.c) First financing round

By June 2001, when insolvency was imminent, the incubator leapt in. Keen to avoid an early dropout of one of its portfolio ventures, and convinced about CardioGenix' inherent potential, the incubator's MD arranged €250.000 bridge financing for CardioGenix. Some of this money came from the incubator's own funds and some from a small young German venture capital firm that – as a latecomer - wanted to get a foothold in the biotech sector, and at the same time to benefit from the governmental fund-matching scheme.

To be sure, the money was crucial for extending CardioGenix' lifeline. However, from a non-monetary perspective, the new investor contributed even less than the incubator to CardioGenix' other fundamental problem, i.e. the development of its business model. The VC firm, a university spin-off itself, was led by two academics who claimed to focus on 'commercialising scientific research in a way it was done in the U.S.' Yet, it had no relevant practical knowledge regarding business/corporate development, and no idea about the pharmaceutical industry.

Thus, whilst the new VC took a seat in CardioGenix' supervisory board, its contribution remained a monetary one.

Nevertheless, the fresh funds - accompanied by an additional small research grant from the state government - allowed CardioGenix to move into some proper laboratory space, and to hire two new scientific employees. Both had a very positive impact on project progress. Thus, in July 2002, CardioGenix managed to achieve its first significant milestone, the 'proof-of-concept' of its technology in mice. Moreover, not much later, CardioGenix was finally informed about the EPO's favourable decision on its patent application for its core technology. Together these facts provided the basis for CardioGenix to go back and approach investors for further funding, this time about €5-10m.

However, it now became clear that the company really had lost extremely valuable time. The market window had closed almost completely, and as Sean recalled, 'The few experienced equity firms still active were either only funding ventures already in their portfolios or they were looking for more mature ventures, with a pipeline full of late-stage candidates, led by seasoned managers, supervised by a well-reputed board, and ideally 'validated' by several deals with 'big pharma' et cetera'. From this perspective, CardioGenix had little more to offer but 'potential' – something all other ventures claimed to have, too.

I.III.2.d) Second financing round

After a considerable number of failed attempts to attract high-profile investors, CardioGenix realised that there was no choice; the markets were basically closed for companies without track record, products, and a watertight strategy. Thus, in November 2002, the team finally 'gave in' and accepted the only offer on the Table – just over €1.5m – from a syndicate comprising a mid-sized German equity company (as the new lead investor), and CardioGenix' two investors from the previous round. The new lead investor was brought in by CardioGenix' first round lead VC who had a personal relation to its managing director going back to the times when they studied together at the same university.

However, the new lead investor had only very limited experience in investing in German platform-technology biotech start-ups, but not in drug-developing or even bio-pharmaceutical companies. Consequently, Sean realised, CardioGenix couldn't expect much more from the investors than cash, which however 'was too much to die with but too little to prosper on'.

As a consequence, Sean reckoned, it would be best for him to resign as CEO and hand over to someone with sufficient pharmaceutical experience and contacts to sort out the company's business model and strategy. Yet, with the current team already working on temporary, low-budget 'consultant'-contracts, it was impossible to offer anything close to a competitive salary to a more senior CEO - should one be found at all.

Therefore, Sean suggested having 'focus groups' with all stakeholders to jointly develop a sustainable business model. This was something not uncommon for (biotech) start-ups in the U.S., as Sean had read in an industry publication:

> '[...] Choosing the appropriate development strategy requires in-depth knowledge about the interplay between technology, products, and markets as well as knowledge about the time-requirements. If all stakeholders agree in their perception of technology, products and markets, this will support the timely development of an appropriate strategy, the provision of adequate funding, and the avoidance of conflicts [...]'

However, with the exception of the incubator, the investors were not interested in his suggestion at all; and Sean was turned down by one of them with the words: 'you better be aware of our respective roles. We have given you our money and you better do everything to get your technology up and running'.

Then again, the investors themselves appeared not always to be clear about their respective 'roles'. The lead investor was in fact supposed to be the main point of contact between CardioGenix and the investor group. But the other investors soon started approaching Sean for various financial and project-progress reports on an individual basis. Initially, Sean didn't mind too much, partly because he got on rather well with one of the lead VC's investment managers. So he didn't want to be considered 'difficult' and trusted the investment manager to sort out this lack of coordination. Accordingly, he did his best to respond in an open and timely way to all investors' requests.

At the same time the syndicate made it clear that the investors weren't really interested in CardioGenix becoming a bio-pharmaceutical company developing and manufacturing customized drugs. Instead, their view was that the company's focus should be on developing one candidate with the potential to become an 'off-the-shelf' drug. So, having no choice, CardioGenix team finally gave up its hope on realising the tempting but more challenging idea any time in the near future. Instead, the company now solely focussed on developing non-customized drugs.

But even with this strategy another problematic issue soon turned up. According to the – rather vague - term sheet CardioGenix would have to bring one product candidate into clinical stage I, as a precondition for further funding. However, it soon appeared to the team that there might be a good chance for additionally developing further also a second candidate. This would have broadened CardioGenix' pipeline from one to two product candidates. However, because of the limited resources, it seemed unlikely that any of the two candidates would make it into clinical stage I within the current round.

Sean, therefore, asked the investors to respecify the original term sheet to take this apparent change of strategy into account. But they declined, insisting that CardioGenix focus on one product only regardless of the conditions of the contract. Sean now began to suspect that this increased focus on one product was because the investors were essentially only interested in increasing the value of their investment within the current round and not necessarily the long-term viability of the company. By so doing they could, the logic went, exit their investment and pass the baton on to the next investor – should there be one.

At the same time, Sean also acknowledged that in this context the VCs made their potentially most valuable 'contribution'. Specifically, they agreed that CardioGenix would 'leap-frog' from the original lead product to the next one in its pipeline. Although targeted towards a slightly smaller market, this second candidate promised to be a 'safer bet' and to make it faster into the clinical stage.

So, over the next couple of months, Sean remembered, 'The team worked its socks off; they [the VCs] told us to jump, and we did'. Indeed, given the circumstances, CardioGenix made astonishing progress. By January 2003 the venture had 'grown' to nine employees (5 full-time and 4 part-time), it had filed another three patent applications, and it had received some additional, albeit small, research grants. Furthermore, it had contacted more than 100 companies worldwide for partnering, with about 20 of them expressing an interest, and it had started an informal joint venture with a pharmaceutical company. Most importantly, however, it actually succeeded not only in bringing its lead product into clinical stage I but also in completing this stage successfully. Thus, in June 2003, the good results even surpassed Sean's expectations. The clinical effect was observed even in the lowest dose group; but also with the highest dosage, the drug showed positive results with only small side effects. At the same time, also the technological feasibility of production and application could clearly be demonstrated.

But the overall favourable position didn't mean that CardioGenix' other problems would disappear. On the contrary, another setback occurred when the investment manager of the lead VC, with whom the team got on with best, left his firm. Then Sean learned the real meaning of the common saying that 'the VC business is a people business'. As soon as the investment manager had left, the other investors recommenced their 'un-coordinated and increasingly annoying' reporting requirements. Thus, the team in general, and Sean in particular, suffered increasingly from over-reporting. The situation further worsened when the investors began talking about more restrictive conditions to be imposed on additional funding for the firm.

These elements conspired to form a vicious circle. The team lost its trust in the investors and became increasingly reluctant to correspond with the investors' reporting requirements. This, in turn, led the investors to demand even more information and to try implementing even more rigorous reporting rules. Soon, the relation between the two turned really sour, a situation manifested in a series of personal clashes between the investors and the team as a whole but particularly between the investors and Sean.

Thus, in December 2003, not long before CardioGenix was about to run out of money again, Sean really wanted to get new investors on board for a third financing round. Given that CardioGenix had made considerable progress and now even had some 'track-record', chances were that new investors could actually be convinced. For the next financing round, the company planned to bring its lead product into the approval stage, to start clinical phase I for the second product, and to develop pre-clinically several further products with high market potential. Together, this was expected to provide the basis for an extraordinary increase in the company's value, and present a very attractive opportunity for potential investors.

However, having finally realised CardioGenix potential, the old investors now wanted to increase their share in the venture. At the same time, they still insisted on a very low valuation of the company. Moreover, they required the inclusion of several clauses into the new term sheets regarding personal liabilities of the management team in the event of failure at clinical stage II.

For Sean, this was 'over-stretching' it; and to him it was the final proof that continuing with the old investors just wouldn't work. However, he was aware that new investors would be unlikely to be found within the time remaining, particularly since the old investors' lack of reputation wouldn't signal sufficient credibility to new investors.

So, from Sean's perspective, the only way out of this dilemma was to leave the company; and this he did in May 2004. The old investors now 'tried hard' to keep in with the remaining team. But soon Sean's colleagues had lost their faith in the investors, too. Thus, in July 2004, CardioGenix filed for insolvency.

I.IV. Summary and discussion

I.IV.1. Summary

Our cases examine and contrast the early development of two new biotechnology-based firms (NBFs) - UrGenT and CardioGenix. Table I-2 a) and b) summarizes the main dis-/similarities between the two ventures.

Table I-2 a): Major similarities between the two case study ventures

Panel A: Similarities	**UrGenT & CardioGenix**
Origin	Outcome of German BioRegio competition
Founders	Scientists with no/limited commercial/industry experience
Town/region	Rhineland, a winning region of BioRegio competition
First company base	Same incubator (initially)
Industry sector	'Red' biotechnology, 'genomics'-based drug development
Market size	Great potential
Non-financial resources	Dependent on external advise
Financial resources	Dependent on external funding
Seed round	1 seed round, involving same incubator / governmental program
Subsequent rounds	2 VC rounds each
Current status	(Almost) bankrupt

Table I-2 b): Major dissimilarities between the two case study ventures

Panel B: Dissimilarities	**UrGenT**	**CardioGenix**
General		
Foundation	June 1997	December 1999
Founders	Well-known/-connected professors and junior scientists	Unknown, junior researchers
Industry sub-sector	Functional genomics	Pharmacogenomics
Business idea	Not specified: 'capitalize on capabilities in basic research'	Fairly specific: innovative drug with 'proof of principle'
Business model	'Typical' biotech company, focussing on early-stage R&D, reliant on co-operations with pharmaceutical partners	Not finalised, two options: either 'typical biotech' or fully-fledged 'bio-pharmaceutical' company
Seed Round		
Round date	June 1997	December 1999
Financial markets/ environment	Early beginning of biotech boom, opening 'window of opportunity'; public grants and subsidies easily available particularly to well-connected senior co-founders	Short before peak of biotech boom and closing of 'window of opportunity'; public subsidies still available but involve time consuming application procedures
Investors	Incubator, Angle, public grants/subsidies	Incubator, public grants/subsidies
Funding	€1m	€300,000
Investors' involvement/ contribution	Fairly high involvement: de-signing research strategy, hiring scientific staff, organising seminars, introduction to professional service providers and investors	Some involvement: organising seminars, introduction to professional service providers and investors; but no contribution regarding business model
Relation with investors	Good as incubator staff had sufficient time/manpower	Good, but incubator staff has only limited time/manpower
Company progress	Move into incubator that still has plenty of space (amongst	Move into incubator that has only limited space (amongst

Panel B: Dissimilarities	UrGenT	CardioGenix
	first tenants); expansion of staff (to 12); joint ventures with some well-known (U.S.) research institutes; good progress with basic research but not with tangible 'product'	last tenants); one additional admin staff; some progress with product but - because of financial constraints - less than would have been possible (two co-founders stay in old jobs and one co-founder is busy with admin/business model); problems with patent lead to additional loss of valuable time
first Round		
Round date	December 1999	June 2001
Financial markets/ environment	Peak of boom, additionally fuelled by hype surrounding Human-Genome-Project	After boom, markets in visible downswing, window of opportunity closed
Investors	High profile, experienced, inter-/national VCs	Low profile, inexperienced, national VC
Funding	€5m	€250,000 (bridge financing)
Investors' involvement/ contribution	High involvement, value added contributions, e.g. participation on supervisory board, 'hands-on' support regarding fin./mgt. issues, hiring of CFO	No involvement/contribution despite mgt. team's explicit wish for input regarding business model
Relation with investors	Good and open, mutual under-standing, IPO as the common goal	No relation, since just monetary contribution
Company progress	Good progress with basic research, but little progress towards actual product; joint-venture with foreign biotech company; move into new (but expensive and oversized) building to realise expansion strategy; expansion of staff (to 30); several patent applications	Good progress with product – given circumstances/funding; achievement of 'proof of concept in mice', core patent obtained; two additional staff; move into new laboratory space
Second Round		
Round date	January 2002	November 2002
Financial markets/ environment	Plummeted after dot.com Bubble burst; additional difficulties because of new 'realism' regarding Human Genome Project and changing gene-patent laws	Market downswing about to reach its lowest point
Investors	Medium-profile, fairly experienced, inter-/national VCs	Low-profile, rather inexperienced particularly with respect to business model, national VCs
Funding	€15m	€1.5m
Investors' involvement/ contribution	Replacement of CEO; dramatic shift in strategy focusing on product development rather than solid R&D - to increase short-term value of company	Hardly any constructive involvement; CEO willing to hand over, but financial situation doesn't allow to hire experienced manager; VCs not interested in biopharmaceutical business model but require to pursue typical biotech strategy with focus on one product
Relation with investors	Tougher pre-round negotiations (e.g. regarding company valuation, VCs' influence, trade-sale as possible exit-route) suggest more difficult relationship; but investors 'incentivise' mgt. team with additional share options, required strategy shift creates conflicts between 'finance and science fraction'	Deteriorates when one investment manager leaves and remaining VCs approach venture with unorganized reporting requirements and even mention additional conditions (personal liability) for further funding to be obtained; finally: mutual loss of trust and substantial personal conflicts

Panel B: Dissimilarities	UrGenT	CardioGenix
Company progress	Initially substantial expansion of staff (to ca. 60); failure to close deal with big pharmaceutical company; subsequent reduction of staff (to ca. 50); new, 'retargeting' strategy initially shows some success (identification of promising product-candidates, deal with mid-sized pharmaceutical company) but finally turns out to have been a 'risky bet' when candidate fails in clinical tests - that are conducted although pre-clinical test had already indicated possible problems	Very good progress; new lead candidate successfully passes clinic I; expansion of staff (to 9); further patent applications; promising efforts to find pharmaceutical partner

The two ventures were similar in several ways. For instance, they were founded in Germany, a country that took a particular approach to kick-start its late entry into the biotech sector by financially supporting the foundation of NBFs; their founders were scientists with very limited commercial experience; they were seed-funded by the same governmental programme; they were started in the same incubator; they were engaged in genomics-based drug development, and they were dependent on both external funding and advise.

At the same time, there were some noteworthy differences between them. For instance, the two NBFs differed with respect to the reputation of their founders and with respect to their (potential) business models. Arguably most important, however, UrGenT was founded at the beginning and CardioGenix was founded - not even three years later - at the peak of the (bio-/high-tech) boom. This apparently small difference initially seemed to profoundly influence the further development of the two ventures as it was associated with very different early resource endorsements. But, today, both ventures find themselves in surprisingly similar situations.

UrGenT, despite being a rather 'typical biotech venture' focussing on basic R&D and having no specific product idea, attracted some high-profile and experienced VCs. Those VCs not only provided sizeable initial funding but also made valuable non-monetary contributions to the company. This translated into UrGenT's impressive early growth. However, when the general market conditions deteriorated and when UrGenT did not meet one milestone, the VCs' behaviour changed dramatically. They pushed UrGenT into a high-risk strategy aimed at increasing its short-term value at the expense of its long-term sustainability. This strategy eventually failed and left UrGenT with little more than cash lasting for a few months (in fact, not long after our case study ended, UrGenT filed for bankruptcy).

In contrast, CardioGenix, despite its potential to become a 'fully integrated bio-pharmaceutical company' developing, manufacturing, and marketing products for which an initial 'proof-of-principle' already existed, only managed to attract low-profile VCs. Those VCs did provide neither sufficient funding nor the much-needed non-monetary support to realise CardioGenix' innovative but challenging business model. Instead, they urged the venture to pursue a typical biotech company strategy that promised a faster increase in its value. Although - given the circumstances - CardioGenix made impressive progress, tensions build up between the management team and its investors. But due to the market conditions new investors were not to be found. Therefore, CardioGenix never really got off the ground, and eventually ceased its activities.

Thus, the two cases provide several interesting insights, for instance, with view to the relative importance of VCs' non-/monetary contributions to the ventures' development, and with view to the interrelatedness of those contributions with the market/industry context.

I.IV.2. Discussion

Given that we have only conducted two case studies, and given that those cases were set in Germany, a country with an apparently distinct development regarding both its biotechnology and venture capital sectors, it is obvious that we cannot draw very far-reaching conclusions, and that we cannot generalize from our findings.

Nevertheless, as we will outline in the following, we believe that our cases provide several noteworthy insights with view to both our research question and extant research. Those insight, furthermore, also suggest some interesting avenues for future research.[314]

[314] Our cases clearly provide insights into many different aspects of entrepreneurship and entrepreneurial finance. For instance, they suggest that there are many more factors but venture capital with potential impact on the development of ventures, such as the appropriate business model, patent issues, internal relationships within the ventures' management teams, external alliances, governmental programs. However, in following, we concentrate only what was in the focus of our research (question): the impact of VCs (and their knowledge) on the development of entrepreneurial ventures, and the role of market- and industry-related aspects in this context.

I.IV.2.a) Findings in the light of the research question

With view to our research question, our case studies suggest that differently knowledgeable VCs can influence the development of early stage biotech ventures in several ways, and positively as well as negatively. However, our case studies also show that there is no – or not always a - simple relation between VCs' knowledge and VCs' influence on the development their investee ventures. Instead, what is really going on is more complex, and the actual impact of VCs' knowledge, seems inter-related with and moderated by contextual factors, such as the developments in the financial markets and in the ventures' industry.

For instance, our cases suggest that at least the knowledgeable VCs can actively, and positively, influence the development of their investee ventures. But our cases also suggest that, when the markets are bullish, at least some knowledgeable VCs follow hypes by investing substantial amounts even in high-risk venture without sound business strategy. In contrast, when the markets plummet, at least some knowledgeable VCs over-react and behave myopic, for instance, by demanding drastic strategic changes that intend to increase the short-term success potential of ventures whilst simultaneously putting their long-term survival at risk.

This partly complements and partly contradicts extant empirical and theoretical literature.

I.IV.2.b) Findings in the light of the literature

Empirical literature

By looking in more detail at 'what is really going on between VCs and ventures' than most extant empirical literature, our case study approach provides further support for some of the findings in the extant empirical literature, but it also help to explain some of the ambiguities and apparent contra-dictions in this literature.

To begin with, our cases provide clear support for the existing anecdotal and empirical evidence that VCs can and often do play a crucial role as financiers of entrepreneurial high-tech ventures (Gorman & Sahlman, 1989; Rosenstein et al., 1993). Although our case study ventures had received some governmental support, their highly uncertain business models would have hardly attracted further funding from other sources but VCs. As such, our cases corroborate Steier and Greenwood's (1995: 337) argument that 'penetrating the venture capital network is a significant first step in securing financial resources'.

Furthermore, our cases also support previous research suggesting that VCs' contribution to the development of entrepreneurial ventures can go far beyond the provision of capital and that VCs often get actively involved in the post-investment development of their investee ventures (e.g. Fried & Hisrich, 1995).

With view to the latter though, we have already outlined in our general literature review further above (Chapter C) that the extant empirical literature indicates a great deal of variance in the VCs' actual post-investment involvement – whilst providing no clear indication as to what determines this involvement and/or how this involvement is related to venture performance.

For instance, considerable extant literature explains the variance in VCs' involvement with differences in the risks or requirements of different ventures (Barney et al., 1989; Busenitz et al., 1997; Ehrlich et al., 1994; Gorman & Sahlman, 1989; Hellmann & Puri, 2002; Lerner, 1995; Morris et al., 2000; Sapienza & Gupta, 1994). Some other literature explains this variance with differences in the types or preferences of different VCs (Elango et al., 1995; Gorman & Sahlman, 1989; MacMillan et al., 1988, 1989).

At the same time, extant literature is ambiguous with view to whether, and if so, how differences in the intensity and type of VCs' post-investment involvement translate into differences in venture performance. For instance, with view to the intensity of VCs' involvement, some studies suggest a positive relation between the intensity of VCs involvement and investment performance (Fredriksen et al., 1997; Manigart & Vermeir, 1996; Ruhnka et al., 1992; Sapienza, 1992; VDI et al.'s, 2000); but other studies find no relation (MacMillan et al., 1989; Sapienza et al., 1996; Sweeting & Wong, 1997). Similarly, with view to the type of VCs' activities, some studies suggest a positive relation between some VC activities and performance of investment companies (e.g. Fried & Hisrich, 1995; Gomez-Mejia et al. 1990; MacMillan et al., 1989; Murray 1996; Sapienza, 1992; Sapienza & Timmons, 1989; Schefczyk & Gerpott, 2001); other studies don't find any relation (Barney et al., 1996; Busenitz et al., 2004; Fried & Hisrich, 1995; Rosenstein et al., 1989); and others studies again note that there might even be a negative relation between some VC activities and investment performance (Barney et al., 1996; Busenitz et al., 2004; Fried & Hisrich, 1995). Steier and Greenwood (1995), for instance, note that 'the operating logic of venture capital [...] may be incompatible with the needs of a start-up firm'.

With view to those apparent ambiguities, we have already argued throughout the previous chapters, that most extant literature has failed to account for differences in VCs knowledge (and/or used VC characteristics to differentiate between VCs, which are arguably inadequate to proxy for VCs' knowledge). Whilst some authors acknowledge that VCs' experience is likely to be of considerable importance for the outcome of their activities (Bygrave, 1987; Lerner, 1994; Sapienza & Timmons, 1989; Sapienza et al., 1996; Sorensen & Stuart, 2001) most studies simply imply that VCs have sufficient expertise to undertake their relevant functions. This is despite it seems plausible to assume that differences in VCs' knowledge could impact both the VCs' post-investment involvement and its impact on the development of investee ventures, and despite some, albeit very limited, extant research also points into this direction. Bottazzi et al. (2004), for instance, find that more specialized VC firms show a more active investment style, providing more governance and support to their portfolio ventures. Sapienza et al. (1996) furthermore, not only find that VCs with greater 'new venture experience' interact more frequently with their ventures but they also perceive (self-assessment) to add significantly more value to them than those VCs without such experience. Similarly, Busenitz et al. (2004) find a positive relation between the quality of strategic advise given by VCs to their ventures and the outcome of those ventures.

In this context, our cases - in contrast to most extant empirical research, but in line with our previous three chapters – further support the assertion that aspects of VCs' knowledge and VCs' investment approach are indeed closely interwoven and are likely to contribute jointly to the ventures' development. Specifically, our cases suggest that only some, knowledgeable, VCs are able – in principal - to add value to their ventures by getting actively (and constructively) involved, whilst other, ignorant, VCs are either not getting involved at all or not in a constructive way.

Whilst some authors acknowledge that VCs' experience is likely to be of considerable importance for the outcome of their activities (Bygrave, 1987; Lerner, 1994; Sapienza & Timmons, 1989; Sapienza et al., 1996; Sorensen & Stuart, 2001) most studies simply imply that VCs have sufficient expertise to undertake their relevant functions.

But equally important, our cases also show that the (potentially) positive impact of VCs' knowledge and active involvement on the ventures' development is, at least at times, (co-) determined/moderated by other, exogenous, factors such as the cyclical and sometimes erratic developments in the financial markets.

Here, much has already been written in the popular press about the recent 'Internet-Bubble' when many investors, including VCs, apparently suffered from an irrational exuberance' (Shiller, 1998). However, so far, only limited academic research has been dedicated to this period, and to the impact it had on the VC-venture relationship. The study by Valliere and Peterson (2004) presents one interesting exception though. From interviews with VCs that were actively investing in Internet ventures during the 'Bubble', these authors conclude that VCs' evaluation process is not always rational. Not too surprisingly, the authors emphasize the role of investors unfamiliar with the sector as an important underpinning of the Bubble and its burst. Interestingly though, Valliere and Peterson (2004) also note that whilst some of the more established VCs realized the high level of uncertainty, many of them believed that the 'rules of the investment game had changed'. As a consequence, the authors point out, some investors could be accused of having reacted irrationally to the potential for quick and easy financial gains; but many investors also appear to have tried making rationalized - although logically flawed – decisions.

As our cases suggest, similar might have also occurred in the context of biotechnology. Furthermore, our cases also show that the hype not only can affect VCs' investment criteria/valuations but also their investment approach/involvement. Even (UrGenT's) apparently knowledgeable VCs seemed to have followed the general 'genomics hype' being willing to invest substantial amounts into a venture without clear business idea/plan; but they also followed the general panic when the Bubble did burst - pushing the venture into a high-risk strategy – although, as experienced biotech investors, they could/could have known that ventures and their projects in this sector take time.

Thus, we feel, the greatest contribution of our study to the extant empirical literature is that it explicitly points out that the VC-entrepreneur relationship and the value added of VCs (and their knowledge) must not be studied in a vacuum. Contextual factors, such as changes in the markets and developments in the ventures' industry, clearly have a non-negligible impact and should be taken into account more diligently than was the case in most extant literature. Again, also this assertion is in line with Steier and Greenwood's (1995: 337) argument that 'the activities within the deal structuring and the post-investment stage are more dynamic and iterative than current models suggest'.

Theoretical literature

Building upon the above, our cases also could contribute to the theoretical oriented literature. For instance, when viewing our cases in light of the three main theoretical perspectives on the VC-venture relationship that have been outlined in Chapter C, we find support for some (aspects) of some theories but not others.

Our cases arguably provide the clearest support for the least commonly used theoretical perspective in the venture capital literature, the *resource-/knowledge-based perspective* (cf. Bygrave, 1987; Locket & Wright, 1999): differences in VCs' resources/capabilities certainly can play an important role for the development of their investee ventures. In this context, the VCs' financial resources are certainly of prime importance, but the role of their knowledge must not be neglected. With view the latter, furthermore, our cases also provide further insights regarding the unresolved question in the literature of whether VCs are mainly in the business of 'picking or building winners' (Baum & Silvermann, 2004). As is particularly evident with view to UrGenT's first financing round, at least some, knowledgeable VCs actively help building ventures that are not obvious 'safe bets', for instance, by contributing to the development of an organizational structure and by identifying suitable people to complement their team. In contrast, as can be seen throughout CardioGenix development, less knowledgeable VCs do/can not contribute much to their investee ventures' development beyond cash (if at all); and VCs' ignorance can present a serious obstacle to the realization of arguably valuable venture ideas.

Similarly, our cases also provide support for the *signaling perspective* that views VCs as intermediaries, who can send important signals to third parties (cf. Hsu, 2004; Manigart & Sapienza, 1999; Megginson & Weiss (1991; Stuart et al., 1999): VCs' reputation can make a vital difference when it comes to attracting additional staff, and particularly when it comes to attracting additional funding. However, in contrast to most extant literature that takes this perspective by emphasizing the importance of positive signals through VCs, our cases also show that VCs and their (lack of) reputation can send out negative signals to outsiders. For instance, UrGenT's crucial deal with a major pharmaceutical company arguably also fell through because of its VCs; and CardioGenix found it difficult to attract other investors because their existing VCs had no reputation and market presence. Thus, it seems equally possible that VCs help ventures overcome their 'liability of newness and smallness' as that VCs (without reputation) even increase venture's liability of newness.

Interestingly though, our cases only provide little support for the most commonly taken theoretical - *principal-agent* - *perspective* on the VC-entrepreneur relationship, or at least not for the way this perspective is commonly applied (cf. Admati & Pfleiderer, 1994; Amit et al., 1998; Arthurs & Busenitz, 2003; Barney et al., 1989; Barney et al., 1994; Barry et al., 1990; Fiet et al., 1997; Gompers, 1995; Hellmann, 1998; Kaplan & Strömberg, 2001/2/3). Specifically, in case of our ventures, there seems only little reason for the VCs to worry about moral hazards or hidden actions on the entrepreneurs' part. Quite contrary, our cases suggest that if there are principal-agent problems at all, the roles of those involved might be opposite to what is suggested by most literature. For instance, CardioGenix' management team was actively seeking the involvement of its VCs in the planning and management of the business; but those VCs were unable and/or unwilling to provide the relevant support to realise the venture's apparent potential. On the other hand, in case of UrGenT, the second round VCs pushed the venture into a high-risk strategy aimed at increasing its short-term value whilst threatening its long-term success.

However, in this context, our cases could lend some support to a very limited number of recent studies that emphasizes the importance of trust and 'procedural justice' in the VC-entrepreneur relationship (cf. Busenitz et al., 1997, 2004; Sapienza & Korsgaard, 1996; Sapienza et al., 2000). In fact, both cases provide evidence that as long as the ventures' management felt treated fairly, they were happy to confirm with VCs requirements. This changed however, to some extent, when the VCs' requirements seemed too get too harsh, and when the management felt to be put on a very short leash. So, if anything, our cases point towards a situation of double-sided moral hazards in the VC-entrepreneur relationship (cf. Casamatta, 2000; Inderest & Mueller, 2001; Repullo & Suarez, 1998).

Furthermore, with view to the principal agent perspective in the venture capital literature, it must also be mentioned that most extant work focuses on the principal agent relationships between either the VCs and the investee companies or the VCs and their investors (or the financial markets in general). But virtually no study looks at the interaction between these two pairs (Barry, 1994), and how this maps into the final outcome for those companies.

In this context, our cases address two important relations that have been much neglected in the literature. Firstly, they address the relation between VCs' expertise and its impact on VCs' activities. Secondly, they address the relation between the markets and VCs' activities. And finally our cases suggest that those relations interact in quite a complex manner and this interaction impacts on the performance of investee companies.

I.IV.2.c) Conclusion

Summarizing the above, and consistent with the intent of grounded theory, we suggest the following general proposition as a stimulus for further research:

There can be a positive relation between VC knowledge and venture performance, but this relation is moderated by market- and industry-related factors.

To examine this proposition, and to ascertain how far the themes developed in this chapter have wider generalizability, further empirical work clearly is needed. This might involve larger samples as well as comparisons across industries and regions.

Furthermore, we feel that more work is also needed on a theoretical level. The above-mentioned theoretical perspectives in the extant literature on venture capital look at the VC-entrepreneur relationship as if it was set in a vacuum. But, as our cases show, this doesn't do justice to the complexity found in practice, where the VC-entrepreneur relationship and the value added even of knowledgeable VCs, at least at times, seem strongly influenced by (changes in) contextual factors. Thus, there is certainly a need for more encompassing theoretical perspectives than have been used for in most research on venture capital so far.

Finally, it should be mentioned that our cases also raise further questions that haven't been in the immediate focus of our current research. For instance, assuming that our conclusion from the cases indeed has some more general validity, one might wonder whether venture capital really is the most suitable source of funding when it comes to developing high-tech/-risk ventures or whole industries that involve long gestation periods and, consequently, require a long time-horizon and a favourable attitude towards risk also from their investors. The markets are known to be erratic, but if even apparently knowledgeable VCs at times behave irrational, they might not present the sort of reliable 'intermediary' they claim to be. As a consequence, one might ask, for instance, whether there are any better sources of funding available, and what improved role the government could play in this context.

CHAPTER J: SYNTHESIS

This final chapter provides a broader, but also more integrated, perspective on the insights gained from the previous chapters, including their main findings, implications, limitations and directions for future research.[315]

J.I. Main findings

In this section we highlight the main findings from our large sample analyses and the case studies by first summarizing the findings from the large sample analyses and then interpreting the cases studies in the light of those findings. This enables us to put some 'meat on the bones' of the large sample findings.

J.I.1. Findings from the large sample analyses

In our large sample analyses, we found overall support for the three research hypotheses: VCs' level and type of knowledge does indeed play a role with view to both VCs' investment approach (as regards 'syndication' and 'staging') and the performance of VCs' investments. Table J-1 shows the predicted signs and outcomes for our theoretical variables in the three hypotheses.[316]

Table J-1: Summary of main findings from large sample analyses

*['(+/-)': (non-) sig. pos./neg. relation; ' * * *'/' * *'/" *': p<.01/.05/.10; 'n.a.': not tested]*

Hypothesis [Dep. Variable] / Theoretical variable	Investment approach				Venture performance	
	H1. [Syndication y/n]		H2. [Round-length]		H3. [IPO y/n]	
	Relation		Relation		Relation	
	pre-dicted	found	pre-dicted	found	pre-dicted	found
[Lead] VC age	-	- *	-/+	(-)	+	(+)
[Lead] VC non-biotech exp.	-	- * * *	-/+	(-)	+	(+)
[Lead] VC total experience	-	- * * *	-/+	(-)	+	(+)
[Lead] VC biotech expertise	-	- * * *	-/+	- * * *	+	+ *
[Lead] VC biotech-stage exp.	-	- * * *	-/+	- * * *	+	+ * *
[Lead] VC biotech-sector exp.	n.a.	n.a.	n.a.	n.a.	+	+ * *
Syndicate age	n.a.	n.a.	-/+	(-)	+	(-)
Syndicate non-biotech exp.	n.a.	n.a.	-/+	- * *	+	(+)
Syndicate total experience	n.a.	n.a.	-/+	- * *	+	(+)
Syndicate biotech expertise	n.a.	n.a.	-/+	- * * *	+	(+)
Syndicate biotech-stage exp.	n.a.	n.a.	-/+	- * * *	+	(+)
Syndicate biotech-sector exp.	n.a.	n.a.	n.a	n.a.	+	+ * *

[315] As in the previous chapters, unless specified further, the term 'VC' refers to both individual (lead) VCs and syndicates.

[316] Table J-1 only shows the results of our *main* analyses, and only for the main parts of our hypotheses. For more details, it should be referred to the individual Chapters F, G, and H.

At the same time, the large sample analyses also show that factors *other* than VCs' knowledge often are similarly or even stronger related to the VCs' investment approach and the performance of VCs' investments.

Therefore, in what follows, for each examined research hypothesis, we first summarize our findings with a view to the role of VCs' knowledge, and then with a view to the role of those other factors.

J.I.1.a) Investment approach

Whilst we assumed that VCs' knowledge is related to all features of their investment approach, given the scope of our project and the nature of the data available, we chose to explore two particular features, the syndication and staging of investments. They were interesting for our research because a) they are widely considered to be very characteristic for the VCs' investment approach, and b) one of them, syndication, offered itself for a study of the role of the individual VCs' knowledge, whilst the other, staging, allowed studying and comparing the knowledge of both lead VCs and syndicates overall. Our findings from these two analyses are restated next.

J.I.1.a.i. Syndication

The role of VCs knowledge

With view to the relationship between VCs' knowledge and VCs' propensity to syndicate, we found the expected negative relationship for all knowledge proxies employed, and we also found that the relationship was stronger the better matched the VCs' knowledge was to the venture under consideration.

These findings supported our assertion that, for their syndication decision, VCs carefully weigh the potential benefits and costs associated with syndication. The more knowledgeable VCs are with respect to a particular investment opportunity, the more confident they are in their pre-investment assessment and/or in their ability to ensure the success of their investment by conducting post-investment activities alone. By making a lone investment they also get a larger share of any profits arising from it. Consequently, more experienced VCs should be less inclined to incur the possible costs and risks of syndication.

Thus, our findings were also consistent with the resource-based theory of syndication as a means by which VCs get access to missing and/or complementary intangible resources.

However, whilst our findings provided clear support for our hypotheses we noted that VCs' knowledge only accounted for a relatively small proportion of the variability in syndication activity, and was not the dominant predictor of the odds of syndication for a particular investment. A number of other factors serving as control variables in the analysis were found to be more powerfully related to VCs' propensity to syndicate including financial and macro elements. These factors had been identified as important in other theories of syndication available in the literature.

The role of other factors

With view to the relation between other factors but VCs' knowledge and syndication, our findings indicate that *financial factors* in fact have the greatest predictive power regarding the VCs' decision to syndicate: the greater the 'deal size' (in absolute or relative terms), the greater a VC's propensity to syndicate. This offered, we argued, clear support for the widespread assertion that monetary issues – such as overcoming resources constraints and/or spreading financial risk - are central to the VCs' decision to syndicate.

But also several other, *venture-related factors* likely to be associated with a VC's perception of the inherent riskiness of an opportunity – such as whether the 'investment was at an early stage' or if it was the 'first investment by a VC in this venture' – were positively related to the VC's propensity to syndicate. This suggested that VCs use syndication to share the risk and/or to get second opinions in those cases that are difficult to evaluate or where access to complementary (non-monetary) resources for the management of those investments is difficult to obtain.

Here, however, it was more difficult to explain our finding that 'first rounds' were less likely to be syndicated than later rounds. This seemed counter-intuitive because one would assume first rounds would be perceived as particularly risky and this would increase the VC's likelihood of syndication. Several possible explanations for this counter-intuitive finding were offered, such as that first rounds are much smaller than later rounds (thus reducing the financial motive for syndication), or that VCs might want to get a first mover advantage by investing alone and early in the venture's life.

Finally, it was also evident in the large sample analysis that *context-related factors* played a powerful role in the VCs' decision to syndicate. Specifically, the 'growth in the number of biotech ventures receiving venture capital', as a potential proxy for the market 'hotness' of the biotech sector, was found to be positively related to syndication; whilst the dummy variable for the 'boom years 1996-2000', as a potential proxy for the 'overheating' of the venture capital sector, was negatively related to the VCs' propensity to syndicate. One may associate the latter half of the 1990s with excessive greed amongst VCs with an accompanying reduction in risk aversion and prudence, both of which might have encouraged them to syndicate (share) less with their colleagues despite the potential advantages of so doing.

J.I.1.a.ii. Staging

The role of VCs knowledge

With view to the relation between VCs' knowledge and round-length ('staging') we found a negative relationship for all knowledge proxies, this relationship being stronger the better matched the VCs' knowledge was to the venture under consideration.

Here, we felt it was impossible to predict a priori the sign of the relationship between VCs' knowledge and round-length, as arguments could be adduced for both positive and negative signed relationships: more knowledgeable VCs might be either more confident in their pre-investment decisions thus resulting in longer rounds, or they might be more aware of the unavoidable risks, thus resulting in shorter rounds.

Given the negative relationship we found in the data between round-length and expertise, this finding suggested that more knowledgeable VCs are indeed more aware of the unpredictable risks associated with entrepreneurial ventures, particularly in high-tech sectors such as biotechnology, and as a result they use a conscious strategy of shorter round-length to deal with it – despite the greater administrative costs involved with this strategy.

At the same time, we found no support for the hypothesis that the relationship between VCs' knowledge and round-length should be more pronounced for lead VCs' knowledge than for syndicates' average knowledge. If anything, the opposite seemed to be the case. This suggested that in syndicates it is not just the lead VC that determines important decisions but the syndicate members jointly.

Finally, whilst our findings provided clear support for the main part of our Hypothesis with respect to the theoretical variables, VCs' knowledge once more did not explain a high proportion of the variability in the round-lengths found in practice; several other factors were found to have a similar or even greater explanatory power in this context.

The role of other factors

With view to the relation between other factors but VCs' knowledge and round-length, the *deal size* was found to be as strongly correlated with round-length as the VCs' knowledge, although with the opposite (i.e. positive) sign.

Furthermore, as with syndication, we again obtained the seemingly counter-intuitive finding that 'first rounds' were much longer than later rounds. One plausible explanation for this finding offered was that first rounds, especially in biotechnology, often involve early stage projects that have comparatively small cash-burn rates whilst at the same time being unlikely to result in early information to VCs that would allow them to get a better estimate of the venture's ultimate success ('good science takes time'). Yet again, the fact that first rounds were found to be longer than later rounds, controlling for deal size, venture age and development stage seemed to contradict this interpretation.

In this context, our findings suggested another possible explanation for the 'unexpected' length of first rounds. Specifically, it was found that the knowledge of first round VCs was substantially smaller than that of later round VCs. As such, one might speculate that first round VCs are simply too ignorant to appropriately deal with the particular risks of first round investments and to realise the (option) value of having shorter rounds.

Another interesting finding concerned the fact that 'syndicated rounds' were significantly longer, controlling for the deal size. Combining this with our insights from the previous section on the relation between VCs' knowledge and syndication, this suggested that more knowledgeable VCs tend not to syndicate and to have shorter rounds. Their less knowledgeable peers, by contrast, tend to syndicate, which in turn results in longer rounds. This, it was argued, could also have implications for the ultimate performance of ventures backed by ignorant VCs, since longer rounds possibly mean less control (we shall come back to this issue below in the 'conclusion' section).

Finally, also macro context factors were significantly related to round-length. Specifically, the larger the 'annual change in venture capital raised' the longer was the round-length. During the 'boom years 1996-2000' however, rounds-lengths were shortening. One explanation for this could be that, in general, larger inflows of funds into the venture capital sector result in longer rounds because VCs try to benefit from economies of scale, investing larger - and longer-lasting - amounts per deal. But when the venture capital sector really 'overheats', as during the boom from 1996 to 2000, the positive effect of larger investments on round-length might be 'overcompensated' by the VCs' desire to make use of their investors' funds by investing (more and) more frequently in their ventures.

J.I.1.b) Venture performance

Venture performance may be measured in many different ways. However, given both the nature of our data and the fact that one cornerstone in the successful development of biotech ventures is widely considered to be the achievement of an IPO, we used the probability of reaching an IPO as our key measure of venture performance.

This is in line with much previous literature that also focussed on the IPO event, but it is different from this literature in that most previous studies exclusively focussed on those ventures that ultimately made it to an IPO and then analysed, for instance, their time-to-IPO or their post-IPO performance.

Whilst we argued that our main performance measure was more adequate than those used by most previous literature, to compare our findings with those of the extant literature, we additionally analysed the time-to-IPO of our sample ventures.

The role of VCs knowledge

With view to the relation between VCs' knowledge and venture IPO performance we found the expected positive relationship for all examined knowledge proxies, with one exception, the standard measure of experience used in the literature, the (average) age of syndicate VCs. This proxy was negatively related to venture performance.

As predicted, we also found that this relation was the stronger the better matched the VCs' knowledge was to the particular venture under consideration: only (some of) the proxies for the VCs' specific biotech expertise were significantly related to venture performance, but none of the proxies for VCs' general experience.

In addition, we found support for the claim that the average knowledge of all lead VCs in the history of a venture should be more closely related to venture performance than the average knowledge of all syndicates. We interpreted this as support for our assertion that it should be the lead VC, the main point of contact with the venture, whose knowledge should be most relevant to its successful development.

However, we found no support for the idea that the knowledge of VCs investing in a venture's first round is more strongly related to the ventures' performance than the knowledge of the VCs in later rounds. If anything, the opposite was found to be the case. This finding is itself quite interesting, as it may provide support for the widely held assumption that VCs not only 'pick' successful ventures, but also 'build' them by providing value-added monitoring and support.

At the same time it should be kept in mind that the knowledge of VCs investing in first rounds is much lower than that of VCs investing in later rounds.

It is worth mentioning, that we obtained qualitatively similar results regardless of whether we used the ventures' likelihood to go public or their time-to-IPO (in additional Cox regressions analyses, the results of which are not shown in Table J-1), suggesting that the VCs' knowledge not only is related to ventures experiencing an IPO in the first place but also to experiencing this IPO faster.

However, once again, whilst our findings provided clear support for our hypotheses, we found VCs' knowledge to explain only a small proportion of the variability in the performance of VC-backed ventures, and other factors again seemed to be at least of equal importance, giving some weight to complementary theories of finance and macro effects.

The role of other factors

With view to other factors but VCs' knowledge, it is particularly noteworthy that neither the 'amount invested in the first round' nor the 'cumulative amount invested in a venture' was related to the venture's likelihood of an IPO. Combining this with our finding that the VCs' knowledge has an impact on venture performance, this further supports the industry adage that 'it is not so important how much money you get but from whom the money comes'.

Another interesting observation in our analysis of venture performance concerns the fact 'syndication' and 'round-length', which were the dependent variables in our previous two sections, turned out to be negatively correlated with the ventures' likelihood of an IPO. We will have course to revisit this finding in our 'conclusion' section below.

Finally, it should also be mentioned that contextual factors, and here particularly the 'annual change in the number of biotech IPOs', had a significant positive impact on the venture's likelihood of going public. This supports the general belief that the 'window of opportunity' plays an important role for ventures' IPOs – and for studies using the IPO event as a measure for venture performance.

J.I.1.c) Conclusion

In sum, from the above described findings there is little doubt that VCs' level of knowledge is related to both VCs' investment approach and the performance of their investments.

Furthermore, it is also evident that there are considerable differences between different types of knowledge. Some of the knowledge proxies suggested by previous studies, such as the VCs' age or total experience (total number of previous investments) show, if at all, a much weaker relation to the relevant dependent variables than the 'better matched' knowledge proxies suggested by us.

In addition, we find that it makes sense to differentiate between the lead VCs' knowledge and the average syndicates' knowledge more carefully than this was done in most previous literature.

Finally, we find some interesting relationships not only with view to our theoretical and dependent variables but also with view to our control variables - which might help to throw some light on other theories of, for example, syndication, control, and success.

In this context, Figure J-1 illustrates, in a combined form, our findings from the main analyses of our three hypotheses (H1-3) regarding the relations between the theoretical variable (VC knowledge) and those variables that are the dependent variables in some hypotheses and control variables in others.

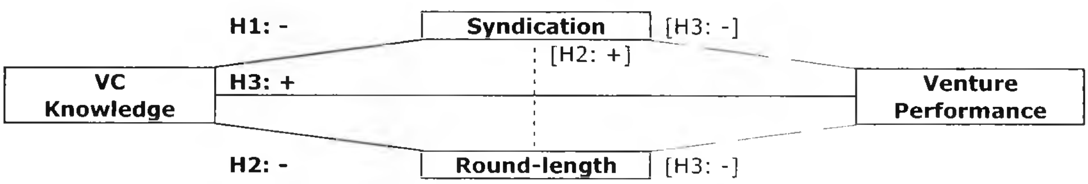

Figure J-1: Relationships between main theoretical and dependent [control] variables
['+/-': significant positive/negative relation; '[]' and 'dashed lines': control variable]

With view to Figure J-1 it is essential to emphasize that – because we use different units of analysis and different samples for the examination of our three hypotheses - it is impossible to draw definite conclusions regarding the actual relationships between the variables across different hypotheses.

For example, in our examination of Hypothesis 3, we only control syndication and round-length in the first rounds of ventures – which, as discussed above, are different from later rounds, for instance, in that they are less often syndicated and longer.

The relations depicted in Figure J-1 have therefore to be interpreted with caution. Nevertheless, we feel that Figure J-1 provides a possible framework to contextualise our findings and to help direct future research in this area.

To begin with, it is plausible to argue that there exists a *direct* relation between VCs' knowledge and venture performance (H3). This could be due, for instance, to more knowledgeable VCs being simply more capable of 'picking winners' pre-investment.

At the same time, from our findings, we also know that VCs' knowledge is related to certain aspects of their post-investment activities (for instance, more knowledgeable VCs are less likely to syndicate and they prefer shorter rounds (H1 and H2)).

Furthermore, with view to our control variables, it seems that those post-investment activities are related not only to each other (e.g. H2: syndicated rounds are longer) but also to venture performance (e.g. H3: syndicated rounds and longer first rounds are associated with a lower chance of an IPO).

Thus, one might further argue that there is not only a direct relation between VCs' knowledge and venture performance but that there could also be an *indirect* relation, in which VCs' knowledge impacts several features of the VCs' post-investment activities, which, in turn, are related both to each other and to venture performance.

From this, one might finally speculate further in two directions.

Firstly, because more knowledgeable VCs tend to invest alone, only 'ignorant' VCs will tend to syndicate with each other. However, ignorant VCs are less aware of the risks associated with investing in biotech ventures, and therefore tend to have longer rounds (this saves them the administrative costs of frequent due diligence audits at each new round). But this 'negligence', in turn, could mean that novice VCs monitor their investments less closely than their more knowledgeable peers, ultimately resulting in an inferior performance of their investments. Alternatively, if there is no causal relationship between round-length and venture performance, it could simply mean that ignorant VCs get it wrong from the beginning. This is, they may make the wrong pre-investment decision in the first place by investing in low-quality ventures. The longer round-length then could occur by 'coincidence' (i.e. it could be an indicator of ignorant VCs without having a causal relation to the investment performance).

Secondly, if VCs' knowledge translates into different post-investment approaches, such as with view to the staging of investments, this suggests that their knowledge is important not only for 'picking winners' but also for 'building winners' (for instance, by closely monitoring their progress). Whilst we acknowledge that, from our large sample approach, it is impossible to draw any definite conclusions in this context, we also note that our additional finding (in H3) - that VCs' knowledge in later rounds (versus first rounds) is more strongly related to venture performance - could provide further support for this assertion.

However, it is also important to note that – as outlined before – many other (control) variables, which are not depicted in Figure J-1, are of relevance with view to the above-mentioned relationships. The impact of these other factors varies depending on the specific relation one looks at; and for some factors, the impact also varies over time. Furthermore, it is also likely that there are various feedback loops in operation, such as between venture performance and VCs' post-investment activities.

Thus, overall, it is obvious that there exists a complex network of relations between VC-related factors (including VCs' knowledge, VCs' (post-) investment activities), venture-related factors (including round number, development stage, and performance), and context-related factors (including developments in the ventures' industry and the financial markets).

As such, in a more complete analysis, one might model this interdependence econometrically.

However, it is also likely that large sample approaches trying to model those relations, at best, can only begin to shed light on them. This is why we additionally conducted some case studies that also intended to complement our findings from the large sample analyses.

J.I.2. Findings from the case studies

In contrast to our large sample examination of the first three hypotheses, which – due to the nature of our data – took a 'black box' approach, our case studies provide a 'richer picture' of 'what is really going on' in the relationship between VCs and ventures, and of the factors influencing this relationship and its outcome.

Therefore, in this section, we subsequently look at what the cases can tell us with view to the syndication, staging and performance of VCs investments – regarding both VCs' knowledge and other factors of relevance.

However, at this point, it should be emphasized that our cases did not focus specifically/exclusively on the three aspects examined on the large sample, and *their main value is that they provide a broader perspective. Therefore, it is not always possible to directly compare the findings from the two approaches. Furthermore, it would obviously be inappropriate to draw general conclusions from just two cases, particularly when they involve ventures located in a country with a very young venture capital and biotechnology industry.*

Thus, the following sections merely present an attempt to relate some of the findings from the cases to those of the large sample analyses where possible, and most of the statements made in this context should be understood as suggestive rather than definitive 'conclusions'.

With view to the key issues of this study, the relation between VCs' knowledge and VCs' investment approach and performance of VCs' investments, our case studies can be viewed as providing support for some of our findings from the large sample analyses, but not for others. At the same time, the cases also demonstrate that many factors other than VCs' knowledge are of relevance (and sometimes greater relevance) to explaining approach and performance.

J.I.2.a) Investment approach

With view to the relation between VCs' knowledge and VCs' investment approach, our cases indicate that VCs' knowledge, or the lack thereof, can indeed influence the VC's investment approach overall. For instance, generally speaking, more knowledgeable VCs seem to be more actively involved in the post-investment development of their ventures than their ignorant peers.[317] But, at the same time, both cases also show that VCs, regardless of their knowledge, can alter or 'interfere with' the strategic direction of their investee ventures.

However, with view to the relation between VCs' knowledge and the two specific features of the VCs' investment approach that have been in the focus of our large sample research, syndication and staging, our cases at best (can) only provide limited support for the findings there, although they provide additional insights in this context.

[317] This is particularly obvious in case of UrGenT's first round, where the very experienced lead VC helps in developing the organizational structure, in financial matters, and in finding new staff to complement the management team.

J.I.2.a.i. Syndication

The role of VCs knowledge

Our cases do not throw further light on the proposition that more knowledgeable VCs with a better match between experience and the current opportunity are less likely to syndicate. Instead, they suggest that if VCs know each other, and particularly if they have already good experience in syndicating together, the chances of syndicating the current deal are higher.[318] In other words, past syndication increases the chances of future syndication. Thus, VCs' knowledge – particularly in terms of 'being known' – might even be positively related to VCs' propensity to syndicate, but the influence may be syndicate-specific.

At the same time however, the cases suggest other factors that might influence the composition of the syndicate.

The role of other factors

One unique insight from our cases revolves around the fact that it is not always the VCs who decide about the composition of the syndicate. Instead, at least during boom periods, the ventures themselves can clearly have a say in syndicate membership, i.e. in what particular investors they want to have. Then, even experienced VCs might be willing to form/join a syndicate.[319] Outside boom periods, the situation may be quite different: ventures may have little choice but to take whatever investment they can get.

Furthermore, the cases also show that VCs from previous rounds often stay on board and bring in new VCs, either because of financial constraints, or because of a need for risk reduction. In these circumstances, it may be a choice between whether a VC joins an existing a syndicate or will turn down the investment opportunity altogether. In this situation, one might expect even a knowledgeable VC to be willing to (join a) syndicate if they believe in the investment's potential.

Both above-mentioned factors might help to explain why we only find a relatively weak negative relation between VCs' knowledge and their propensity to

[318] In fact, according to the interviewed lead VCs, it was less important whether or not their syndicate partner had particular expertise in the same type of venture as the one under consideration now. Instead, they were more interested in general acquaintance with the other VC and/or in his overall reputation.

[319] For instance, in UrGenT's first round, which occurred at the peak of the boom 'when investors were 'queuing up', it was the venture that decided who should be in the syndicate (although the non-lead syndicate members had been suggested by the lead VC)

syndicate in our large sample analysis. Although knowledgeable VCs, on average, might be less inclined to syndicate, there will be many situations where they simply 'have no choice'.

J.I.2.a.ii. Staging

The role of VCs knowledge

With respect to the relationship between VCs' knowledge and round-length, our cases provide no additional support for the finding from the large sample analysis that more knowledgeable VCs and those with experience better matched to the current opportunity have shorted round-lengths.

Instead, the cases suggest that the round-length in fact is a product of many different factors many of which we were unable to control for in the large sample work.

The role of other factors

As already with syndication, our cases suggest that round-length is not always determined by VCs (and their knowledge). Specifically, at least in boom times, a venture apparently can be in such a strong negotiating position that it can determine (at least substantially) the amount of funds that will be invested by VCs, and consequently, other things equal, how much time they have before they approach investors again for a new 'injection' of money.[320] Outside these boom periods, as we saw with syndication, the power then lies with the investors who decide how much money the ventures receive, and consequently also how long the round will 'last'.

Furthermore, our cases also provide further insights into the – weaker than expected - positive relation between the deal size and the round-length found in the large sample analysis. As it seems, larger deal sizes do not proportionally translate into longer rounds because of different cash burn rates associated, for instance, with different numbers of employees. This is shown in Table J-2, which schematises the round characteristics of the two case study ventures.

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[320] For instance, during UrGenT's first round, when there was an opportunity to get considerable larger funds even from very experienced VCs, its team felt that there was 'no real need to give away too much equity'.

Table J-2: Round characteristics of case study ventures

	UrGenT	CardioGenix
Seed round		
Deal size [€Mio]	1.0	0.3
Duration [yrs.]	2.5	1.5
Cash burn rate [€Mio/yrs.]	0.4	0.2
Employees at end of round	12	3
First round		
Deal size [€Mio]	5.0	0.3
Duration [yrs.]	2.0	1.5
Cash burn rate [€Mio/yrs.]	2.5	0.2
Employees at end of round	30	5
Second round		
Deal size [€Mio]	15	1.5
Duration [yrs.]	2.0	1.5
Cash burn rate [€Mio/yrs.]	7.5	1.0
Employees at end of round	60	9

In this context, it should also be recalled that, in our large sample analysis, we argued that more knowledgeable VCs prefer shorter rounds, other things held constant. Here, the case studies show that the more knowledgeable VCs (of UrGenT) chose to invest a larger amount, lasting for a longer time, than the less knowledgeable VCs (of CardioGenix). In other words, the effect of amount and experience work in opposite directions, and the effect of round amount seems to have outweighed that of experience. The dates of the financing rounds were also different: UrGenT's rounds occurred more at the peak of the boom (when money was plentiful) whilst CardioGenix' rounds occurred at the end of the boom (when money was getting scarce).

An additionally important insight from the cases concerns the importance of *interim* (i.e. intra-round) monitoring and control by the VCs. Whilst in our chapter on staging the focus was mainly on the control exercised by the VCs in the form of staging (inter-round investment), VCs' actual intensity of control can vary without necessarily influencing the round-length.[321] Although this does not contradict the potential importance of staging (and round-length) as a control mechanism, it is important to keep in mind that VCs also have other control means but staging.

Finally, an singularly important aspect of funding that emerges from the case study analysis is that the amount VCs are willing to invest in a venture is also influenced by the funds available to the VC from their own investors, which, in turn, is also a function of the general conditions in the markets prior to the

[321] Again it should be referred to UrGenT's second round that lasted about as long as its first round, although 'all investors required more influence, for instance, in form of more rigorous reporting and regular management appraisal'.

investment under consideration.[322] We were not able to control adequately for this feature of the investment decision in the large sample analysis and we see this as providing a useful starting point for future research in the area.

J.I.2.b) Venture performance

Although neither of our two case ventures made it to IPO (the key measure of venture performance in our large sample analysis), our case studies provide valuable insights into the reasons for failure, in particular because they look in more detail at those factors and events in the early development (or: performance) that lead ultimately to failure.

This is quite different from most other research in venture capital and entrepreneurship, which commonly tries to identify factors and events contributing to the ventures' success, not failure.

The role of VCs knowledge

As regards the relationship between VCs' knowledge and venture performance, our cases complement the findings from the large sample analysis in several ways. To illustrate this, in the following, we look at the cases with view to the various parts of our Hypothesis 3 in the large sample analysis.

- *Overall relation between VCs knowledge and venture performance*

Notwithstanding the fact that VCs' overall *level* of knowledge obviously does not guarantee a venture's ultimate success, our cases indicate that VCs' knowledge, or the lack thereof, may be related to ventures' early development and performance.[323]

However, our cases also indicate that there is no straightforward explanation for the (causal) relation between VCs' knowledge and venture performance. As we have already noted several times above, VCs' knowledge could be related to venture performance because more knowledgeable VCs are particularly good in identifying the most promising investment opportunities pre-investment ('picking

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[322] Also in this context UrGenT's second round provides a good example in that its investors agreed to provide a substantial amount (also) because they 'had to find investment opportunities for the funds drawn from their investors during the boom period – and UrGenT clearly was one of the most 'mature' opportunities in the German life-science sector in those days

[323] Obviously, this statement only refers to the early stage development/performance of the ventures. If one takes the IPO event as the ultimate performance measure, one will come to a different conclusion from our cases – namely, that there is no relation between VCs' knowledge and venture performance.

winners') and/or in supporting the successful development of their investee ventures post-investment ('building winners'); and our cases could provide support for both arguments.

With view to 'picking winners' argument the support is less obvious. On the one hand, it seems that all VCs in our cases, knowledgeable or ignorant, 'identified' and invested in opportunities that had great potential (i.e. could potentially be 'winners') but that ultimately failed despite this fact.[324] This might suggest no relation between VCs' knowledge and 'picking winners'. But our cases suggest at least an indirect relation by showing that ventures, when looking for funding, try to approach the most well known - and arguably most knowledgeable - VCs first. Furthermore, as mentioned above (see 'syndication') those VCs might also be invited more frequently to join a syndicate. From this one might conclude that more knowledgeable (or, at least, more well-known) VCs have better access to more – and more promising – investment opportunities. This could ultimately translate into better performance of those ventures backed by more knowledgeable VCs. However, perhaps the main insight gained from the cases in this context is that selection is not a one-way street: it is not simply a matter of VCs selecting ventures, but also the other way round, of ventures selecting VCs. And the cases show that the relative importance of the two actors in the selection process may itself be a function of the state of the capital markets.

With view to 'building winners', our cases demonstrate the impact of VCs' knowledge more visibly. Specifically, the cases suggest that more knowledgeable VCs may become more – and more constructively - involved in the post-investment development of their investee ventures than their less knowledgeable peers.[325] For example, it is obvious from the cases that the venture with the more knowledgeable VCs (UrGenT) developed much faster than the venture with the less knowledgeable VCs (CardioGenix) - at least in terms of its size/staff (see also Table J-2 above). Again, this is likely to translate ultimately into a better performance of ventures backed by more knowledgeable VCs.

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[324] In fact, even from hindsight, not only the interviewed entrepreneurs but also the VCs stated that they believed that both ventures - in principal - had great potential, and that they failed not merely because there was anything inherently wrong with them but much rather because of the 'circumstances'.

[325] This is particularly evident with respect to UrGenT's seed and first-round investors, which - according to the venture's team – provided very valuable non-monetary support to the venture's development.

Thus, generally speaking, our cases could be understood as providing at least some support for our finding from the large sample analysis that there is a positive relation between VCs' level of knowledge and ventures' performance, at least in their early stages. Furthermore, the cases also indicate that this positive relation can be due not only to the VCs' 'picking winners', but also to ventures 'picking the right VCs' and the VCs 'building winners'.

But, at the same time, our cases also complement the large sample analysis by providing evidence that lack of experience among investors can seriously hamper the successful development of a promising venture.[326]

- *General experience versus specific expertise*

Another interesting facet of the impact of VCs' knowledge concerns the second main finding from our large sample analysis of Hypothesis 3, namely, on the relation between the *type* of VCs' knowledge and a venture's performance, where we found experience matched at industry level with the investment under consideration was superior to general experience in generating project success. Here, our cases provide a more ambiguous picture than that suggested by the large sample analysis.

Specifically, our cases suggest that not only a VC's industry-specific expertise but also his more general experience might enhance the ventures' development and performance. General experience might be relevant, for instance, because VCs with more general experience or 'reputation' have a better 'deal flow', namely, one including more high-quality investment opportunities. Furthermore, it could also be relevant because science-based entrepreneurial teams are likely to have particular deficits with respect to more general business- and finance-related matters, which VCs with general experience might help to overcome. However, our cases also show that VCs' industry-specific expertise may be highly valuable, at least for some ventures.[327]/[328]

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[326] For instance, CardioGenix' inexperienced VCs weren't interested at all in the venture's potential of becoming a bio-pharmaceutical company developing and manufacturing customized drugs (although several more experienced VCs initially showed considerable interest in this idea and argued that they would be able to realize it). Instead, their view was that the company's focus should be on developing one candidate with the potential to become an 'off-the-shelf' drug, i.e. on becoming a 'traditional' biotech venture.

[327] UrGenT's team, for instance, perceived its incubator's 'scientific' input regarding the development of a research strategy and the identification of additional research staff as very helpful. But it also claimed to have benefited considerably from the incubator's seminars on managerial, financial, and

Thus, with view to the type of VCs' knowledge, our cases rather suggest that the relative importance of the particular type of VCs' knowledge varies both across ventures and for the same venture across stages of development.

- *Lead VC's versus syndicate's knowledge*

Yet another finding from our large sample analysis concerns the role of the lead VCs' knowledge versus the syndicates' knowledge for venture performance. Here, we found that the positive impact of VCs' knowledge on venture performance was more pronounced for that of the lead VC than that of the syndicate. This finds some support in our cases, which indicate that lead VCs are indeed the main point of contact between the syndicate and the venture, and therefore are likely to have the largest impact on ventures' development.[329]/[330]

- *First versus later round VCs' knowledge*

The last aspect of the relation between VCs' knowledge and venture performance dealt with in our large sample analysis concerned the role of VCs' knowledge at first rounds versus that at later rounds.

Here, in the large sample analysis, we found no clear indication as to whether first or later round VC knowledge, should be more important for venture performance. But we concluded - contrary to our hypothesis - that, if anything,

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legal issues. Similarly, the team also perceived its first round VCs' input regarding the development of an organizational structure and the identification of an apparently suitable CFO as very valuable.

[328] CardioGenix' team, on the other hand, was mainly hoping for its VCs to provide very industry-specific support, such as with view to the development of a suitable business plan for a rather unique bio-pharmaceutical company.

[329] The positive role of the lead VC is evident, for instance, with view to UrGenT's first round lead VC who substantially contributed to the ventures development. But the importance of the lead VC is also evident in case of CardioGenix second round: when the lead VC's investment manager, who was responsible for CardioGenix, left his firm, the relationship between the venture and its syndicate deteriorated significantly.

[330] In this context, it is also noteworthy that the cases support our approach in the large sample analyses to refer to the most knowledgeable VC in the syndicate as the 'lead' VC: in all four VC investment rounds of our case ventures, the lead VC was the most knowledgeable VC in the syndicate. Furthermore, the cases also support our approach in the large sample analysis to study the syndicates' average, and not cumulative knowledge: in all VC rounds of the case ventures at least one investor from the previous round remained 'on board' (thus inflating the cumulative knowledge of all syndicate by double-counting the knowledge of the same investor) and because the syndicate members often had invested witch each other before in different ventures (thus rendering their previous knowledge not unique).

there might be a slightly stronger relation between the later round VC knowledge and venture performance.

In this context, the findings from our cases mirror those of the large sample analysis in that they also provide no clear indication as to which round-level knowledge might be more important.[331]

Thus, overall, our cases either provide further support or at least do not contradict the findings from the large sample analysis regarding the relation between VCs' knowledge and venture performance. However, it is also evident from our cases that a large number of other factors either moderate or overshadow the impact of VCs' knowledge on venture performance.

The role of other factors

Consistent with the large sample analyses our cases demonstrate that VC knowledge is just one of many different factors impacting on the early development and performance of ventures. Whilst it is impossible to list (and know) all of these factors, noteworthy are, for instance, the following:

VC-related factors, such as the VCs' financial contribution, the appropriate co-ordination of the syndicate's activities, the level of control requested and exercised by the VCs, the level of active support provided by the VCs, and the adequacy of VCs' interference in strategic issues.

Venture-related factors, such as the entrepreneurial team's background and connections, the fit between the venture's technology and business strategy, the fit between the venture's business strategy and its available non-/monetary resources, the impact of patent issues, the collaboration with and certification by established (pharmaceutical) companies, the team's perception of being treated fairly by their VCs, and the critical element of luck in science-based projects.

Context-related factors, such as governmental support programs and incentives, changes in the general legal and political environment, scientific/technological developments in the ventures' industry (and in other industries that are attractive for VCs), and swings on the financial and private equity market.

With respect to these groups of factors the cases show unambiguously that chief

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[331] For instance, UrGenT had the most experienced VCs in its first round. In this round it also made considerable progress with its projects. However, UrGenT experienced its biggest expansion in its second round where the VCs were (slightly) less experienced. CardioGenix, on the other hand, made – given its circumstances – good progress throughout all rounds, although all its VCs were inexperienced.

amongst them with respect to their impact on venture performance is the first, namely the VCs' financial contribution to the venture.

Without the financial support by the VCs, the ventures certainly would not have had a chance to realise their apparent potential at all, and as a consequence of the discontinuation of the VC funding, we shall of course never know for certain whether the ventures would have realised that potential.

Here, it should also be recalled that whilst in our large sample analysis financial factors did not seem to play a major role in the venture's success, additional analyses showed that the amount invested by VCs' in the first round of a venture was indeed negatively related to the venture's time-to-IPO. This suggests that once a venture is on a 'success trajectory' (moving to an eventual IPO rather than failure), finance accelerates this development. This might be because such businesses are less likely to be capital-constrained at the critical early stage development of their life. From this perspective, our cases provide further support for the findings of the large sample analysis.

Also supporting the findings from the large sample analysis, the cases attest to the fact that developments in the ventures' industry and particularly in the financial/private equity markets, may play a key role in venture performance; for instance, because they tangibly affect the VCs' willingness to provide the necessary funding.

Bearing in mind the main focus of our research, the cases also make it plain that these latter factors moderate the impact of VCs' knowledge on the VCs' investment approach, and ultimately on the ventures' performance.[332]

On a final practical point, in the large sample analysis of this thesis, given the limitations of our data, we were able to control only for a subset of the above-mentioned factors.

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[332] For instance, at the beginning of the boom, UrGenT's very experienced first-round VCs were willing to invest substantially more than they were ultimately 'allowed to', although the venture's business plan was all but well-developed. Towards the end of the boom UrGenT's (still relatively experienced) second round VCs continued investing substantial amounts in the venture - because they needed to make use of the funds they had drawn from their investors during the boom, but despite UrGenT hadn't made real progress towards a marketable product (and, at the same time, CardioGenix, that had made significant progress towards a marketable product, couldn't find investors because it was perceived to be too immature!). Finally, after the boom, UrGenT's investors demanded a drastic change in the venture's strategy although they knew that this was a highly risky bet, which could mean loosing their investment completely – as they ultimately did.

Thus, our cases certainly add to the findings of the large sample analysis by pointing to a substantially greater variety of factors potentially impacting venture performance. Furthermore, the cases illustrate how these factors may interact, how such interactions can vary with the cycle and how they can ultimately conspire to bring about failure of ventures considered viable by both founders and investors.

J.I.3. Conclusion

Comparing the main findings of the large sample analyses with the insights from the cases, we find support for some of the findings but not for others and are unable to draw conclusions on some of the issues.

For example (see Figure J-1), we are unable to draw conclusions from the cases regarding the large sample finding of a negative relation between VCs' knowledge and their propensity to syndicate (H1), and the negative relation between syndication and venture performance (see control variable 'syndication ' in H3). Similarly, we are unable to draw conclusions regarding the negative relation between VCs' knowledge and round-length (H2) and the negative relation between round-length and venture performance (see control variable 'round-length' in H3).

Thus, with view to the above aspects it is obvious that the findings from our two different approaches are not really comparable.

However, we found an illustration in the cases of a positive relation between VCs' knowledge and venture performance at least with view to a venture's early stage development.

Furthermore, our case studies certainly add an interesting perspective to the interpretation of our findings from the large sample analysis: they show that what is 'really going on' in practice is a result of a complex network of (inter-) relationships, which hardly can be done justice by analysing average values obtained from large scale samples.

Thus, we see our cases complementing the large sample findings in a way that might be summarized as our overall conclusion:

In general, VCs' knowledge can influence VCs' investment approach and it can be positively related to venture performance (directly, by picking winners, and/or indirectly, by building winners). However, a variety of factors - and chief amongst them the developments in the ventures' industry and in the financial markets - can conspire so that even knowledgeable VCs, at least at times, adopt *an 'irrational' or 'myopic' investment approach, which ultimately can lead to inferior venture performance.*

This conclusion is quite different from, or at least complementary to that of some other researchers in the field, who often emphasize the importance of VCs as intermediaries in the financial markets. Here, the reader might refer back to our introductory chapter where we cited Gompers and Lerner (2001a: 62) remarking that VCs 'can act as a buffer between the volatile suppliers of capital and the hungry entrepreneurial firms that need it – smoothing out the capital formation process so that innovator can implement their ideas'. As our study shows, it is important to emphasize the word 'can' at the beginning of this quote.

J.II. Main implications

Our study and its findings have implications from an academic as well as a practical perspective.

J.II.1. Academic perspective

With view to the implications from an academic perspective, we shall distinguish between the general propositions resulting from our study that might direct future research and the specific limitations of our study that should be addressed by future research.

J.II.1.a) Propositions

Whilst our study certainly has several implications from an academic perspective, three seem particularly noteworthy in that they could serve as general propositions for future research.

The *first proposition* is that VCs undoubtedly differ, also in their knowledge. Not all VCs have the necessary (knowledge-) resources to provide 'smart' money, and treating them – as was often the case in the existing literature - as a homogenous group of 'experts in picking and/or building successful ventures' is clearly wrong. Thus, when being interested in VCs' investment approach or the performance of their investments, one has to take into account differences between VCs in general, and between their knowledge in particular.

With view to the latter, the *second proposition* is that not all types of VCs' knowledge (e.g. general experience versus specific expertise) and not all types of VCs (e.g. lead VCs versus syndicates) are equally relevant with view to VCs' investment approach and the performance of VCs' investments. Some types of VCs' knowledge and some types of VCs suggested in the existing literature have no / hardly any influence in this context. Thus, when being interested in the impact of VCs' knowledge on the VCs' investment approach or the performance of VCs' investments, one has to be careful about the adequate choice of proxies.

The *third proposition*, finally, is that VCs' knowledge, whilst important, is only one of many factors related to VCs' investment approach and the performance of VC-backed ventures. Several other factors - VC-, venture-, or context-related - apparently have a stronger influence on VCs' investment approach and the performance of VCs' investments than VCs' knowledge. Furthermore, some of those other factors are also likely to 'overshadow' or moderate the influence of VCs' knowledge. For instance, the impact of VCs' knowledge varies across different rounds of ventures, and it varies with changes in the environmental context. Thus, *when being interested in the actual impact of VCs' knowledge on VCs' investment approach and/or the performance of VCs' investments, one has to control for a range of factors - as well as their interactions with each other and with VCs' knowledge.*

Particularly with view to this last implication, we also note that the sheer amount of possibly influential factors as well as their (changing) inter-relations makes it very difficult, at best, to realistically model this complexity based on average values obtained from large samples.

Furthermore, in this context, it should also be noted that our study can neither fully support nor refute the applicability of any of the theoretical concepts that have been commonly applied in the venture capital research. Whilst this might partly be due to the limitations of our study (which we will come to in the next section), it seems also plausible to argue that the existing theoretical models are in fact incapable of adequately capturing the complexity of the investor-VC-venture relationship.

Thus, another implications of our study could be that further theoretical work is needed, which is more specifically tailored to the venture capital context than those existing concepts that have chiefly been developed in the context of mature firms and markets.

The findings of our study have to be understood as a first attempt to shed a some light on an issue that has been almost completely neglected in the literature so far; and one has to keep in mind the limitations of our study, some of which we will highlight in the following.

J.II.1.b) Limitations and future research

As all studies, also our study suffers from limitations in several aspects, four of which we shall highlight at this stage, also to direct future research if it intends to examine our above propositions further.

Research design

As already noted before, one problem of our study might be seen in the general research design comprising two main methods, the quantitatively oriented large sample analyses and the qualitatively oriented case studies.

Both methods have their individual merits, but also their individual problems. For instance, in the large sample analyses it is virtually impossible to draw conclusions about the actors' actual motives and perceptions, and about certain causal relations, or to control for all potentially relevant variables and their interactions. The case studies by contrast amend some of those problems by providing a richer picture. However, they lack generalizability.

In this context, we believe that our unique approach of combining both methods (in a triangulation approach) is promising and superior to most previous approaches in the area. Notwithstanding the shortcomings of the individual approaches, when combined, they can provide two different but very complementary perspectives on the relations of interest. As such we would encourage future research to follow a similar design.

At the same time, we are aware that one of problem with our research design is that our cases take a very broad perspective on the VC-venture relation, without explicit focus on the questions and hypotheses dealt with in the large sample analyses. Together with the fact that our cases are based on two German biotech ventures that were active during the most extreme boom period so far, this does not allow us to compare our findings from the two different approaches in great detail.

Thus, future research might take better advantage of the triangulation approach by better matching case studies to the available large sample data and vice versa.

Sampling sources

Another possible criticism regarding our study might concern its sampling sources and their reliability. Whilst, for the reasons already outlined in Chapter E, we feel that this is not a major problem, we acknowledge that there is room for improvement.

As regards our source for the large sample analyses, the Venture Economics VentureExpert (VE) database, this has already been widely used by other researchers in the venture capital area, and it is generally considered to be one of the most comprehensive and reliable sources of information on venture capital investments.

Nevertheless, as mentioned in the chapter on our case studies, we found – by coincidence – that the information provided by VE is not perfect. This might particularly concern information on non-US deals. We therefore recommend future research to crosscheck and complement information from various sources, including for instance, the above-mentioned Venture One database and databases of (non-US) venture capital organizations.

On the other hand, with view to the sources of information used for our case studies, we are confident that particularly the information we obtained from the venture teams is reliable. This is mainly because, as outlined before, we had good personal relationships with the founders of both ventures long before the cases started, and we agreed full confidentiality.

Nevertheless, we are aware that our case ventures are not necessarily representative for VC-backed biotech venture in general.

As such, we would recommend future research, especially if it intends to draw more general conclusions, to examine more and more representative ventures.

Sample selection

With view to the sample selection, we are aware that one possible criticism regarding our study could be that we focus only on one particular industry, the biotech sector.

In this context, we note that one of the main objectives of our study was to examine differently fine-tuned proxies for VCs knowledge, with a particular focus on the VCs' industry- and venture-specific expertise. This clearly requires a 'reference' industry. For this purpose, we have chosen the biotech industry, on the one hand, because it is generally considered to be one of the most promising sectors in the 21st century, and, on the other hand, because it is widely accepted that this sector critically depend on venture capital funding.

But at the same time, we acknowledge, and in fact we emphasised throughout our thesis, that the biotech sector is different in several ways from other high-tech sectors, and that ventures from this sector might present particular challenges to VCs – and their knowledge.

As such, it might well be that our findings obtained from this sector are not necessarily transferable and generalizable across different sectors. For instance, one might expect the impact of VCs' more specific expertise to be less pronounced when looking at less risky industry sectors, although VCs general experience in financing entrepreneurial ventures might still be of relevance in such sectors.

However, in this context, it should also be taken into account that the biotech sector is characterized by an extremely high level of company-specific risk. As our case studies have shown in detail, due to the scientific nature of their projects, ventures in this industry almost always – and for a very long time - face the threat of failure, independent of the quality and/or intentions of their staff. Furthermore, most of these ventures are operating at the edge of scientific progress.

As a consequence, hardly any two biotech ventures are alike. This, in turn, makes it more difficult to assess the potential of those ventures and to adequately support their development based on knowledge acquired in the context of previous investments in other biotech ventures.

Therefore, the VCs knowledge – as approximated by us – might in fact be of less relevance in the biotech sector than in other sectors such as, say, the Internet-sector, where ventures are arguably more alike and where the risk often is more market- than company-related (e.g. because the customer adoption is unclear).

This might also contribute to the relatively low explanatory power of our various models. There could be only a weak relation between VCs' knowledge (and biotech expertise) and VCs' investment approach and/or venture performance because the success or failure of biotech ventures is more determined by the scientific nature – and associated problems – of the projects, the outcome of which is almost impossible to predict and/or to influence even for very knowledgeable/experienced investors.

By contrast, in other industries one might expect a stronger relation between VCs' knowledge as approximated by us and VCs' investment approach and/or the performance of VCs' investments.

Consequently, we feel, it would be interesting if future studies replicated our approach in other industries - both high- and low-tech and high and low business-specific risk - and compared their findings with those of our study.

Theoretical variables in large sample analyses

The final issue we shall highlight at this stage as a possible limitation of our study concerns what was the focus of our interest, namely the various proxies for VCs' knowledge used as theoretical variables in our large sample analyses. In this context, several aspects seem noteworthy.

To begin with, we have argued in detail above (see Chapter C, and Chapter D) why we believe that the proxies for VCs' knowledge we have proposed should more suitable than other proxies used in the literature. In this context, we have referred to established theoretical concepts (e.g. Bayesian 'learning' and the 'learning curve'), which suggest that organizations learn by doing - or, in the venture capital context: by investing. Furthermore, previous literature on venture capital has suggested that learning curve effects should be observable in the venture capital industry (e.g. Barry et al., 1990; Bygrave, 1987; Dimov & Shepherd, 2004; Hsu, 2003; Shepherd et al., 2003; Sorenson & Stuart, 2001).

Therefore, we feel there are good reasons to believe that our new proxies for VCs' knowledge, based on the number and type of VCs' previous investments, should be adequate to measure VCs' level knowledge and to differentiate between different types of knowledge.

This assertion also seems supported from our empirical findings for all three hypotheses. As predicted, the examined relations between the various dependent variables and the main theoretical variables are the stronger the better matched the VCs' knowledge is to the venture under consideration. Interestingly in this context, and contrary to what has been assumed in some previous venture capital literature, our study suggests that VCs do not accumulate relevant knowledge merely because they get older, and not even because they simply develop overall experience in financing entrepreneurial ventures overall.

Thus, from our study it seems plausible to assume that VCs learn - in the sense that they show a different investment approach depending on their prior experience - and that our proxies indeed can measure this learning. This makes us confident that our proxies indeed capture what they intend to capture, i.e. that they have validity. But we acknowledge that also our proxies are not without deficiencies, some of which we shall highlight in the following.

To begin with, it is important to note that, because of its cross-sectional design, our study cannot actually prove that VCs learn. Although it seems unlikely to us, it might still be that differences in VCs' knowledge 'coincide' with differences in their investment approach and in the performance of their investments, without a causal relationship between these aspects. Here, it would be certainly interesting for future research to use a longitudinal design that could allow us to study the actual effects of learning by an individual VC over time.

Furthermore, our study also cannot show that VCs learn from their previous experience in the sense that their acquired knowledge makes them more successful. This is because we do not measure the actual (e.g. portfolio) performance of VCs, but only the performance of individual ventures they invest in. Thus, whilst it seems plausible to assume that with increasing expertise VCs change their behaviour to the better (i.e. to become more successful), from our study we cannot conclude that there actually is a performance enhancing 'learning-curve effect' in the venture capital context. Future research in this area therefore should also examine whether higher levels of knowledge actually correlate with better *VC* performance.

Another issue with our knowledge proxies, which we have already mentioned above, concerns the possibility that, particularly in organizations as small as most VC firms are, individual learning and knowledge (i.e. on the level of investment managers) might play a relatively more important role than organizational learning and knowledge. This would not fundamentally alter the interpretation of our findings. However, it might present an additional explanation for the relative weak relations we find between dependent and theoretical variables, and for the overall limited explanatory power of our models. For instance, if the individual knowledge is relatively more important than the organizational knowledge in the VC industry, high fluctuations of staff could 'water down' the effects of VCs' knowledge as approximated by us. Consequently, it might be worth for future research to 'dig deeper' by examining the actual knowledge available to a VC firm in terms of previous investment experience of their individual investment managers. The outcome of those studies would have also interesting practical implications. For instance, if it turned out that a VCs firm's knowledge (e.g. in particular high-tech sectors) in fact is due to the its individual investment managers rather than the firm as such, entrepreneurs searching for funding (or investors wishing to put funds into a VC firm) might be better advised to look for the top investment managers rather than the top VC firms – and vice versa.

Another issue of our theoretical variable concerns the fact that we did not account for the possibility of what is sometimes referred to as 'organizational forgetting' – the fact that more distant knowledge is less important, or might even be lost completely. This idea is also captured in the flattening out of most learning curve (!) models. It could be because key people leave the firm and/or because knowledge simply becomes outdated. The latter is particularly likely with view to knowledge regarding such fast developing sectors as biotechnology. As a consequence, knowledge from more distant investments may not be as valuable as more recent ones. We believe that this should not be so much of a problem since the vast majority of the investments in our sample occur within a relatively short period of time. Nevertheless we acknowledge that - particularly because biotechnology is such a rapidly evolving field - part of VCs' knowledge accumulated some years ago might not be of much value. Therefore, future research might consider those aspects of knowledge 'depreciation'.

Another issue with our theoretical variable concerns the calculation of different types of knowledge. For instance, in all our hypotheses, we argued that the impact of VCs' knowledge on the respective dependent variable should be the more pronounced the better matched the VCs' knowledge is with view to a particular focal venture. Indeed, this is what we found throughout all analyses. However, in this context, we have to emphasize that we only analyse the *absolute* level of a VC's 'specialization' in a particular type of venture, but not the *relative* degree of his specialization. This might have some implications for the interpretation of our findings. To illustrate this: when we calculate, say, a VC's biotech-stage expertise, we add together all his previous investments in biotech ventures of the same development stage as the focal venture under consideration. If he has previously invested in, say, 10 ventures of the same stage, he receives a biotech-stage score of 10. This score, however, neglects any other investments the VC may have made in ventures other than those of the same stage and in biotechnology. As a consequence, two VCs with the same number of previous investments in biotech ventures of a particular stage would receive the same score for this type of investment, regardless of whether one of these two VCs might have made an extra 100 investments in non-biotech ventures (thus receiving a non-biotech score of 100) whilst the other has just invested in those 10 ventures of the same stage but in no other ventures (thus receiving a non-biotech score of 0). Whilst it is reasonable to assume that these two VCs indeed have the same level of expertise as regards biotech ventures of this particular stage, it would be certainly wrong to assume that they are equally qualified overall. Those differences though, are very likely to influence both the VCs' investment approach and the performance of VCs' investments. As such, we acknowledge that our proxies for VCs' knowledge are accurate as far as the absolute level of VCs' knowledge with respect to a particular type of venture, but none of our proxies for a particular type of VCs' knowledge provides any information about the overall level and/or relative specialization of VCs' knowledge. Therefore, future research in this area certainly would be recommended to define and examine proxies also for the VCs' relative level of specialization.

Yet another issue of our theoretical variables concerns the examination of the different impact of the 'lead' VC's knowledge vs. the average syndicate's knowledge, on round-length (H2b) or venture performance (H3a ii). Here, we have already mentioned before that our findings in this context might be partly influenced by the way in which we calculate these proxies. Specifically, our variable 'lead VC knowledge' comprises both the knowledge of true lead VCs (in syndicated deals) and of sole VCs (in unsyndicated deals). Thus - referring back to our chapter on syndication, where we have shown that more knowledgeable VCs' tend *not* to syndicate – it seems likely that the 'true' knowledge of 'lead' VCs in syndicates is lower than suggested by our variable, whilst the actual knowledge of sole VCs (which we do not analyse) is in fact higher than suggested by our variable. Similarly, our variable 'average syndicate knowledge' comprises both the average knowledge of VCs (in syndicated rounds) and the 'average' knowledge of sole VCs (in unsyndicated rounds, where the VC's average knowledge obviously is identical to his absolute knowledge). Thus – and again referring to our chapter on syndication – it seems likely that the 'true' average knowledge of syndicates is lower than suggested by our variable. Therefore, we caution that our findings regarding the impact of the 'lead' VCs' vs. the syndicates' knowledge have to be interpreted keeping in mind that both variables are based on average values that combine the knowledge of syndicated and sole VCs. Consequently, our findings might look different if we had only looked at truly syndicated rounds. Future research therefore might differentiate more carefully between syndicated and unsyndicated rounds when examining the impact of the lead VCs' vs. the syndicates' knowledge. Furthermore, future research in this area might also examine more carefully whether the knowledge of different VCs in a syndicate is complementary (because it was acquired by previously investing in different ventures) or identical (because it was acquired by previously investing the same ventures). Based on such a differentiation, future research might then account more accurately for the knowledge actually available in a syndicate than we did by just examining he average knowledge of all VCs in a syndicate.

Finally, and possibly most importantly, for the main part of our large sample analyses we examined the individual effects of our various theoretical variables only controlling for other factors (i.e. keeping those other factors constant or using their average values). This allowed us to come to conclusions that are valid on average. However, one would expect that the impact of VCs' knowledge is also different depending on the particular investment scenario. To give an example, one might expect a venture in an early development stage to present a smaller risk to a knowledgeable VC than to an ignorant VC; and it might present an even smaller risk if the deal size was small. Consequently, the impact of VCs' knowledge, say, on his investment approach is likely to differ in those different scenarios. Similarly, also our case studies indicate clearly, that the actual impact of VCs' knowledge varies, for instance with changes in the market environment. In this context it should be noted that we have conducted some additional analyses on the impact of VCs knowledge in specific situations such as in first investment rounds, which resulted in qualitatively similar findings as our main analyses. Nevertheless, a more fine-tuned examination of the possible interactions between our theoretical variables and various control variables certainly would present a rich ground for future research.

J.II.2. Practical perspective

Notwithstanding its above-outlined limitations, our study has implications from a practical perspective for VCs, entrepreneurs, and other stakeholders.

Venture capitalists

For VCs, arguably the most fundamental implication of our study is: 'biotech is no easy money'. VCs who consider investing in biotech ventures should be aware that although biotech ventures are 'high-tech' they are quite different in their requirements from many other high tech ventures. VCs investing in this type of venture should be prepared to invest substantial amounts, and they should be willing to take a long-term perspective on their investment. In many cases, they will not be able to find out for a long time whether their investment ultimately will pay off; and this might even take more time than the typical lifespan of a VC fund.

Furthermore, VCs should also be prepared to invest more than just money. Given that the ventures they fund are often run by scientists with little prior exposure to business and industry, VCs often will have to put in considerable extra non-monetary resources – in form of their own expertise and/or in form of their contacts to relevant third parties - to increase the chances of a successful outcome of their investment.

This certainly must involve a very diligent initial assessment of the investment opportunity, including its technological/scientific feasibility and the chances that its products, if developed, can be 'circumvented' by competitors in this rapidly evolving industry. But this might also involve getting their 'hands dirty' by actively supporting the venture's team.

Thus, VCs wishing to invest in this sector should be very clear about whether or not they can add sufficient value to those ventures. If they feel that they cannot, but want to get a foothold in this sector nevertheless, they might consider syndicating. However, in this context, they would seem well advised to be careful about their potential partners' actual experience in the sector. Since more experienced VCs might tend not to syndicate, only ignorant VCs might be left to partner with. But syndicates of ignorants might, at best, contain the financial loss for the individual partners, but are unlikely to increase the chances of success.

An additional means for VCs to contain potential losses is to invest only smaller chunks of money, sufficient for the venture to reach certain milestones. This certainly gives the VCs some necessary control over how their funds are spent, but they should be aware that due to the 'nature' of the projects unforeseen new avenues can open up that also demand a good portion of flexibility on the VCs' part. So, VCs should carefully balance their need for control over the venture against the entrepreneurs' need to have sufficient freedom to play out their scientific creativity.

Finally, taking into account that an IPO is often the most desirable exit-route from biotech investments, it is certainly crucial for VCs to get their timing right. There will only be small windows of opportunity to get a biotech venture to the market. But an investment strategy that is mainly driven by the - often erratic - developments on the financial markets may will run counter to the development of a sustainable biotech company; and chances are that rushing and pushing science-based projects this will result in disaster.

Entrepreneurs

Also for entrepreneurs our study is likely to have several implications. Chief amongst them: be clear and realistic about your business plan and strategy. This includes asking questions such as 'what is the actual product I want to develop', 'what if the project fails technically, are there any alternative routes', 'what is my business model?', and, key, 'what resources do I have, and what additional resources do I need, to realise this model?'.

If those questions are answered one can determine the most appropriate ways and sources of funding for a project, and their actual availability.

For those few ventures that have sufficient non-monetary resources available in-house, the choice of the right VC might not be as critical - although having truly ignorant VCs might be counter-productive. The vast majority of ventures will need both monetary and non-monetary external resources. Thus, all ventures are well advised to be aware of the differences between VCs.

In this context, the amount of funding to be obtained/obtainable from VCs certainly is an important issue. At the same time, there seems considerable truth in the industry adage that 'it is not only how much money you get but also from whom this money does come from'. Some VCs indeed appear to provide more than just cash, but 'smart money'. This 'smartness' of some VCs can be vital for ventures in several ways. For instance, it might simply be good to be associated with a VC whose 'smartness' is widely recognized, because it might serve as a crucial 'certification' of the venture's quality, and it might ease access to further resources. But having a smart VC, particularly if he has plenty of industry experience, might also be of more direct value in that he might help in actually building the venture.

At the same time this doesn't come for free. 'Smart' VCs are likely to be more aware of the risk inherent in all science-based projects. As a consequence, they might request more control and keep the venture on a 'shorter leash', for instance, by providing only smaller chunks of funding. This, in turn, could mean that a venture has to go through the 'hassle' of in-depth due diligence audits and negotiations at the beginning of new rounds more frequently.

Nevertheless, it might ultimately pay off, because having smarter VCs could increase the venture's likelihood of experiencing an IPO, and it can decrease the time-to-IPO. Thus, ventures seem well advised to focus primarily on the quality of their VCs and not so much on the quantity of their VCs' funds. In fact, there are even indications that the amount received by a venture, be it in its first round or overall, does not to have any/the same positive effect on its long-term performance as has its VCs knowledge.

As such, ventures should not be blinded by the often larger amounts offered by VC syndicates. Not only might those funds not be as useful as they seem to be, having to deal with a syndicate might also involve additional costs, for instance, in terms co-ordination. But arguably even more crucial, it should be kept in mind that it is often the ignorant VCs who syndicate, whilst the smart VCs tend to go it alone. So, the average knowledge of a syndicate often will be lower than that of a sole VC.

This notwithstanding, the ventures' focus generally should be on the differences in the quality of the lead VCs, who serve as the main point of contact between the syndicate and the venture, and are correspondingly most likely to get involved in it.

However, and this is one of the key implications from our study for entrepreneurs, they should not only be aware of the differences between different (lead) VCs, they should also be aware of the differences in the behaviour of the same (lead) VCs over time.

Most VCs are themselves 'agents' for institutional investors who have the bulk of their funds invested in the stock markets that are much more liquid than the private equity markets. Thus, most VCs have the stock markets as a 'benchmark' for their performance, and their behaviour is to a considerable degree determined by the – at times erratic – developments on those markets. This, can lead even knowledgeable VCs to behave – seemingly or actually - irrational and myopic, by focussing only on the most profitable and/or 'safe bet' ventures whilst neglecting the more ambiguous ventures in their portfolios. This, in turn, can have severe negative consequences for those 'neglected' ventures that might be viable but needed a more constant and/or longer commitment from their VCs.

In sum, ventures should be careful about getting the right VCs at the right time: if there is a chance, pick your VCs carefully; but if there is no chance and if time and competition permits, consider waiting rather than prematurely giving away your 'baby' in the wrong hands.

Other stakeholders

Finally, it should be noted that our study also has possible implications for other stakeholders.

For instance, institutional investors using VCs as vehicles for investments in private equity should be aware of the apparent differences in VCs' expertise – which, as our study suggests, can be measured by their number and type of previous investments. Providing funds to ignorant VCs who are planning to 'sink' them into the biotech sector might be a good recipe to loose those funds. On the other hand, if institutional investors provide funds to VCs who are experts in biotech, they should take into account that investments in this sector have different requirements for success than investments in many other sectors, for instance, as regards the time horizon. Thus, to benefit from the potentially spectacular returns from investments in this sector, they might allow knowledgeable VCs more flexibility.

But our study has also possible implications for policy makers wishing to develop their countries' biotech sectors. If they, such as is the case in Germany, provide subsidies to those start-up ventures by matching the funds the ventures have previously attracted from VCs, it seems recommended to have a closer look at the actual quality of those VCs. 'Throwing good money after bad' will hardly help in developing a sustainable biotech industry.

At the same time though, given that even knowledgeable VCs at times are myopic, policy makers may also want to explore alternative, more steady routes of funding for their fledging biotech sectors that are less impacted by the sometimes erratic swings in the capital markets.

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APPENDIX I – BACKGROUND TO THE BIOTECH INDUSTRY

J.III. Biotechnology – an industry overview

Many consider biotechnology to be one of the key technologies in the 21st century – positioned to redefine our lives and to reshape virtually every other industry and (Enriquez & Goldberg, 2000); and some even refer to the 21st century as the 'coming age of biotechnology' (Oliver, 1999). However, although it is common to talk about 'biotechnology' in general, this term actually spans a variety of different techniques, and definitions.

With reference to modern biotechnological discoveries, the OECD provides a widely used definition of biotechnology as:

> 'the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods, and services'.

Within this broad definition of biotechnology it is further common to distinguish between three main areas: 'green biotechnology' (e.g. agriculture/breeding), 'grey biotechnology' (e.g. environmental protection/ cleaning), and 'red biotechnology' (e.g. pharmaceutical research, development, and production). However, even within those areas, there are a variety of sectors and sub-sectors. Venture Economics (VE), for instance, differentiates between seven main sectors and more than 20 sub-sectors of biotechnology, some of which are shown in Table L-1.

Table L-1: Main and sub-sectors in the biotech industry

(adapted from Venture Economics)

Main Sectors (VE number)	**Sub-sector examples**
Biotech-Human (4100)	Therapeutic products
	Diagnostic products
Biotech-Agriculture (4200)	Animal breeding/engineering
	Plant growing/engineering
Biotech-Industrial (4300)	Food processing
	Pollution control/toxic waste treatment
Biosensors (4400)	Biosensors for industrial applications
	Other biosensors
Biotech Equipment (4500)	Research & production equipment
	Analytical instruments & apparatus
Biotech Research (4600)	Research services
	Other services
Biotech Other (4700)	Biotechnology and Pharmacology
	Other biotechnology related

Whereas all the above biotech sub-/sectors are assumed to impact and even revolutionise many different areas, its main domain of application currently is – and presumably will be for years to come – the 'red' biotechnology. The Boston Consulting Group (BCG, 2001a), for instance, predicts the total revenues of the global biotech industry to increase from $136bn to $433bn between 1999 and 2010, with the share of red biotechnology increasing from $57bn (about 42%) to $214bn (almost 50%) in the same period. This is also reflected in the VE database, where of all 1,712 biotech ventures that received venture capital between 1973 and 2002 about 54% were mainly engaged in 'red', or pharmaceutical-oriented, biotechnology (VE sub-sectors 4100).

Therefore, in the following, we use the pharmaceutical-oriented biotechnology sector to illustrate the overall potential of this industry.

J.III.1. Biotechnology in the pharmaceutical industry

To understand the relevance of biotechnology for the pharmaceutical industry, it makes sense to start with a short history of this industry.

J.III.1.a) A short history of the pharmaceutical industry

The pharmaceutical industry was traditionally based on chemistry but not biology. Merely adopting a 'trial-and-error' approach to drug development, for a long time, its focus was on the symptoms rather than the causes of diseases. Furthermore, pharmaceutical R&D targeted only about 500 major diseases, leaving aside a much larger number of less widespread ailments. At the same time, due to the lack of knowledge regarding the biological mechanism underlying the targeted diseases, new drugs often were rather inefficient and even associated with severe side effects.

This not withstanding, the traditional pharmaceutical approach occasionally led to the discovery of 'block-buster' drugs (i.e. those with annual revenues over $500Mio); and, until lately, the industry was very profitable. Two digit growth rates in annual revenues and profits were the rule. This was also due to a combination of patent protection for existing drugs and a lack of competition by new entrants.

However, the general inefficiency of the traditional pharmaceutical drug development approach combined with increasing requirements by the drug-approving governmental bodies regarding clinical trials and their documentation, amplified the cost and time needed for successfully developing new drugs as well as the (commercial) risk associated with this process. For instance, it is now widely accepted that it takes up to 15 years and more than $800Mio to develop a new drug. The reason for this becomes evident with view to Table L-2, which provides an overview over a 'typical' drug-development process.

Table L-2: Overview over typical drug development process

(adapted from: Consors Capital, 2002; Lehman Brothers, 2001)

	Step	**Activity**	**Duration [yrs]** (cumulative)	**Costs [% of total]** (cumulative)	**Success-rate [tested compounds to final drug]**	**Outcome**
Research	Discovery					
	Target analysis	Identification of targets (e.g. genes or proteins) related to disease, characterizing of target function	2.5 (2,5)	4 (4)	10.000	Target
	Compound screening	Identification of compounds (biological or chemical) with efficacy against target, in-vitro validation	3 (5,5)	15 (19)	50	Lead
	Pre-clinical Testing	Animal testing of lead compounds (toxicology, safety, stability etc.)	1 (6,5)	10 (29)	12	Clinical candidate
Development	Clinic Phase I	Application to 20-30 healthy volunteers to check for safety and dosage	2 (8.5)	15 (44)	5	Clinic I test results
	Clinic Phase II	Application to 100-300 patient volunteers to determine efficacy and side effects	2.5 (11)	22 (66)	3	Clinic II test results
	Clinic Phase III	Application to 1,000-5,000 patient volunteers to confirm efficacy and safety in I	2.5 (13,5)	31 (97)	2	Clinic III test results
	Approval	Governmental bodies (e.g. FDA in the US), examine filed application documents	1.5 (15)	3 (100)	1	Approved drug

As a consequence, it is more and more challenging for pharmaceutical companies to bring new, innovative products to the market. The pharmaceutical industry began to suffer from a 'productivity gap'. Research by Accenture shows that whilst R&D spending in the pharmaceutical industry increased by 43% between 1995 and 2001, new drug approvals decreased by 49%. The pipelines of many established pharmaceutical companies were running dry and the focus of pharmaceutical R&D more and more shifted towards marginally improving existing drugs rather than developing new ones. At the same time (marginal) product-improvements reduced the time of market exclusivity for many drugs; and, with the patent expiry for many drugs, generics began to dominate the market.

Thus, today, a key success factor for companies to compete in this business increasingly becomes their level of innovativeness. They have to be at the forefront of science and technology to increase the likelihood of success in the development process whilst simultaneously reducing development times and costs. As the Boston Consulting Group points out, 'in the pharmaceutical industry's struggle to reach the levels of growth expected of it, one of its key aims will be to increase R&D productivity. And a key means of meeting this challenge is to adopt the new technologies and approaches broadly defined as genomics' (BCG, 2001b: 6).

J.III.1.b) Impact of biotechnology on the pharmaceutical industry

Based on the above, biotechnology is expected to have a major impact on the pharmaceutical industry, both from a scientific and a commercial perspective. In this context, Table L-3 provides an overview over some of the most noteworthy innovations in the history of biotechnology.

Table L-3: Major events in biotechnology *(adapted from Consors Capital, 2002)*

Year	Innovator	Innovation
1865	Gregor Mendel	Publication of 'rules of inheritance'
1869	Friedrich Mieschner	Discovery of Deoxyribonucleic Acid (DNA) molecule
1900	William Johansen	Introduction of terms 'gene', 'genotype', and 'phenotype'
1944	Oswald Avery	Prove of DNA to be the carrier of 'hereditary information'
1953	James Watson & Francis Crick	Identification of double-helix structure of DNA, chemical explanation of Mendel's rules of inheritance
1961	Marshall Warren Nirenberg	Deciphering of the first 'codon' (base-pair triplet in DNA, coding for an amino acid, the key ingredient of a protein)
1966	Har Gobind Khorana	Complete deciphering of the genetic code
1970	Hamilton Smith	Isolation of the first 'restriction enzyme' able to cut DNA
1972	Janet Mertz & Ron Davis	Creation of the first recombinant DNA segment
1973	Stanley Cohen & Herbert Boyer	Birth of 'gene-technology': creation of 'recombinant DNA' by inserting of DNA segments from a toad into a bacterium
1975	Georg Koehler & Cesar Milstein	Development of Hybridom-technique to create 'monoclonal antibodies'
1976	Robert Swanson & Stanley Cohen	Foundation of Genentech (Genetic Engineering Technology) as the first commercial biotechnology company
1977	Walter Gilbert & Frederick Sanger	Development of two methods for DNA-sequencing
1980	Genentech	IPO raising $35m provides the starting signal for the foundation of many further biotech ventures
1982	Eli Lilly & Genentech	Production of Insulin as the first biotechnological drug
1985	Karry Mullis	Development of the Polymerase Chain Reaction (PCR) to produce millions of copies from a single DNA fragment
1986	HUGO (Human Genome Organisation)	Birth of the 'Human Genome Initiative' aiming to decipher the whole human genome
1990	HUGO & French Anderson	Start of the 'Human Genome Project' (HGP), first gene-therapy on a human
1997	Ian Wilmut	Creation of Dolly the sheep by cloning
1999	Celera	Celera starts own Human Genome Sequencing Programme
2001	HUGO & Celera	Presentation of a working draft of the Human Genome
2002	HUGO & Celera	Completion of the Human Genome Project

J.III.1.b.i. Scientific perspective

Biotechnological innovations have already begun to enter the pharmaceutical industry some time ago. However, particularly the more recent scientific advances surrounding the Human Genome Project (HGP) promise to have a major impact on the future of the industry. Before the HGP, scientists already knew that many diseases are caused by proteins (or the lack thereof) encoded by 'malfunctioning' genes; and they had already identified several genes that are of importance in this context. But the vast number of human genes remained unknown, as did their protein products and the pathways leading to the corresponding diseases. As a consequence, the HGP was initiated in the late 1980s to identify and create a map of all human genes; and when its completion came near, this gave rise to high expectations.

However, when the first 'working draft' of the Human Genome was presented early 2001, it was clear that the expectations had been premature. Being exclusively concerned with 'structural genomics', the HGP was just the beginning. Having a map of all human genes was like having a dictionary that doesn't provide the meaning of words. By itself, the HGP didn't make it easier to identify the genetic causes of diseases or develop corresponding drugs.

Nevertheless, the HGP was very important. It did push the frontiers of biotechnology further and opened the doors for many new activities and approaches. For instance, one major task immediately following from the HGP became identifying the function of the discovered genes ('functional genomics'). Closely related to this is the analysis of the structure and function of proteins encoded by genes ('structural/functional proteomics'). Furthermore, another new area of biotechnology resulting from the HGP is that of 'pharmacogenomics'. This refers to the development of drugs that are tailored towards the genetic profile of individual patients; and it seems particularly promising because it is known that small differences in patients' genetic profiles can substantially affect the effectiveness/efficacy of drugs. These new biotechnological areas are summarized in Table L-4.

Table L-4: Overview over recent developments in pharmaceutical biotechnology

Structural Genomics Identification of genes (possible gene-targets)
Functional Genomics Identification of genes related to diseases (gene-targets)
(**Structural**) **Proteomics** Identification of proteins (possible protein-targets)
Functional Proteomics / Protein-pathway analysis Identification of proteins related to diseases (protein-targets)
Pharmacogenomics Development of drugs tailored to patients' genetic profiles

J.III.1.b.ii. Commercial perspective

The new insights and approaches in the biotechnology arena undoubtedly (will) have a positive impact on the pharmaceutical drug development process. For instance, the Boston Consulting Group (BCG, 2001b), expects that by making appropriate use of genomics-related insights up to one third of the drug development costs and two years of the development time could be saved. In addition, the new technologies and approaches also have the potential to dramatically change the size and structure of the overall marketplace for pharmaceuticals. For instance, over the past 20 years drug research had focussed on about 500 different diseases. But with the recent scientific advances, the number of potential targets is likely to increase tenfold over the next years, making it impossible for the traditional pharmaceutical companies to do research on all those targets and providing many opportunities for new entrants. At the same time, new approaches such as pharmacogenomics are assumed to change the structure of the pharmaceutical market. If doctors eventually are able to treat patients with 'designer drugs' tailored to their genetic makeup, the significance of one-size-fits-all blockbuster drugs will drop. For drug- companies this spells economies of scope rather than scale. Developing and marketing individualized medicine on the one hand, might require greater efforts for diagnosis, production and distribution. But this is likely to be compensated for by premium prices chargeable for more efficient/effective drugs.

However, coping with all the new genomics-based biology puts continual pressure on the established pharmaceutical companies, which initially have vastly neglected the area and now find it difficult to catch up. Stuart et al. (1999), for instance, point out that at the scientific advent of contemporary biotechnology, established chemical, pharmaceutical, and agriculture firms were poorly positioned to enter the new field. Biotechnology required skills in molecular biology and biochemistry, which were quite distinct from those demanded by the chemistry-based technologies for which they were expected to substitute. Hence, biotechnology represented a competence destroying development (Tushman & Anderson, 1986): it relied on a novel set of techniques, which existing chemical and pharmaceutical firms found difficult to acquire. As a result, the commercialization of biotechnology was shepherded by start-up, dedicated biotechnology firms.

Furthermore, with the ever-more rapid scientific developments in the area, it is very risky to bet on and invest in building up certain capabilities and technologies. What might seem very promising today could be almost obsolete tomorrow. Thus, investment decisions have to be made, weighing risk against potentially high rewards. Companies will need to decide how to participate in the scientific development, whether and how deeply to invest in new approaches. With the new wealth of options and the increased interdependencies across the value chain, strategic issues will prove more complex than in the past. Many traditional ways of doing business will be disrupted by genomics technologies, and companies may need to restructure fairly drastically (BCG, 2001b: 7).

In sum, biotechnology dramatically impacts the pharmaceutical industry, both from a scientific and a commercial perspective.

J.III.2. Promises of and challenges for new biotechnology-based firms (NBFs)

From the above it is evident that, in the pharmaceutical industry, changes in the relevant skills base as well as in the overall market size and structure allow for – and often require – the formation of new, specialized businesses models to serve the rapidly developing and increasingly fragmented marketplace. This clearly opens many opportunities particularly for innovative, biotechnology-based firms (NBFs).[333] At the same time though those ventures also face a plethora of challenges, and so do their (potential) investors. Both the promises of and challenges for those ventures, therefore, shall be considered in more detail in the following.

J.III.2.a) Promises of NBFs

Probably the most obvious promise of NBFs lies in their innovativeness when it comes to developing new technologies, methods, and ultimately drugs. Here, NBFs are generally assumed to be more apt to undertake innovating activities than established pharmaceutical companies, for instance, because they usually

- focus on selected highly innovative areas with high profit potential
- have close ties to academia and therefore access to the latest scientific insights

[333] There is no clear-cut definition of new biotechnology-based firms (NBFs); and differences in the definitions lead to different figures to be found in articles and reports on the industry. Unless stated otherwise, the figures provided in this document refer to dedicated biotech companies that are mainly engaged in biotechnology; but they are to be understood as indicating trends rather than 'hard facts'.

- are small enough to flexibly react on changing circumstances and developments
- attract high-calibre scientist who are likely to prefer flat hierarchies
- use stock options to align the employees' interests with that of the company

Arguably the best proof for the innovative – and, therefore, commercial - potential of NBFs is the fact that their 'competitors', the incumbent pharmaceutical companies, increasingly 'outsource' their R&D activities to them. According to Consors Capital (2002), established pharmaceutical companies today spend about 21% of their revenues on royalties paid to NBFs; and this share is expected to rise even further. Thus, capturing an ever-rising share of the pharmaceutical value chain NBFs clearly have the potential to provide substantial monetary and non-monetary returns to their stakeholders (entrepreneurs, investors, and general public).

The commercial potential of NBFs was first recognized – and realised – in the US, where the foundation of Genentech in 1976 is widely considered to present the birthmark of the commercial biotech industry. Genentech's success – it turned profitable already in 1979 and it went public in 1980 - is often said to have laid the foundation stone for the biotech industry in several ways. The successful outcome of the company's initial research project showed the commercial potential of recombinant DNA techniques. Furthermore, Genentech proved two things to would-be entrepreneurs. First, their intellectual property could be monetized; and second, they could focus on just one component of the R&D supply chain and did not have to enter the industry as a fully-fledged drug company. This inspired many US scientists to set up their own biotech ventures already in the early 1980s, creating and maintaining the US lead in biotechnology in the international comparison (Senker, 1996). Thus, over the next two decades, an increasing number of US NBFs have turned into highly profitable public organizations. They have brought several blockbuster drugs to the market each earning more than $1Bn a year; and some have achieved market caps far above those of established pharmaceutical companies. Clearly, the early investors in those ventures could enjoy substantial returns on their investments.

With a time lag of 10 to 20 years, the apparent success story of the US biotech sector also triggered similar developments in other countries, and particularly in the UK; And more recently, also other countries – such as Germany – began to recognize the potential of biotechnology, and put considerable efforts into developing this sector to make up for their late entry. As a consequence, particularly in Europe there was to be observed a dramatic increase in the number of NBFs over the past decade. For instance, a survey by the German Federal Office for Statistics shows that between 2000 and 2002 alone, the number of R&D employees and the amount of R&D spending by German NBFs rose by 42% and 109% respectively, whilst the same indicators for large pharmaceutical companies dropped by 10% and 16% respectively (Statistisches Bundesamt, 2003). Nevertheless, the US still has a substantial lead, and countries such as Germany lag far behind.

J.III.2.b) Challenges for NBFs

From the above it is evident that NBFs promise substantial benefits to their stakeholders. However, to realise their potential, NBFs have to overcome substantial challenges, which are arguably greater than for most other entrepreneurial ventures.

To begin with, NBFs face the high levels of risk and uncertainty characterizing the pharmaceutical drug developing process outlined above. Due to both their scientific nature and the strict requirements of drug-approving bodies, the odds are high that their time- and cash-consuming projects never result into marketable and profitable products, even despite the most diligent R&D efforts. In this context, it is further critical that most NBFs have only a limited pipeline of projects. Hence, failure of one project often threatens the survival of the whole company. This is in contrast to established pharmaceutical companies, which usually have the relevant financial resources to make up for the occasional 'flop'. Furthermore, these financial resources also enable established companies to buy in scientific and managerial expertise that might help prevent some project failures. As such, one might argue, the lack of resources – both monetary and non-monetary – presents the greatest challenge for NBFs.

Whilst many entrepreneurial ventures are likely to suffer from a lack of monetary resources, this aspect presents a particular challenge in case of NBFs. As was outlined before, the financial resources required to develop a drug are massive, amounting up to $800m. Although most NBFs focus only on certain, early, segments of the pharmaceutical value chain – and therefore do not incur the full costs for developing a drug – they nevertheless need substantial funds. The Boston Consulting Group (BCG, 2001a) outlines the financial requirements for a typical pre-IPO drug-developing NBF as follows:

- €500,000 for initial prove of principle (pre-/seed phase)
- €1.5–2.5m for early establishment of business (startup/early stage phase)
- €15-20m minimum before IPO (late stage/expansion phase)

Thus, the financial requirements of most NBFs are likely to be even higher than those of other (high-tech) ventures.

However, NBFs present even bigger challenges to their investors than many other ventures, making it even more difficult for them to obtain the required financial resources.

The vast majority of NBFs remains without revenues - let alone profits - for much longer periods than any other type of entrepreneurial venture. Referring back to the above outlined drug developing process, it is not unusual for NBFs to depend on external funding for more than 10 years.

At the same time, this process involves many different steps - from basic research over testing and manufacturing, to marketing and sales – which, in turn require a variety of different skills and capabilities, of which 'hard science' is just one. Arguably equally important for this purpose is knowledge about financial and managerial issues as well as market- and industry-related knowledge, such as on competitive and/or complementary technologies.

Yet, it is unlikely that those skills and capabilities are possessed in full by a small entrepreneurial team, particularly when taking into account that founders of NBFs are often scientists with limited commercial experience, at best. Indeed, the vast majority of NBFs are founded by entrepreneurs or as spin-offs from academic institutions, as is evident from the Table L-5.

Table L-5: Origins of European NBFs [Ernst & Young (1999)

[Numbers are estimates taken from a graph]

Established by an Entrepreneur	~49%
Academic Spin-Off	~24%
Industrial Spin-Off	~16%
Other	~11%

Moreover, most NBFs usually have no - or only very specialized - tangible assets. What they usually have are some brilliant minds with fascinating ideas and, ideally, one or more patents to protect these ideas. But such 'soft assets' have no active markets that list their value, and it is usually impossible for investors to recoup their value in case a venture fails.

Finally, as was outlined above, biotechnology is a very complicated and fast developing sector. This makes it particularly difficult for investors to keep up and to realistically evaluate the potential of a NBF's projects. Furthermore, it increases the likelihood of significant information asymmetries to exist between entrepreneurs and (potential) investors.

Together, the above requires investors to have both a favourable attitude towards risk and the willingness to take a long-term perspective on their investments. As such, NBFs are likely to attract funds only from a very limited spectrum of theoretically available investors. Furthermore, the availability of funding for NBFs also strongly depends on the wider context of the markets.

Here, Jonathan Leff and Stewart Hen from Warburg Pincus summarize the difficulties in funding biotechnology from the investors' perspective (cited in E&Y, 2002):

> 'Biotechnology investing generally appeals to growth investors. The industry certainly offers a number of favourable growth characteristics: explosive sales potential of new products, high margins, long product life-cycles, and intellectual property protection. Simply stated, when biotechnology companies succeed, revenues and valuations can grow exponentially. Not surprisingly though, value investors tend to steer clear of biotechnology. Few companies in the sector have positive cash flows, strong balance sheets, and historical track records of operating and financial performance sought by classic value investors [...] however, if one defines value investing as the art of finding companies whose assets and prospects are significantly undervalued, then biotechnology can be a particularly attractive sector to seek out value. The challenge of course lies in identifying that value in the absence of the usual metrics.... In the absence of traditional valuation metrics, the valuation assigned by the capital markets to a given biotech company, and hence the terms on which that company can access financing, can fluctuate dramatically based on nothing more than the shifting winds of the market sentiment and momentum. Periods of unapologetic enthusiasm for the entire industry follow long spells of blanket pessimism. In these periods, the markets hardly distinguish those companies deploying investor capital wisely from those pursuing flawed business models. Moreover, within this overall volatile market environment, individual sub-sectors and companies within the industry can fall in and out of favour based on developments that may or may not accurately reflect their prospects. For example, even very young genomics companies were celebrated in 2000 due to publicity surrounding the HGP; by contrast, in the mid 1990s, relatively mature companies developing monoclonal antibody technology and products were essentially written off by investors following a series of setbacks. Also,

for a single company, a single disappointment can destroy market capitalisation in a manner disproportionate to the real impact on intrinsic value, leaving the company orphaned by the markets and cut off from further financing. The unforgiving way in which investors punish a company whose lead programme stumbles is a particularly prominent phenomenon in biotechnology, because drug discovery and development carry perhaps the longest and most high-risk product development cycle of any industry. Since far more products fail than succeed, even the best companies will experience unpredictable setbacks on their path to success. All these discontinuities are exacerbated by the fundamental challenges involved in assessing intrinsic value in biotechnology. In any given company, the critical success factors – scientific, medical, regulatory, commercial, financial – are often difficult to evaluate for even the most skilled practitioners. Even worse, investors often have access to very limited information beyond the public disclosures and statements of management.'

J.III.3. Importance of venture capital(ists) for NBFs

The above explains why obtaining funding is as crucial as problematic for most NBFs. As such, it also explains why those ventures, during their development, (have to) use a variety of different funding sources. Between inception and (ideally) IPO, the funding of NBFs usually occurs in several rounds, where particularly in the middle stages ventures capital plays a dominant role (adapted from Consors Capital, 2002):

1. *Pre-/seed round* (sources: university, government, friends & family, business angel): 'proof of principle' for technology, development of business model and organizational structure
2. *Startup round* (sources: first venture capital (VC) syndicate, national): 'proof of concept' for technology, completion of management team, business development, first research cooperation
3. *Early-stage/development round* (sources: second VC syndicate, international): 'pre-clinical development' of technology, second alliance/cooperation incl. out-licensing of candidates
4. *Expansion/pre-IPO round* (sources: third VC syndicate, international): 'clinic I trials' for technology, cross-boarder alliance to reach 'critical mass', preparation of IPO
5. *IPO round* (sources: inter-/national underwriter, public market): further development of product candidates; often some income from out-licensing candidates but often still un-profitable overall

6. *Post-IPO/secondary round(s)* (sources: public market): after successful clinical trials, potential in-house expansion of NBF and/or take-over of company with complementary/competitive technology.

The importance of venture capital is also depicted in table L-6 with view to European NBFs.

Table L-6: Founding sources for European NBFs in 1998

(E&Y, 1999; figures are estimates taken from a graph)

Source of founding	**% of NBFs that received funds from source**
Private equity / venture capital[334]	54
Government grants	44
Operations / Sales	43
Debts	14
Strategic alliances	10
Other	9
Follow-on public offering	6
Initial public offering	4

Thus, whilst VCs might be important investors for several types of (high-tech) ventures, in hardly any other industry they play a more dominant role than in biotechnology. Indeed, the development of the US biotechnology industry is said to have been largely the outcome of a marriage between venture capital and university scientists (Senker, 1996). Furthermore, the US biotech industry is said to owe much to one particular VC, Robert Swanson from the VC firm Kleiner & Perkins. Realising the commercial potential of genetic engineering, he approached Herbert Boyer, co-inventor of the gene-splicing process, to launch Genentech – the first commercial biotechnology company – in 1976 (Senker, 1996). But also countries such as Germany that only recently realised the potential of NBFs as driver of innovation for their economies, have established public programmes that provide public subsidies only to those NBFs that first managed to attract independent VCs.

Thus, it is widely accepted that successful commercialisation of biotechnology has been reserved for markets that foster and support venture capital (EY,

[334] Strictly speaking, venture capital is a subset of private equity and refers to equity investments made for the seed, startup, or expansion of a business. Overall, buyout (later stage) investments dominate the private equity markets since they involve large investments in older companies. In the context of the young biotech industry with its many young and small ventures, however, venture capital clearly dominates the private equity investments. Over the past 10 years, for instance, the average fraction of venture capital in all private equity investments in biotechnology was about 93% (median 96%) globally and 94% (median: 96%) in the U.S. (VE, 2004). Therefore, in the context of biotechnology, the terms private equity and venture capital can be used almost interchangeably.

2002). This, in turn, clearly makes an industry focus on biotechnology very suitable for research on venture capital.

Whilst private equity/venture capital (short: venture capital) arguably is vital for the development of most new biotechnology-based firms (NBFs) its availability varies significantly - with time, sectors and regions.[335]

Arguably most importantly, the availability of venture capital for NBFs varies with the overall situation in the financial markets. This is because VCs depend on the financial markets for raising their funds (usually from institutional investors such as pension funds in the US) and for exiting their investments via IPO. The latter is important for all VC investments but particularly so for biotech, where most ventures require substantial funding often over long periods of time but are also prone to failure. Thus, a small fraction of VCs' biotech portfolio has to make up for many losses and requires an exit route for the VC to be able to cash in.[336] For this purpose, it is generally accepted, IPOs are the most profitable exit route. As a consequence, the 'window of opportunity' (i.e. the period when the financial markets are willing to invest in public equity) plays a crucial role also for funding NBFs with private equity.

This notwithstanding, financial markets are known to be volatile and possibly erratic in their allocation of funds. The 'irrational exuberance' of these markets became particularly evident, for instance, during the recent 'dot.com' Bubble, and its bursting as documented in Shiller's book, written just before the collapse of the high-tech sector (Shiller, 1998). Some of the features of this Bubble were documented in an early chapter of this thesis (see chapter E.b). Thus we observed that from the mid 1990s the aggregate amount of private equity raised increased dramatically until 2000, after which point a similarly dramatic plunge was experienced.

Figure L-1 below illustrates simultaneously two aspects of the private equity industry, important with respect to the funding of NBFs. First, it shows that the

[335] The figures in this section are based on the Venture Economics (VE) database. Although this database is widely considered an authority in the field, one has to take into account that also VE does not have information on all private equity deals. Furthermore, many, but not all biotech ventures receive private equity. Therefore, it is again important to emphasize that the figures below present general trends but do not claim to represent the 'whole picture' for either the private equity or the biotech industry. Furthermore, it should be noted that in contrast to the previous figures, the subsequent figures use € amounts instead of $, and they mainly refer to the past decade only.

[336] In the case of biotech ventures this will often happen even if the firm has no marketable product at the time.

overall funds available for investments vary substantially, even on a yearly basis. Second, private equity investors tend to focus on the most innovative sectors, thought to promise the highest returns.

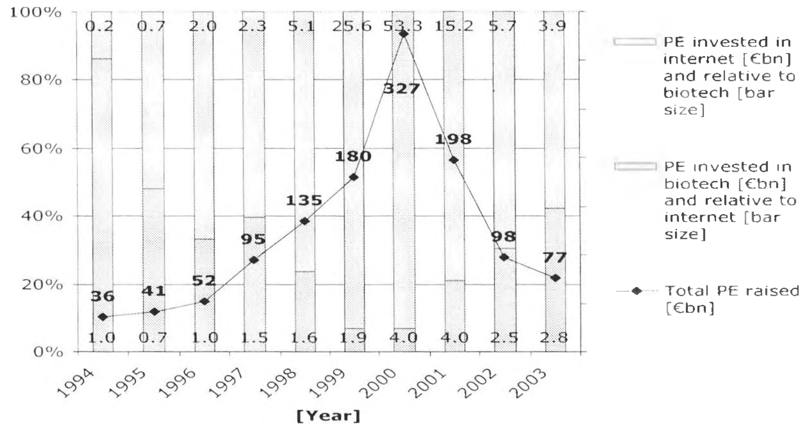

Figure L-1: Total private equity raised [€bn] & private equity invested [€bn] in biotech and Internet ventures 1994-2003 (*VE, 2004*)

Although the 'Bubble' particularly affected the Internet sector, on a much smaller scale, a parallel development can also be observed in biotech. The general rise and fall in investors' attitude towards high-tech ventures was arguably the most important single factor affecting the development in the funding of NBFs. However, the biotech sector was additionally affected, both positively and negatively, by a number of 'endogenous' events. These include the increasing 'hype' surrounding the Human Genome project and its alleged implications for new drug development and sales. Likewise, after 2001 the biotech sector was hit by bad news and scandals surrounding a few flagship biotech companies in both the US (e.g. ImClone) and in Europe (e.g. Elan).

As shown in Figure L-2 below, in 2000 there was an unprecedented peak in the number of biotech IPOs as well as in the overall funds raised in biotech IPOs.[337]

[337] With view to Figure 3 it must be mentioned that this is based on information from the venture economics database only, and exclusively lists IPOs of U.S. private equity based NBFs. The actual global numbers of NBF IPOs were about twice that shown in fig. 3. Ernst and Young, for instance, report that in 2000 alone there were 66 biotech IPOs in the U.S., 39 in Europe, and 12 in Germany. However, the overall trend reported by different sources is similar and represented in Figure 3: a sudden and dramatic increase in the number of biotech IPOs in 2000 was followed by an even more abrupt decrease the year since when hardly any biotech IPOs took place worldwide.

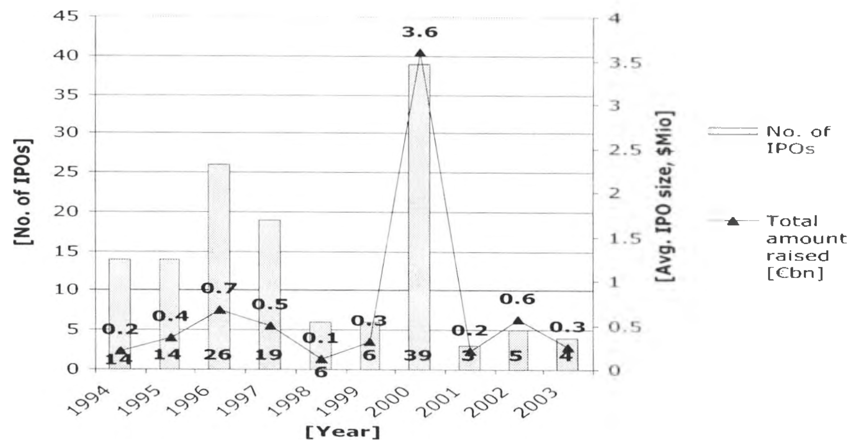

Figure L-2: Number of private equity backed biotech IPOs in the US & total amount raised in IPOs [€bn] 1994-2003 *(VE, 2004)*

Similarly, as shown in Figure L-3 below, the amount of private equity invested in the biotech sector increased by a factor 8 from €0.5bn in 1994 to €4bn in 2001 only to decrease to €2.5bn in 2002. In this context, one has also to take into account that in contrast to institutional investors who easily shift their funds across the globe private equity investors tend to operate largely on a *national* level. Although there is a trend towards more cross-boarder private equity activities, the majority of investments in a given country are still made by home-country investors. As a consequence, private equity investors are sensitive to the economic situation in their particular region. Thus, as figure L-3 below indicates, there are considerable differences between regions regarding the funding of NBFs.

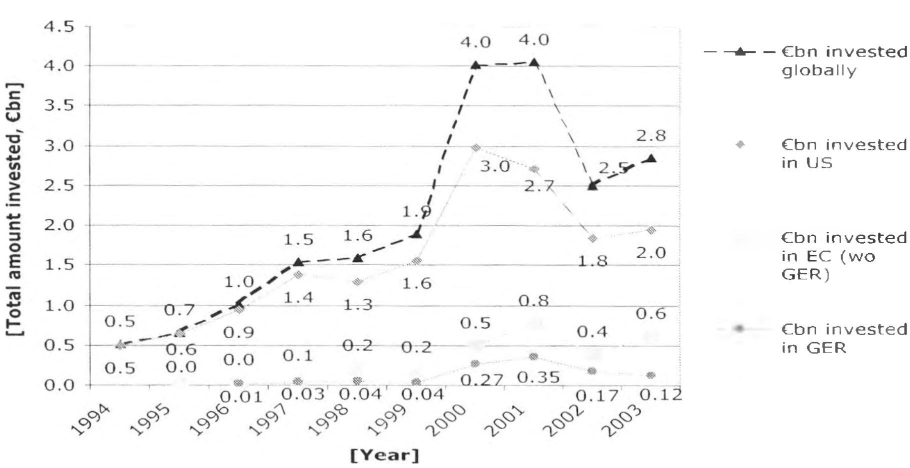

Figure L-3: Total amount of private equity invested in biotech [€bn] & regional distribution 1998-2003 *(VE, 2004)*

Significant regional differences also exist with respect to the number of NBFs receiving financing and the average deal size, as illustrated in Figure L-4 below.

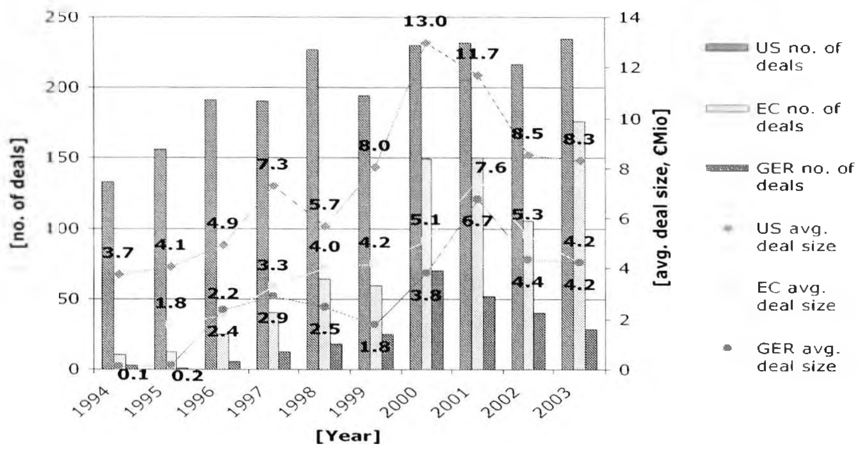

Figure L-4: Number of biotech deals & average deal size [€m] in the US, Europe, and Germany (*VE, 2004*)

At the same time, the regional differences in the private equity activity are manifest not only with view to the monetary resources available to NBFs in a given country but arguably also with view to the non-monetary contributions they can expect from their investors. This is particularly evident when comparing the average experience of investors (measured by their previous number of biotech investments) in US and German NBFs, as illustrated in Figure L-5 below.

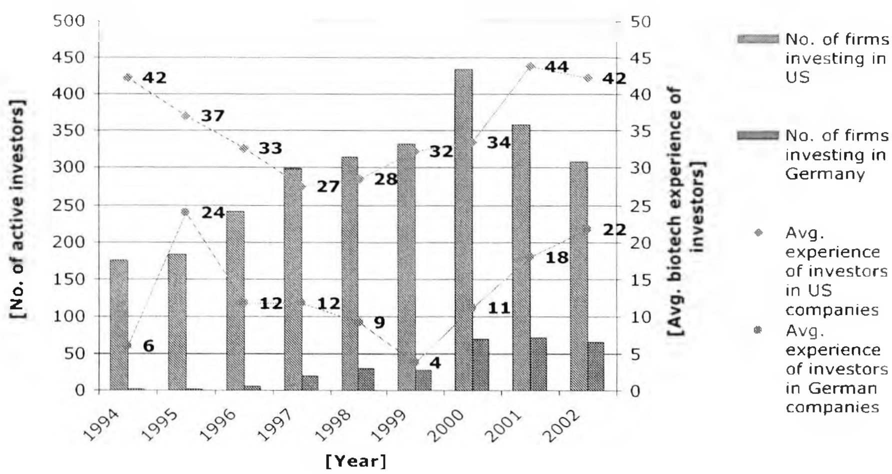

Figure L-5: Average biotech experience of investors** (**avg. no. of previous biotech deals**) **& total number of deals in the US and Germany from 1994 to 2003 (*VE, 2004*)

The above section indicates significant differences in the funding situation for NBFs between different regions. Those differences may partly be explained by different sizes of the regions. However, an additional explanation undoubtedly lies in the different development (-stages) of the biotech and venture capital sectors in those regions, which we outline in the following section.

As we will show in the following section, the development of the German biotech sector – and the role VCs played in this context – is different from the corresponding developments in the US, and from other European countries such as the UK. Thus, to some degree we must caution the more general applicability of some of the findings. However, we also feel that general lessons (e.g. with respect to the role of the VC cycle and its impact on VC strategy) can be drawn for other countries.

J.IV. The biotech sectors in the US, Europe, and Germany

Whilst our main focus is on the development of the biotech sector in Germany, we start with an overview of the corresponding developments in the US and in Europe. This is because, from the very beginning of biotechnology, the US was far ahead of all other countries. With a time lag of at least ten years, also the UK started catching up; and, finally, over the past 5-8 years, also other European countries – and here particularly Germany - began to put significant efforts into developing their biotech sectors.

J.IV.1. The US biotech sector - reaching its 'maturity'

The development of the US biotech industry started about three decades ago; but it is argued that, apart from heavy funding of the science base, the US Government did very little to actively promote the exploitation of biotechnology. Already by the late 1970s 11% of all federally funded R&D in the US was directed towards basic biomedical research; and by 1987, US Federal spending in this area in current prices was in the range of $2.7 billion. The significant support of basic research resulted in a rapidly increasing number of scientists and in some path-breaking discoveries in the field (Senker, 1996). At the same time, also the entrepreneurial culture in the US – particularly in the academic institutions - was helpful for the development of the biotech industry. US universities traditionally have been very open-minded towards the commercialisation of scientific discoveries. There was a long tradition of professors consulting for the industry. Furthermore, many academic institutions - such as the University of California, the Stanford University, the Massachusetts Institute of Technology, and the Harvard University - had well-established technology transfer departments. Thus, these institutions also functioned as initiation points for the development of clusters comprising many university 'spin-offs' as well as providers of relevant professional services such as patent attorneys, accountants, and investors.

However, it is also widely accepted that the commercialisation of biotechnological discoveries in the US would hardly have been possible without venture capital, a 'phenomenon' that first turned up in the US. The first venture capital fund – American Research and Development Corporation – was already established shortly after the end of world war two. Its aim was to supply risk capital to new, science-based companies; and it also functioned an example, inspiring the formation of many VC firms across the country. Already by 1979, there were 250 VC firms in the US – but only about 12 in the UK and none in Germany. Moreover, as mentioned before, the US biotech industry is said to owe much to one particular VC, Robert Swanson from the VC firm Kleiner & Perkins. Realising the commercial potential of genetic engineering, he approached Herbert Boyer, co-inventor of the gene-splicing process, to the launch of Genentech – the first (venture capital backed) biotechnology company – was founded in 1976 (Senker, 1996). Genentech's success – it turned profitable already in 1979 and it went public in 1980 - is often said to be responsible for the birth of the US biotechnology industry in several ways. The successful outcome of the company's initial research project showed the commercial potential of recombinant DNA techniques. Furthermore, Genentech's deal with Eli Lilly in 1982 proved two things to would-be entrepreneurs. First, their intellectual property could be monetized; and second, they could focus on just one component of the R&D supply chain and did not have to enter the industry as a drug company.

Together, this contributed to a flood of new entrants, predominantly university spin-offs, which has continued over the past two decades, with company formation having its peak in 1987 with 91 newly founded ventures. So, already by 1991 in the US there were approximately 750 new biotechnology firms. These small firms created and maintained the US lead in biotechnology in the international comparison (Senker, 1996). Today, by all measures, the US biotech sector clearly is much more mature than that of any other nation. One sign of its maturity is, for instance, the fact that the total number of US biotech ventures remained relatively unchanged over the past five years, whilst the number of late-stage, privately held NBFs with a strong financial and technological fundament is many times higher than anywhere else. Furthermore, the US has more than half of all public biotech ventures; and they are responsible for about three quarters of both revenues and R&D expenses worldwide; and one US public NBF, Amgen, has about the same market capitalisation as all European public NBFs combined. The US public biotech ventures have brought several blockbuster drugs to the market each earning more than $1bn a year. Furthermore, more than 190 biotech products are approved for marketing and more than 300 biotech products are in phase III trials (compared to about 100 in Europe). Together this is expected to make the US biotech sector as a whole the first to become profitable by 2008 (E&Y, 2004a).

In sum, the successful early development of the US biotechnology industry is said to have been largely the outcome of a marriage between venture capital and university scientists, in a culture, which encouraged a close relationship between university science and industry and supported entrepreneurship (Senker, 1996).

J.IV.2. The European biotech sector - passing its 'puberty'

Within Europe, the first country trying to catch up with US was the UK. The rapid growth of the US biotech sector caused concern in the UK that there a similar phenomenon was not occurring (Senker, 1991, 1993; HoC, 2003). As a consequence, in 1980, the UK government set up the first British biotech company, Celltech, which received £12m backing from the government and the City, and it got preferential access to research sponsored by the UK's Medical Research Council (MRC). Furthermore, in 1981, the Science and Engineering Research Council set up the 'Biotechnology Directorate' to encourage mainly established pharmaceutical companies to become active in the area of biotechnology.

However, the UK government initially didn't increase the funding for the sector; and public sector spending on biotechnology R&D in current prices was only about £84m in 1987/8 (Senker, 1996). At the same time, British universities and academics had a rather negative attitude towards commercial activities, defending their values against demands of material progress. In this context, another crucial problem was the lack of venture capital in the UK. Thus, during the 1980s, hardly any small biotech firms were founded in the UK. A study in the late 1980s found only 48 UK biotech companies, which were new and independent at formation. By 1993 another survey identified 125. Yet another survey found that only about one-third of the founders of new biotechnology firms in the UK came from a public sector research background; over 64 percent came from the industry (Senker, 1996).

This only began to change in the late 1980s, i.e. with a delay of 5-10 years compared to the US, with public programmes aimed at increasing collaborative research between industry and universities, whilst simultaneously public funding for universities decreased forcing them to acquire funding from the industry. At the same time, also a risk capital sector began to develop. Together, this resulted in the foundation of a number of biotech companies in the late 1980s and the early 1990s, and the development of clusters around elite universities such as Cambridge. The UK now is second to the US with respect to the number of public biotech companies as well as with respect to their revenues and product pipelines. With a further delay of at least another five years, similar developments were to be observed in continental Europe. This was mainly due to political changes both on an EC level and national levels. Several countries set out to develop their biotech sectors by building up an infrastructure and providing substantial funds.

As a consequence, there was to be observed a dramatic growth of the European biotech industry since the mid 1990s, as becomes evident from the comparison of the developments in the European and the US biotech sectors from 1998 to 2003, as illustrated in Table L-7 below.

Table L-7: Comparison of the biotech industries in the US and Europe 1998-2003

(E&Y, 2004b)

	2003		**1998**		**Change**	**98-03**
	US	**Europe**	**US**	**Europe**	**US**	**Europe**
Public companies						
Revenues [$bn]	35,9	7.5	16.7	0.9	115 %	754 %
R&D expense [$bn]	13.6	4.2	6.7	0.7	101 %	556 %
Net loss [$bn]	3.2	0.6	1.9	0.4	71 %	58 %
No. of employees	146,100	32,470	106,000	11,449	38 %	184 %
No. of companies						
Public companies	314	96	316	68	-1 %	41 %
Private companies	1,159	1,765	995	1,110	16 %	59 %
Public & private companies	1,473	1,861	1,311	1,178	12 %	58 %

Whilst the above seems to suggest a true success story of the European biotech sector, it must be emphasized though that the European biotech sector still falls far behind that of the US on almost all key variables but the total number of companies. For instance, as yet, no European biotech company has brought a self-developed product to the market; and, overall, the European sector is characterized by a high proportion of early-stage companies.

In this context a major problem for the European biotech sector over the past years was that – because of the comparative immaturity of the European biotech and (risk-) capital industry - European NBFs couldn't replenish their cash reserves during the latest 'window of opportunity' to the same degree as their

US counterparts. This led to a significant funding shortage, as illustrated for public NBFs in table L-8 below.

Table L-8: Comparison of cash reserves of US and European public NBFs *(E&Y, 2004b)*

Cash reserves lasting	US [% of public NBFs]	Europe [% of public NBFs]
> 5 yrs	38	11
3-5 yrs	17	21
2-3 yrs	14	23
1-2 yrs	16	22
<1 yr	15	19

As a consequence, and particularly because of the recent downswing in the financial markets, it is expected that that European sector first has to go through some period of consolidation and restructuring - before it can finally leave behind its 'puberty', and eventually catch up with the maturity of the US sector.

J.IV.3. The German biotech sector - suffering from 'growing pains'

Particularly compared to the US but also compared to some European countries, the biotech sector in Germany has lagged far behind. This had various reasons, some of which dating back to the 1930s.

As Momma and Sharp (1999) describe, historically, the development of the life sciences in Germany has been constrained in number of different ways. To begin with, the 'Third Reich' had led to a huge loss of human capital due to the prosecution and murder of Jewish and other 'unwanted' scientist and students. After world war two, furthermore, many young scientists left Germany in search of better working conditions, which they mainly found in the US. Together, this led to a dramatic shortage of experienced scientists in Germany; and in the 1970s, when biotechnology began taking off in the US, in Germany there were only some isolated centres of excellence in biology (e.g. in several Max-Plank Institutes and some Universities).

Furthermore, similar to their UK colleagues, German professors for a long time remained uninterested in commercialising their scientific findings. At the same time, however, also the German pharmaceutical industry, once called the 'world's pharmacy', remained focused on synthetic chemistry rather than biological sciences. As a consequence, there were hardly any co-operations between pharmaceutical companies and universities. In this context, also the German culture of incremental rather than radical innovations – in a corporate rather than an entrepreneurial setting - was another obstacle for developing a national biotechnology industry.

Finally, and quite importantly, there was a massive suspicion in the German public regarding genetic science linked to 'eugenics'. In the German consensus-oriented society, this clearly presented a major hurdle for the development of a biotech industry.

This somewhat changed in the early 1980s, when the potential of ('red') biotechnology began to be recognised at least in the pharmaceutical industry. However, because of a lack of public acceptance, a scarcity in local capabilities, and harsh governmental regulations, large German pharmaceutical and chemical companies increasingly began investing abroad (again mainly in the US), further threatening the development of a sound bio-science sector at home.

Alarmed by those developments German policy makers began to search for new approaches to foster the biotech sector. By 1983, the Federal Ministry for Science and Research set up an advisory board for large public research projects, with particular focus on biotechnology. Not much later an expert commission for biotechnology was established up to develop a federal biotechnology programme. One of the early goals, the doubling of federal expenditure in the field, was achieved within 5 years in 1990. This paved the way for some considerable improvements in the national science base.

Furthermore, in 1984 the Parliament set up the 'Enquete Commission' for biotechnology, which included a broad spectrum of stakeholders and experts (from science, law, theology etc.). The participants developed recommendations that provided the basis for a Gene Law, which was passed in 1990. Particularly the amendment of this law in 1993 is widely seen as an important cornerstone for the development of biotechnology in Germany. At the same time, the intensified public discussion about biotechnology resulted in a shift in the public attitude towards this sector. Although the overall scepticism towards biotechnology continued, more began to realise potential benefits, particularly in the medical field.

However, a major obstacle for the development of a biotech sector in Germany remained the absences of venture capital. In Germany, companies usually turned to banks for credit financing, shying away from equity investments – but also foregoing the chance of rapid expansion or starting new cash-consuming ventures. The concept of high-risk, high-return venture capital was unfamiliar in Germany, and so was the idea of setting up an NBF.

As a consequence, according to Momma and Sharp (1999) until 1995, in Germany, there were still less than 70 *dedicated* biotechnology firms, of which 14% (i.e. about nine companies) were service- or platform-technology-provider, businesses with limited risk but also limited upside potential compared to drug-developing companies.

By the mid 1990s, Germany's economy increasingly began to suffer from the burden of re-unification and from the constant under-investment in new technologies, and unemployment rates reached a historic height with more than 11%. As a consequence, the German federal government began to realise the urgent need for change, and it made biotechnology one of its key priorities.

Arguably the most important step in this context was initiated by the Secretary of Economic Affairs, Dr. Juergen Ruettgers (formerly Head of Research with the pharmaceutical company Roche). In 1995, he organized the so-called BioRegio competition. Inspired by the apparent success of US biotech clusters, this competition aimed at identifying several competence centres for Biotechnology in Germany, and developing their existing infrastructure and networks further to achieve 'critical mass' of industry-relevant know-how.

Indeed, the competition, together with its networking efforts and the publicity generated, provided the push that finally started the industry. Out of 17 participating regions the three winning regions (Munich, Rhineland, and Rhine-Neckar) received a total of about €80m in funding, disbursed from 1997 to 2002. Those funds were locally administered by private-public organizations, which also set up incubators, organized business plan competitions, offered seed funding and start-up relevant advice.

Whilst the BioRegio Competition was mainly targeted towards developing the required infrastructure (cluster), both the federal and the state governments additionally set up various programmes to financially support the foundation and development of individual NBFs. As a consequence, would-be-entrepreneurs and NBFs got access to a vast array of different funding sources on both the state and federal level.

For instance, on the federal level important funding institutions – not only but also for biotechnology - are the Credit-Institute for Reconstruction (KfW) and the German Bank for Equalization Payments (DtA) with its subsidiary Technology Equity-Participation Organisation (tbg); and a key element of the Federal 'equity for young technology companies' (BTU) programme.

In the start-up phase, a NBF can obtain up to €1.5m from the tbg.[338] However - and that is the very characteristic of the BTU programme - for the NBF to apply for this funding, it first has to find a lead venture capitalist (VC) providing both non-financial and financial support. The tbg then will match the VC's funds up to the amount mentioned above. Simultaneously, NBFs can obtain a further €1m from another DtA programme also matching the VC's investment. The lead VC, in turn, can get a loan from the KfW for up to 70%, or a maximum of €1.4m, of his investment, repayable within a maximum of 10 years. The KfW, furthermore, guarantees half the loan in case the venture fails.

Furthermore, parallel to the above BTU programme, there are several biotech-specific programmes that provide considerable, non-repayable subsidies to NBFs. For instance, programmes such as BioFuture, BioChance, and BioProfile all intend to encourage and support scientists turning entrepreneurs.

The government's funding schemes for NBFS undoubtedly made the German biotech sector very attractive for venture capitalists, resulting in the establishment of many national venture capital funds as well as in a massive influx of venture capital from other countries.

Together, from the mid 1990s onwards, this encouraged many scientists to set up their own ventures, and it resulted in an unprecedented growth of the German biotech industry. For instance, between 1996 and 2001, the number of German core biotech companies rose from about 100 to more than 360.

There is no doubt, over the past years, nowhere else has the development of the biotech sector been more dramatic than in Germany – in both a positive and negative sense. Despite its late start, the German model was clearly very successful in kick-starting the biotech industry. As shown in Table L-9 below, this is most obvious with view to the number of newly created NBFs. After the US, Germany today has the largest number of NBFs worldwide. The apparently successful launch of the German biotech sector caused some 'jealousy' amongst other young biotech nations, and not just a few seem inclined to imitate the German approach.

[338] Before the start-up stage, in the pre-/seed stage, a NBF can obtain up to €150.000 from the tbg for developing its business concept and organizational structure to a stage when it should be able to attract the first funding from VCs. For this purpose the tbg requires the venture to have a 'mentor' providing support in form of management and industry knowledge for about six months. Simultaneously, a NBF can obtain up to €250.000 from another DtA programme. In addition there are also some other DtA soft-loan schemes for later stages, bringing the total amount of possible government backing to more than €7m per venture.

Table L-9: Overview over the German biotech sector from 1998 to 2003

(source: E&Y, various reports)

Germany	1998	1999	2000	2001	2002	2003
No. of public companies			12	12	12	11
No. of all companies	222	279	332	365	360	350
Revenues [€bn]	0.4	0.5	0.8	1.1	1.0	1.0
R&D expense [€bn]	0.2	0.3	0.7	1.2	1.1	1.0
No. of employees	5,650	8,124	10,673	14,408	13,400	11,535

However, it is obvious, the German sector is still very immature. Most of German NBFs – and even the public ones - hardly play a role on the international scene. There are only 11 public NBFs in Germany compared to 43 in the UK, and more than 300 in the US. Amongst the top 10 European NBFs, there is not a single German one. Similarly, comparing the market caps of European public NBFs, Germany is only on the fifth position, behind, the UK, Switzerland, Ireland, and the Netherlands. Also, the product pipeline of German public NBFs in 2003 is much less mature than that of several other European countries, as illustrated in Table L-10 below.

Table L-10: Comparison of the pipeline of European public NBFs in 2003 *(E&Y, 2004b)*

Country	Pre-clinic	Clinic I	Clinic II	Clinic III	Total
Total	147	82	95	68	392
UK	50	37	46	27	160
Switzerland	33	8	14	20	75
France	15	12	8	1	36
Sweden	13	7	8	1	29
Denmark	10	7	7	4	28
Germany	8	3	2	2	15

Overall, and particularly when compared to the US and the UK, the biotech sector in Germany is clearly characterized by an extremely high proportion of small NBFs, as illustrated in Table L-11 below.

Table L-11: Size distribution of German NBFs in 2003 *(E&Y, 2003b)*

Number of employees per NBF	% of German NBFs in 2003
1-10	44
11-30	33
31-50	10
51-100	9
101-300	3
<301	1

In this context, another characteristic of the majority of German NBFs is that they are still in a very early development stage, as can be seen from Table L-12 below.

Table L-12: Stage distribution of German NBFs in 2003 *(E&Y 2003b)*

Development stage	% of German NBFs in 2003
Start-up, before first round	28
After 1st round	37
After 2nd round (incl. IPO)	35

More than two thirds of all German NBFs did not yet go through a second financing round, and more than a quarter not even through a first financing round. This seems particularly critical when taking into account the recent downturn in the financial markets' sentiment for the biotech sector that hit Germany particularly hard. Not only did the overall capital available for the sector and the number of deals plummets but also the investors' willingness to finance early stage NBFs, as illustrated in Figure L-6 below.

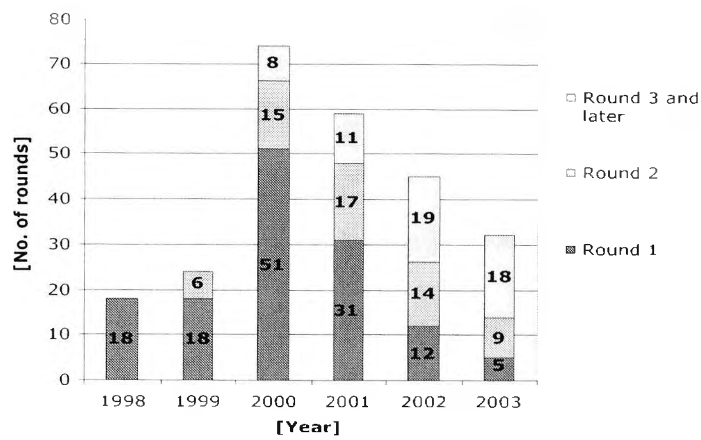

Figure L-6: Number of investments in round 1, 2, and later in German NBFs 1994-2003 *(VE, 2004)*

As a consequence, there developed a build up particularly of early stage companies that soon require either a first or a second round but that are unlikely to receive the funds unless a drastic change occurs in the financial markets. Therefore, the German biotech sector currently is characterized by downsizing and cost cutting, leading to the second consecutive year of shrinking. Also, to survive, a number of NBFs have changed their business model from an exclusive focus on the high-risk/return drug development to a partial focus on low-risk/return service provision that promises at least some - albeit small - early revenues. Moreover, it is assumed that many smaller companies that officially are still active might actually be in a state of hibernation - from which they might not wake up anymore.

In sum, the development of the Germany biotech sector both benefited and suffered significantly from the parallel developments on the global markets.

Initiated by governmental support programmes, the significant growth of the German biotech sector was further pushed by a simultaneous upswing in the global markets' sentiment for high-tech ventures in general and NBFs in particular. But the downswing in the global markets' occurred at a time when the German biotech sector was still in its infancy, characterized by a large number of early-stage NBFs that are vitally dependent on external funding.

Together with the now empty public pockets, this made the biotech sector in Germany feel the global problems much more than in any other country. And it remains to be seen whether and when the German biotech sector will make it through its 'infancy'.

APPENDIX II – TABLES

J.V. Tables Chapter C

Table C-1: Overview over the most common 'VC-differentiators' used in the previous literature that might serve as proxies for VCs' 'knowledge'

VC 'differentiator' (X)	Operationalization	Authors	Focus of study - for details, see lit. review, section:	Key conclusion regarding impact of VC 'differentiator' (X)	Suitability of proxy / method
Age / years of activity	Age in years since foundation	Sorenson & Stuart (2001)	Ex ante: Originating	X can be related to origination	- / +
		Sapienza et al. (1996)	Ex ante: Monitoring / Supporting	X can be related to monitoring / supporting	- / +
		Bottazzi et al. (2004)	Ex ante: Monitoring / Supporting	X can be related to monitoring / supporting	- / +
		Gompers (1996)	Ex ante: Exiting	X can be related to exiting	- / +
		Manigart et al. (2002)	Ex post: Performance	X can be related to performance	- / -
		Barry et al. (1990)	Ex post: Performance	X can be related to performance	- / -
		Hochberg et al. (2004)	Ex post: Performance	X can be related to performance	- / +
	Age relative to peers	Kaplan et al. (2004)	Ex ante: Contracting	X can be related to contracting	- / -
		Lerner (1994)	Ex ante: Syndicating	X can be related to syndication	- / +
		Lerner (1995)	Ex ante: Exiting	X can be related to exiting	- / +
	Years of operating in industry of focal venture	Sapienza et al. (1996)	Ex ante: Monitoring / Supporting	X can be related to monitoring / supporting	- / +
		Bottazzi et al. (2004)	Ex ante: Monitoring / Supporting	X can be related to monitoring / supporting	- / +
Funds under management / invested	Funds under management	Bygrave (1987, 1988)	Ex ante: Syndicating	X can be related to syndication	- / +
		Barry et al. (1990)	Ex post: Performance	X can be un-related to performance	- /-
		Kaplan & Schoar (2003)	Ex post: Performance	X can be related to performance	- / +
	Funds under management relative to peers	Lerner (1994)	Ex ante: Syndicating	X can be related to syndication	- / -
		Lerner (1995)	Ex ante: Exiting	X can be related to exiting	- / +
		Kaplan et al. (2004)	Ex ante: Contracting	X can be related to contracting	- / -
	Cumulative funds invested	Gulati & Higgins (2003)	Ex post: Performance	X can be related to performance	- / +
		Hochberg et al. (2004)	Ex post: Performance	X can be related to performance	- /+

(continued) Table C-1: Overview over the most common 'VC-differentiators' used in the previous literature that might serve as proxies for VCs' 'knowledge'

VC 'differentiator' (X)	Operationalization	Authors	Focus of study - for details, see lit. review, section:	Key conclusion regarding impact of VC 'differentiator' (X)	Suitability of proxy / method
	No. of previous funds raised	Kaplan & Schoar (2003)	Ex post: Performance	X can be related to VC performance	+ / -
Reputation / network characteristics	Entrepreneurs' assessment of (lead) VC's 'network resources' and 'industry reputation'	Hsu (2003)	Ex ante: Originating	X can be related to origination	- / -
	Degree score in biotech patent citation network ('technological prominence')	Stuart et al. (1999)	Ex post: Performance	X can be un-related to performance	- / +
	Degree score in biotech deal network ('commercial prominence')	Stuart et al. (1999)	Ex post: Performance	X can be related to performance	- / +
	Degree, closeness, and betweenness in VC network	Hochberg et al. (2004)	Ex post: Performance	X can be related to performance	- / -
Human capital	(Avg.) individual investment manager's 'business experience' or 'science education'	Bottazzi et al. (2004)	Ex ante: Monitoring / Supporting	X can be related to monitoring / supporting	+ / -
	(Avg.) investment managers' 'VC industry experience'	Bottazzi et al. (2004)	Ex ante: Monitoring / Supporting	X can be related to monitoring / supporting	- / +
	Entrepreneurs' assessment of strategic advise' obtained from VC	Busenitz et al. (2004)	Ex ante: Monitoring / Supporting	X can be related to monitoring / supporting	- / -
	% management's educational background in science/humanities ('general human capital')	Dimov & Shepherd (2004)	Ex post: Performance	X can be related to performance	- / -
	% management's educat. or professional background in business/ law/finance ('specific human capital')	Dimov & Shepherd (2004)	Ex post: Performance	X can be related to performance	- / -

(continued) Table C-1: Overview over the most common 'VC-differentiators' used in the previous literature that might serve as proxies for VCs' 'knowledge'

VC 'differentiator' (X)	Operationalization	Authors	Focus of study - for details, see lit. review, section:	Key conclusion regarding impact of VC 'differentiator' (X)	Suitability of proxy / method
IPO track record	Portfolio ventures that went public	Barry et al. (1990)	Ex post: Performance	X can be related to performance	- / -
		Lange et al. (2001)	Ex post: Performance	X can be related to performance	- / -
	Relative IPO success rate in portfolio of Internet ventures	Chang (2004)	Ex post: Performance	X can be related to performance	- / +
	Relative IPO success compared to peers	Hsu (2004)	Ex post: Performance	X can be related to performance	- / +
Number / type of previous investments	No. of previous ventures invested in overall	Sorenson & Stuart (2001)	Ex ante: Originating	X can be related to origination	+ / -
	No. of previous ventures invested in same industry as focal venture	Sorenson & Stuart (2001)	Ex ante: Originating	X can be related to origination	+ / -
	No. of previous investments in focal venture's industry (dummy)	Hsu (2003)	Ex ante: Originating	X can be related to origination	+ / -
	Proportion and no. of investments in high-/low-tech ventures	Bygrave (1987, 1988)	Ex ante: Syndicating	X can be related to syndication	+ / -
	No. of previous investments in biotech	Lerner (1994)	Ex ante: Syndicating	X can be related to syndication	+ / -
	No. of previous investments overall	Hopp & Rieder (2004)	Ex ante: Syndicating	X can be related to syndication	+ / -
	Self-stated preference for venture industry and stage	Lockett & Wright (1999, 2001)	Ex ante: Syndicating	X can be related to syndication	- / -
		Manigart et al. (2004)	Ex ante: Syndicating	X can be related to syndication	- / -
	Familiarity with US investments (dummy)	Kaplan et al. (2004)	Ex ante: Contracting	X can be related to contracting	- / -
	No. of seats hold on the board of different ventures	Stein & Bygrave (1990)	Ex post: Performance	X can be related to performance	- / -
	No. of previous investments in Internet ventures	Chang (2004)	Ex post: Performance	X can be un-related to performance	+ / -
	No. of previous rounds participated in	Hochberg et al. (2004)	Ex post: Performance	X can be related to performance	+ / -
	No. of previous ventures invested in	Hochberg et al. (2004)	Ex post: Performance	X can be related to performance	+ / -

J.VI. Tables Chapter F

Table F-1: Findings from empirical key studies on syndication

Author(s)	**Aspects**	
Bygrave (1987, 1988)	Data source	Venture Economics database
	Period	1966-1982
	Country	US
	VCs	464 VCs; categorized according to size (funds under management), investment preference (high-low-innovation ventures) and absolute number of previous investments
	Ventures	1,501 ventures; only first rounds, early- and later stages, various high-/low-tech industries
	Main findings	No difference in syndication behaviour of large and small VCs; but more syndication in case of riskier (high innovation, high-tech, or early-stage) investments – even so deal sizes are smaller
	Conclusion	Primary motive for syndication is sharing of knowledge rather than spreading of financial risk; VCs gain access to networks by having knowledge that other firms need
Lerner (1994)	Data source	Venture Economics database
	Period	1978-1989
	Country	Not specified but presumably mainly US data
	VCs	Number not specified; categorized for first round analysis by relative size (% of total committed capital in year) and age; and for later round analysis additionally by no. of previous biotech investments
	Ventures	651 investment rounds in 271 privately held biotech ventures
	Main findings	In first rounds, VCs syndicate significantly more often with VCs of similar size/age (but unclear whether similar large/high or similar small/low size/age); older/larger VCs and VCs specializing in (risky) start-up ventures seem to syndicate less (but not significantly). In later rounds VCs also syndicate with VCs of different size/age; and VCs in later rounds are, on average, less established than in first rounds
	Conclusion	Primary motive for syndication is gathering additional knowledge for pre-investment decision-making
Lockett & Wright (1999, 2001)	Data source	Questionnaire-based survey of VCs
	Period	Not specified
	Country	UK
	VCs	Ca. 60 VCs; categorized by self-stated industry-/financing-stage expertise (Likert scale) and/or minimum investment size preference
	Ventures	Not specified, but from several industries and in various stages
	Main findings	VCs rate finance-related motives as more important for syndication than knowledge-related motives; but VCs with smaller minimum investment preferences regard both kinds of motives as more important than VCs with larger min. investment preferences. Syndicate partner selection is driven mainly by past interaction, reputation, and investment style – but less by finance- or knowledge-related motives. Competition in VC market (low level of funds available to VCs) is negatively related to syndication.
	Conclusion	Primary motive for syndication is need to spread financial risk (portfolio diversification) and to gain additional financial resources; although, in some cases, knowledge related motives might be relevant, too.

(continued) Table F-1: Findings from empirical key studies on syndication

Author(s)	**Aspects**	
Sorenson & Stuart (2001)	Data source	Venture Economics database
	Period	1986-1998
	Country	Not specified but presumably mainly US data
	VCs	1.025 VCs; categorized according to experience (previous no. of investments overall and/or in industry of focal venture) and various network position characteristics (affiliation, centrality etc.)
	Ventures	7,590 ventures; not further specified
	Main findings	VCs are more likely to invest in 'distant' ventures (in terms of geographical distance and/or industry distance) the more overall (but not industry) experience they have. This, however, seems to be moderated mainly by the fact that more experienced VCs, over time, develop stronger network-ties
	Conclusion	Syndication is a means to extend the investment reach of VCs, and it is moderated by VCs' experience
Brander et al. (2002)	Data source	Surveys (by Macdonald & Associates)
	Period	1992-1997
	Country	Canada
	VCs	114 Canadian VCs; not further specified/categorized
	Ventures	2,889 ventures from various industries
	Main findings	Annual return for VCs is significantly higher for syndicated than for unsyndicated investments (35-39% vs. 15-20%)
	Conclusion	Primary motive for syndication is post-investment 'value-adding' and not so much pre-investment decision-making
Hopp & Rieder (2004)	Data source	Unspecified
	Period	Unspecified
	Country	Germany
	VCs	812 VC; categorized according to number of previous investments overall (as a basis to categorize VCs in groups one time investor' (1 investment), 'very small VC' (2-3 inv.), 'small VC' (4-6 inv.), 'lower middle field VC' (7-10 inv.), 'upper middle field VC' (11-20 inv.), 'large VC' (21-50 inv.), and 'very large VC' (> 50 inv.)
	Ventures	1,962 venture
	Main findings	More experienced VCs have lower syndication ratios
	Conclusion	Knowledge-related factors can play an important role as motives for syndication

(continued) Table F-1: Findings from empirical key studies on syndication

Author(s)	**Aspects**	
Manigart et al. (2004)	Data source	Survey of European VCs
	Period	Survey in 2001; but investments may come from unspecified period
	Country	Europe (Belgium, France, Germany, The Netherlands, Sweden, UK)
	VCs	317 VCs, categorized according to self-stated investment-stage (early/late) preference and industry specialization
	Ventures	Not specified
	Main findings	For both early- and later-stage VCs, risk sharing, portfolio diversification, and access to larger deals are more important than selection and monitoring of deals; but value adding is not a significantly important motive for any VC. VCs' industry specialization only is significantly (negatively) related to the deal-selection motive for syndication, but not to any other motive for syndication
	Conclusion	For European VCs, primary motive for syndication is risk sharing, portfolio diversification, and access to larger deals
Valliere & Peterson (2004)	Data source	Informal interviews with VCs
	Period	1998-2001
	Country	US and Canada
	VCs	57 US and Canadian VCS that invested in early-stage, high-tech ventures during the boom period 1998-2001
	Ventures	Early-stage, high-tech ventures
	Main findings	Important motive for syndication is sharing of due-diligence efforts, and syndication appears to be more common in case of smaller investments where it is more difficult to amortize due-diligence costs.
	Conclusion	Primary motive for syndication is gaining additional knowledge to reduce costs of pre-investment decision making

Table F-3: Hypotheses 1 - Descriptive statistics

Shown are the summary statistics and correlations for the analyses of Hypotheses 1, as well as the results from a t-test comparing the average values of the variables used in the analyses for syndicated and unsyndicated investments ('***': p<0.01; '**': p<0.05; '*': p<0.1).

Panel A: All investments (9,560)

Panel A: All Investments (N=9560)		Descriptive statistics							t-test
		Mean	SE	Med	SD	Min.	Max.	Sum	un-/synd
DV	Syndicated deal dummy (1=yes)	0.86	0.00	1.00	0.35	0.00	1.00	8,194	
Context controls	% change p.a. in VCs investing venture capital	112.08	0.24	112.26	23.27	81.83	149.00		
	% change p.a. in ventures receiving biotech venture capital	115.59	0.29	106.67	28.69	81.47	350.00		**
	% change p.a. in total venture capital raised	122.44	0.63	117.98	61.83	6.10	1,641.73		
	Dummy for period 1996-2000 (1=yes)	0.35	0.00	0.00	0.48	0.00	1.00	3,312	
VC controls	VC true private equity investor dummy (1=yes)	0.71	0.00	1.00	0.45	0.00	1.00	6,810	***
	VC from US dummy (1=yes)	0.86	0.00	1.00	0.35	0.00	1.00	8,176	
	VC % prev. syndicated biotech deals	74.83	0.34	87.88	33.41	0.00	100.00		***
Finance controls	Deal size ($Mio)	9.30	0.13	4.91	12.82	0.01	150.00		***
	Ratio deal size to avg. prev. investment size in biotech	10.35	0.23	5.43	22.14	0.00	960.00		***
Venture controls	Venture 1st round investment dummy (1=yes)	0.21	0.00	0.00	0.41	0.00	1.00	2,041	***
	Venture start-up/seed/early-stage dummy (1=yes)	0.55	0.01	1.00	0.50	0.00	1.00	5,289	**
	1st investment by VC in venture dummy (1=yes)	0.50	0.01	1.00	0.50	0.00	1.00	4,814	***
	VC and company from different nation dummy (1=yes)	0.12	0.00	0.00	0.33	0.00	1.00	1,178	
VC knowledge	VC age 'experience'	11.82	0.12	9.00	11.43	0.10	131.00		***
	Non-biotech experience	136.81	2.28	49.00	222.99	0.00	2,041.00		
	Total non-/biotech experience	160.57	2.55	62.00	249.47	1.00	2,207.00		*
	Biotech expertise	23.76	0.43	9.00	41.60	0.00	378.00		***
	Biotech-stage expertise	5.79	0.11	2.00	10.45	0.00	121.00		***

Panel A: All Investments (N=9560)		Correlations																			
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
DV	Syndicated deal dummy (1=yes)	1	1.000																		
Context controls	% change p.a. in VCs investing venture capital	2	0.003	1.000																	
	% change p.a. in ventures receiving biotech venture capital	3	0.024	0.534	1.000																
	% change p.a. in total venture capital raised	4	-0.006	0.768	0.535	1.000															
	Dummy for period 1996-2000 (1=yes)	5	0.011	0.757	0.339	0.564	1.000														
VC controls	VC true private equity investor dummy (1=yes)	6	-0.030	-0.013	-0.024	0.009	-0.022	1.000													
	VC from US dummy (1=yes)	7	0.002	-0.009	0.001	0.076	-0.082	0.018	1.000												
	VC % prev. syndicated biotech deals	8	0.134	-0.069	-0.122	-0.053	-0.042	0.081	0.129	1.000											
Finance controls	Deal size ($Mio)	9	0.233	0.038	0.033	-0.070	0.146	-0.051	-0.128	0.054	1.000										
	Ratio deal size to avg. prev. investment size in biotech	10	0.148	0.053	0.055	0.033	0.054	-0.043	-0.031	-0.028	0.371	1.000									
Venture controls	Venture 1st round investment dummy (1=yes)	11	-0.101	0.006	0.064	0.008	0.006	-0.007	-0.106	-0.180	-0.137	-0.079	1.000								
	Venture start-up/seed/early-stage dummy (1=yes)	12	0.020	-0.065	0.015	0.009	-0.137	0.029	0.098	-0.039	-0.227	-0.076	0.276	1.000							
	1st investment by VC in venture dummy (1=yes)	13	0.041	0.022	0.065	0.003	0.035	-0.124	-0.154	-0.242	0.091	0.063	0.517	0.148	1.000						
	VC and company from different nation dummy (1=yes)	14	0.008	0.017	0.002	-0.041	0.075	-0.042	-0.465	-0.029	0.104	0.008	0.031	-0.086	0.114	1.000					
VC knowledge	VC age 'experience'	15	0.026	0.088	-0.015	0.037	0.135	-0.050	0.003	0.117	0.096	0.043	-0.052	-0.062	-0.052	0.032	1.000				
	Non-biotech experience	16	-0.011	0.027	-0.040	0.013	0.044	0.035	0.152	0.145	0.092	0.007	-0.085	-0.074	-0.120	-0.061	0.318	1.000			
	Total non-/biotech experience	17	-0.017	0.031	-0.045	0.010	0.052	0.054	0.158	0.151	0.094	0.004	-0.089	-0.081	-0.136	-0.060	0.316	0.991	1.000		
	Biotech expertise	18	-0.047	0.037	-0.055	-0.012	0.076	0.137	0.129	0.124	0.072	-0.011	-0.083	-0.092	-0.171	-0.031	0.189	0.581	0.686	1.000	
	Biotech-stage expertise	19	-0.032	-0.001	-0.073	-0.036	0.032	0.131	0.097	0.127	0.041	-0.025	-0.036	0.133	-0.122	-0.016	0.181	0.500	0.588	0.843	1.000

(continued) Table F-3: Hypotheses 1 - Descriptive statistics

Shown are the summary statistics and correlations for the analyses of Hypotheses 1, as well as the results from a t-test comparing the average values of the variables used in the analyses for syndicated and unsyndicated investments ('***': p<0.01; '**': p<0.05; '*': p<0.1).

Panel A: All investments (9,560)

Panel A: All Investments (N=9560)		Descriptive statistics							t-test
		Mean	SE	Med	SD	Min.	Max.	Sum	un-/synd
DV	Syndicated deal dummy (1=yes)	0.86	0.00	1.00	0.35	0.00	1.00	8,194	
Context controls	% change p.a. in VCs investing venture capital	112.08	0.24	112.26	23.27	81.83	149.00		
	% change p.a. in ventures receiving biotech venture capital	115.59	0.29	106.67	28.69	81.47	350.00		**
	% change p.a. in total venture capital raised	122.44	0.63	117.98	61.83	6.10	1,641.73		
	Dummy for period 1996-2000 (1=yes)	0.35	0.00	0.00	0.48	0.00	1.00	3,312	
VC controls	VC true private equity investor dummy (1=yes)	0.71	0.00	1.00	0.45	0.00	1.00	6,810	***
	VC from US dummy (1=yes)	0.86	0.00	1.00	0.35	0.00	1.00	8,176	
	VC % prev. syndicated biotech deals	74.83	0.34	87.88	33.41	0.00	100.00		***
Finance controls	Deal size ($Mio)	9.30	0.13	4.91	12.82	0.01	150.00		***
	Ratio deal size to avg. prev. investment size in biotech	10.35	0.23	5.43	22.14	0.00	960.00		***
Venture controls	Venture 1st round investment dummy (1=yes)	0.21	0.00	0.00	0.41	0.00	1.00	2,041	***
	Venture start-up/seed/early-stage dummy (1=yes)	0.55	0.01	1.00	0.50	0.00	1.00	5,289	**
	1st investment by VC in venture dummy (1=yes)	0.50	0.01	1.00	0.50	0.00	1.00	4,814	***
	VC and company from different nation dummy (1=yes)	0.12	0.00	0.00	0.33	0.00	1.00	1,178	
VC knowledge	VC age 'experience'	11.82	0.12	9.00	11.43	0.10	131.00		***
	Non-biotech experience	136.81	2.28	49.00	222.99	0.00	2,041.00		
	Total non-/biotech experience	160.57	2.55	62.00	249.47	1.00	2,207.00		*
	Biotech expertise	23.76	0.43	9.00	41.60	0.00	378.00		***
	Biotech-stage expertise	5.79	0.11	2.00	10.45	0.00	121.00		***

Panel A: All Investments (N=9560)		Correlations																			
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
DV	Syndicated deal dummy (1=yes)	1	1.000																		
Context controls	% change p.a. in VCs investing venture capital	2	0.003	1.000																	
	% change p.a. in ventures receiving biotech venture capital	3	0.024	0.534	1.000																
	% change p.a. in total venture capital raised	4	-0.006	0.768	0.535	1.000															
	Dummy for period 1996-2000 (1=yes)	5	0.011	0.757	0.339	0.564	1.000														
VC controls	VC true private equity investor dummy (1=yes)	6	-0.030	-0.013	-0.024	0.009	-0.022	1.000													
	VC from US dummy (1=yes)	7	0.002	-0.009	0.001	0.076	-0.082	0.018	1.000												
	VC % prev. syndicated biotech deals	8	0.134	-0.069	-0.122	-0.053	-0.042	0.081	0.129	1.000											
Finance controls	Deal size ($Mio)	9	0.233	0.038	0.033	-0.070	0.146	-0.051	-0.128	0.054	1.000										
	Ratio deal size to avg. prev. investment size in biotech	10	0.148	0.053	0.055	0.033	0.054	-0.043	-0.031	-0.028	0.371	1.000									
Venture controls	Venture 1st round investment dummy (1=yes)	11	-0.101	0.006	0.064	0.008	0.006	-0.007	-0.106	-0.180	-0.137	-0.079	1.000								
	Venture start-up/seed/early-stage dummy (1=yes)	12	0.020	-0.065	0.015	0.009	-0.137	0.029	0.098	-0.039	-0.227	-0.076	0.276	1.000							
	1st investment by VC in venture dummy (1=yes)	13	0.041	0.022	0.065	0.003	0.035	-0.124	-0.154	-0.242	0.091	0.063	0.517	0.148	1.000						
	VC and company from different nation dummy (1=yes)	14	0.008	0.017	0.002	-0.041	0.075	-0.042	-0.465	-0.029	0.104	0.008	0.031	-0.086	0.114	1.000					
VC knowledge	VC age 'experience'	15	0.026	0.088	-0.015	0.037	0.135	-0.050	0.003	0.117	0.096	0.043	-0.052	-0.062	-0.052	0.032	1.000				
	Non-biotech experience	16	-0.011	0.027	-0.040	0.013	0.044	0.035	0.152	0.145	0.092	0.007	-0.085	-0.074	-0.120	-0.061	0.318	1.000			
	Total non-/biotech experience	17	-0.017	0.031	-0.045	0.010	0.052	0.054	0.158	0.151	0.094	0.004	-0.089	-0.081	-0.136	-0.060	0.316	0.991	1.000		
	Biotech expertise	18	-0.047	0.037	-0.055	-0.012	0.076	0.137	0.129	0.124	0.072	-0.011	-0.083	-0.092	-0.171	-0.031	0.189	0.581	0.686	1.000	
	Biotech-stage expertise	19	-0.032	-0.001	-0.073	-0.036	0.032	0.131	0.097	0.127	0.041	-0.025	-0.036	0.133	-0.122	-0.016	0.181	0.500	0.588	0.843	1.000

(continued) Table F-3: Hypotheses 1 - Descriptive statistics

Shown are the summary statistics and correlations for the analyses of Hypotheses 1, as well as the results from a t-test comparing the average values of the variables used in the analyses for syndicated and unsyndicated investments ('***': p<0.01; '**': p<0.05; '*': p<0.1).

Panel B: Syndicated investments (8,194)

Panel B: Syndicated Investments (N=8194)		Descriptive statistics							t-test
		Mean	SE	Med	SD	Min.	Max.	Sum	un-/synd
DV	Syndicated deal dummy (1=yes)	1.00	0.00	1.00	0.00	1.00	1.00	8,194	
Context controls	% change p.a. in VCs investing venture capital	112.10	0.26	112.26	23.42	81.83	149.00		
	% change p.a. in ventures receiving biotech venture capital	115.87	0.32	106.67	29.07	81.47	350.00		**
	% change p.a. in total venture capital raised	122.28	0.67	117.98	60.30	6.10	396.25		
	Dummy for period 1996-2000 (1=yes)	0.35	0.01	0.00	0.48	0.00	1.00	2,856	
VC controls	VC true private equity investor dummy (1=yes)	0.71	0.01	1.00	0.46	0.00	1.00	5,791	***
	VC from US dummy (1=yes)	0.86	0.00	1.00	0.35	0.00	1.00	7,010	
	VC % prev. syndicated biotech deals	76.66	0.36	89.29	32.72	0.00	100.00		***
Finance controls	Deal size ($Mio)	10.52	0.15	6.00	13.30	0.01	150.00		***
	Ratio deal size to avg. prev. investment size in biotech	11.69	0.26	6.67	23.43	0.01	960.00		***
Venture controls	Venture 1st round investment dummy (1=yes)	0.20	0.00	0.00	0.40	0.00	1.00	1,611	***
	Venture start-up/seed/early-stage dummy (1=yes)	0.56	0.01	1.00	0.50	0.00	1.00	4,567	**
	1st investment by VC in venture dummy (1=yes)	0.51	0.01	1.00	0.50	0.00	1.00	4,195	***
	VC and company from different nation dummy (1=yes)	0.12	0.00	0.00	0.33	0.00	1.00	1,018	
VC knowledge	VC age 'experience'	11.94	0.13	9.00	11.60	0.10	131.00		***
	Non-biotech experience	135.85	2.49	47.00	225.80	0.00	2,041.00		
	Total non-/biotech experience	158.82	2.78	61.00	252.06	1.00	2,207.00		*
	Biotech expertise	22.97	0.44	9.00	39.99	0.00	378.00		***
	Biotech-stage expertise	5.65	0.11	2.00	10.32	0.00	121.00		***

Panel B: Syndicated Investments (N=8194)		Correlations																			
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
DV	Syndicated deal dummy (1=yes)	1																			
Context controls	% change p.a. in VCs investing venture capital	2		1.000																	
	% change p.a. in ventures receiving biotech venture capital	3		0.533	1.000																
	% change p.a. in total venture capital raised	4		0.803	0.555	1.000															
	Dummy for period 1996-2000 (1=yes)	5		0.767	0.342	0.597	1.000														
VC controls	VC true private equity investor dummy (1=yes)	6		-0.006	-0.017	0.015	-0.012	1.000													
	VC from US dummy (1=yes)	7		-0.005	0.005	0.080	-0.075	0.011	1.000												
	VC % prev. syndicated biotech deals	8		-0.066	-0.127	-0.052	-0.030	0.069	0.094	1.000											
Finance controls	Deal size ($Mio)	9		0.038	0.031	-0.078	0.155	-0.048	-0.141	0.026	1.000										
	Ratio deal size to avg. prev. investment size in biotech	10		0.051	0.052	0.033	0.052	-0.036	-0.031	-0.049	0.348	1.000									
Venture controls	Venture 1st round investment dummy (1=yes)	11		-0.002	0.060	0.002	-0.002	-0.006	-0.083	-0.159	-0.132	-0.076	1.000								
	Venture start-up/seed/early-stage dummy (1=yes)	12		-0.066	0.018	0.009	-0.152	0.034	0.124	-0.042	-0.254	-0.083	0.275	1.000							
	1st investment by VC in venture dummy (1=yes)	13		0.014	0.058	0.001	0.030	-0.128	-0.149	-0.259	0.084	0.057	0.483	0.145	1.000						
	VC and company from different nation dummy (1=yes)	14		0.008	-0.002	-0.048	0.070	-0.041	-0.505	-0.031	0.110	0.007	0.034	-0.087	0.124	1.000					
VC knowledge	VC age 'experience'	15		0.086	-0.020	0.043	0.139	-0.059	-0.001	0.113	0.095	0.039	-0.044	-0.056	-0.054	0.026	1.000				
	Non-biotech experience	16		0.032	-0.039	0.013	0.051	0.030	0.147	0.134	0.103	0.010	-0.066	-0.066	-0.112	-0.068	0.322	1.000			
	Total non-/biotech experience	17		0.035	-0.043	0.009	0.060	0.047	0.151	0.138	0.107	0.009	-0.070	-0.072	-0.126	-0.065	0.320	0.992	1.000		
	Biotech expertise	18		0.043	-0.052	-0.012	0.092	0.131	0.122	0.114	0.098	-0.002	-0.065	-0.079	-0.166	-0.029	0.198	0.606	0.702	1.000	
	Biotech-stage expertise	19		0.001	-0.070	-0.040	0.036	0.125	0.090	0.118	0.057	-0.020	-0.019	0.141	-0.114	-0.016	0.185	0.512	0.593	0.851	1.000

(continued) Table F-3: Hypotheses 1 - Descriptive statistics

Shown are the summary statistics and correlations for the analyses of Hypotheses 1, as well as the results from a t-test comparing the average values of the variables used in the analyses for syndicated and unsyndicated investments ('***': p<0.01; '**': p<0.05; '*': p<0.1).

Panel C: Unsyndicated investments (1,366)

Panel C: Unsyndicated Investments (N=1366)		Descriptive statistics							t-test
		Mean	SE	Med	SD	Min.	Max.	Sum	un-/synd
DV	Syndicated deal dummy (1=yes)	0.00	0.00	0.00	0.00	0.00	0.00	0	
Context controls	% change p.a. in VCs investing venture capital	111.91	0.60	112.77	22.32	81.83	149.00		
	% change p.a. in ventures receiving biotech venture capital	113.93	0.71	106.67	26.24	81.47	350.00		**
	% change p.a. in total venture capital raised	123.40	1.90	117.53	70.36	17.44	1,641.73		
	Dummy for period 1996-2000 (1=yes)	0.33	0.01	0.00	0.47	0.00	1.00	456	
VC controls	VC true private equity investor dummy (1=yes)	0.75	0.01	1.00	0.44	0.00	1.00	1,019	***
	VC from US dummy (1=yes)	0.85	0.01	1.00	0.35	0.00	1.00	1.166	
	VC % prev. syndicated biotech deals	63.86	0.96	77.10	35.36	0.00	100.00		***
Finance controls	Deal size ($Mio)	2.00	0.14	0.50	5.26	0.01	76.70		***
	Ratio deal size to avg. prev. investment size in biotech	2.34	0.21	0.71	7.89	0.00	158.83		***
Venture controls	Venture 1st round investment dummy (1=yes)	0.31	0.01	0.00	0.46	0.00	1.00	430	***
	Venture start-up/seed/early-stage dummy (1=yes)	0.53	0.01	1.00	0.50	0.00	1.00	722	**
	1st investment by VC in venture dummy (1=yes)	0.45	0.01	0.00	0.50	0.00	1.00	619	***
	VC and company from different nation dummy (1=yes)	0.12	0.01	0.00	0.32	0.00	1.00	160	
VC knowledge	VC age 'experience'	11.10	0.28	9.00	10.31	0.10	127.00		***
	Non-biotech experience	142.56	5.56	57.00	205.38	0.00	1,621.00		
	Total non-/biotech experience	171.10	6.31	70.50	233.14	1.00	1,757.00		*
	Biotech expertise	28.54	1.35	11.00	49.94	0.00	378.00		***
	Biotech-stage expertise	6.60	0.30	2.00	11.15	0.00	115.00		***

Panel C: Unsyndicated Investments (N=1366)		Correlations																			
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
DV	Syndicated deal dummy (1=yes)	1																			
Context controls	% change p.a. in VCs investing venture capital	2		1.000																	
	% change p.a. in ventures receiving biotech venture capital	3		0.542	1.000																
	% change p.a. in total venture capital raised	4		0.595	0.433	1.000															
	Dummy for period 1996-2000 (1=yes)	5		0.690	0.324	0.401	1.000														
VC controls	VC true private equity investor dummy (1=yes)	6		-0.054	-0.066	-0.020	-0.079	1.000													
	VC from US dummy (1=yes)	7		-0.032	-0.025	0.057	-0.128	0.063	1.000												
	VC % prev. syndicated biotech deals	8		-0.098	-0.120	-0.055	-0.120	0.188	0.332	1.000											
Finance controls	Deal size ($Mio)	9		0.067	0.006	-0.009	0.088	-0.021	-0.055	0.002	1.000										
	Ratio deal size to avg. prev. investment size in biotech	10		0.126	0.090	0.073	0.112	-0.118	-0.064	-0.085	0.430	1.000									
Venture controls	Venture 1st round investment dummy (1=yes)	11		0.056	0.103	0.032	0.055	-0.032	-0.223	-0.216	0.011	0.039	1.000								
	Venture start-up/seed/early-stage dummy (1=yes)	12		-0.056	-0.012	0.007	-0.053	0.001	-0.055	-0.048	-0.115	-0.084	0.309	1.000							
	1st investment by VC in venture dummy (1=yes)	13		0.068	0.111	0.015	0.067	-0.097	-0.185	-0.202	0.115	0.093	0.745	0.162	1.000						
	VC and company from different nation dummy (1=yes)	14		0.077	0.026	-0.005	0.104	-0.049	-0.223	-0.030	0.078	0.004	0.018	-0.085	0.048	1.000					
VC knowledge	VC age 'experience'	15		0.101	0.021	0.004	0.103	0.014	0.032	0.127	0.070	0.077	-0.084	-0.105	-0.046	0.071	1.000				
	Non-biotech experience	16		-0.001	-0.044	0.017	0.000	0.069	0.188	0.236	0.038	-0.025	-0.199	-0.122	-0.177	-0.014	0.294	1.000			
	Total non-/biotech experience	17		0.001	-0.052	0.012	0.002	0.095	0.202	0.253	0.032	-0.030	-0.215	-0.139	-0.196	-0.020	0.294	0.982	1.000		
	Biotech expertise	18		0.009	-0.064	-0.014	0.007	0.160	0.167	0.210	-0.005	-0.037	-0.183	-0.149	-0.188	-0.037	0.161	0.472	0.630	1.000	
	Biotech-stage expertise	19		-0.011	-0.084	-0.015	0.014	0.159	0.134	0.208	-0.029	-0.056	-0.133	0.091	-0.162	-0.010	0.165	0.434	0.557	0.813	1.000

Table F-4: Hypotheses 1 - Logistic regression results

Shown are the results for the analyses of Hypothesis 2a and 2b. The dependent variable is the dichotomous outcome 'investment syndicated (yes/no)'. ('***': p<.01; '**': p<.05; '*': p<.1)

Panel A: Main analyses on all investments (N=9,560) for baseline models (1-i to 1-iv) and full models (1-1 to 1-5)

Panel A: All Investments (N=9560)		Model 1-i		Model 1-ii		Model 1-iii		Model 1-iv		Model 1-1		Model 1-2		Model 1-3		Model 1-4		Model 1-5	
		Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Context controls	% annual changein VCs investing venture capital	0.998		0.999		0.998		0.999		0.999		0.999		0.999		0.999		0.999	
	% annual changein ventures receiving biotech venture capital	1.004	***	1.006	***	1.004	***	1.004	***	1.004	***	1.004	***	1.004	***	1.004	***	1.004	***
	% annual changein total venture capital raised	0.999	*	0.999	*	1.001		1.000		1.000		1.000		1.000		1.000		1.000	
	Dummy for period 1996-2000 (1=yes)	1.156		1.133		0.756	***	0.800	**	0.813	**	0.811	**	0.816	**	0.824	*	0.826	*
VC controls	VC true private equity investor dummy (1=yes)			0.756	***	0.847	**	0.871	*	0.866	*	0.877	*	0.886		0.920		0.919	
	VC from US dummy (1=yes)			0.897		1.176	*	1.110		1.112		1.189		1.204	*	1.190		1.167	
	VC % prev. syndicated biotech deals			1.011	***	1.009	***	1.010	***	1.010	***	1.010	***	1.011	***	1.010	***	1.010	***
Finance controls	Deal size ($Mio)					1.201	***	1.201	***	1.201	***	1.206	***	1.207	***	1.206	***	1.208	***
	Ratio deal size to avg. prev. investment size in biotech					1.157	***	1.146	***	1.146	***	1.144	***	1.144	***	1.143	***	1.142	***
Venture controls	Venture 1st round investment dummy (1=yes)							0.586	***	0.586	***	0.587	***	0.589	***	0.597	***	0.586	***
	Venture start-up/seed/early-stage dummy (1=yes)							1.771	***	1.763	***	1.735	***	1.726	***	1.727	***	1.914	***
	1st investment by VC in venture dummy (1=yes)							1.460	***	1.455	***	1.424	***	1.410	***	1.382	***	1.390	***
	VC and company from different nation dummy (1=yes)							0.948		0.950		0.945		0.945		0.947		0.960	
VC knowledge	VC age 'experience'									0.995	*								
	Non-biotech experience											0.999	***						
	Total non-/biotech experience													0.999	***				
	Biotech expertise															0.996	***		
	Biotech-stage expertise																	0.981	***
	Constant	5.144	***	2.554	***	0.577	**	0.404	***	0.420	***	0.401	***	0.398	***	0.392	***	0.385	***
Omnibus Tests	Step chi-2	12.82	**	184.64	***	1,605.72	***	83.73	***	2.67		28.59	***	35.12	***	36.00	***	38.89	***
	Block chi-2	12.82	**	184.64	***	1,605.72	***	83.73	***	2.67		28.59	***	35.12	***	36.00	***	38.89	***
	Model chi-2	12.82	**	197.46	***	1,803.18	***	1,886.90	***	1,889.57	***	1,915.50	***	1,922.03	***	1,922.90	***	1,925.80	***
Model Summary	-2 Log likelihood	7,830.86		7,646.22		6,040.51		5,956.78		5,954.11		5,928.18		5,921.65		5,920.78		5,917.88	
	Cox & Snell R Square	0.001		0.020		0.172		0.179		0.179		0.182		0.182		0.182		0.182	
	Nagelkerke R Square	0.002		0.037		0.307		0.320		0.320		0.324		0.325		0.325		0.326	
	Hosmer and Lemeshow chi-2	73.62	***	117.86	***	8,415.01	***	5,965.67	***	5,980.73	***	6,287.08	***	6,364.92	***	6,266.82	***	6,399.44	***

(continued) Table F-4: Hypotheses 1 - Logistic regression results

Shown are the results for the analyses of Hypothesis 2a and 2b. The dependent variable is the dichotomous outcome 'investment syndicated (yes/no)'. ('***': p<.01; '**': p<.05; '*': p<.1)

Panel B: Additional analyses on first investments by VCs in focal venture only (N=4,814) for baseline models (2-i to 2-iv) and full models (2-1 to 2-5)

Panel B: 1st Investments (N=4814)		Model 2-i		Model 2-ii		Model 2-iii		Model 2-iv		Model 2-1		Model 2-2		Model 2-3		Model 2-4		Model 2-5	
		Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Context controls	% annual changein VCs investing venture capital	0.994		0.995		0.994		0.994		0.994		0.994		0.994		0.994		0.994	
	% annual changein ventures receiving biotech venture capital	1.002		1.004	**	1.004	*	1.003	*	1.003		1.003	*	1.003		1.003		1.003	
	% annual changein total venture capital raised	1.000		1.000		1.002		1.002		1.002		1.002		1.002		1.002		1.002	
	Dummy for period 1996-2000 (1=yes)	1.165		1.132		0.726	**	0.790		0.799		0.804		0.808		0.816		0.810	
VC controls	VC true private equity investor dummy (1=yes)			0.750	***	0.860		0.867		0.865		0.871		0.875		0.897		0.893	
	VC from US dummy (1=yes)			1.062		1.245	*	1.137		1.139		1.175		1.183		1.191		1.170	
	VC % prev. syndicated biotech deals			1.008	***	1.005	***	1.004	***	1.005	***	1.005	***	1.005	***	1.005	***	1.005	***
Finance controls	Deal size ($Mio)					1.192	***	1.189	***	1.189	***	1.190	***	1.190	***	1.191	***	1.192	***
	Ratio deal size to avg. prev. investment size in biotech					1.080	***	1.068	***	1.069	***	1.068	***	1.068	***	1.067	***	1.067	***
Venture controls	Venture 1st round investment dummy (1=yes)							0.438	***	0.438	***	0.436	***	0.436	***	0.441	***	0.441	***
	Venture start-up/seed/early-stage dummy (1=yes)							2.711	***	2.695	***	2.700	***	2.698	***	2.699	***	2.809	***
	1st investment by VC in venture dummy (1=yes)																		
	VC and company from different nation dummy (1=yes)							1.164		1.172		1.164		1.165		1.168		1.165	
VC knowledge	VC age 'experience'									0.994									
	Non-biotech experience											0.999	**						
	Total non-/biotech experience													0.999	**				
	Biotech expertise															0.996	***		
	Biotech-stage expertise																	0.986	***
	Constant	9.634	***	5.785	***	1.403		1.417		1.485		1.436		1.433		1.394		1.394	
Omnibus Tests	Step chi-2	3.62		59.29	***	637.99	***	102.23	***	1.70		4.00	**	5.34	**	9.06	***	7.73	***
	Block chi-2	3.62		59.29	***	637.99	***	102.23	***	1.70		4.00	**	5.34	**	9.06	***	7.73	***
	Model chi-2	3.62		62.91	***	700.89	***	803.12	***	804.82	***	807.12	***	808.46	***	812.18	***	810.85	***
Model Summary	-2 Log likelihood	3,691.60		3,632.31		2,994.33		2,892.10		2,890.40		2,888.10		2,886.76		2,883.03		2,884.37	
	Cox & Snell R Square	0.001		0.013		0.135		0.154		0.154		0.154		0.154		0.155		0.155	
	Nagelkerke R Square	0.001		0.024		0.253		0.287		0.287		0.288		0.288		0.290		0.289	
	Hosmer and Lemeshow chi-2	22.72	***	25.00	***	1,177.64	***	469.05	***	470.93	***	476.30	***	477.98	***	463.47	***	469.73	***

(continued) Table F-4: Hypotheses 1 - Logistic regression results

Shown are the results for the analyses of Hypothesis 2a and 2b. The dependent variable is the dichotomous outcome 'investment syndicated (yes/no)'. ('***': p<.01; '**': p<.05; '*': p<.1)

Panel C: Additional analysis on last investments by VCs only (N=1,120) for baseline models (3-i to 3-iv) and full models (3-1 to 3-5)

Panel C: Last Investments (N=1120)		Model 3-i		Model 3-ii		Model 3-iii		Model 3-iv		Model 3-1		Model 3-2		Model 3-3		Model 3-4		Model 3-5	
		Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Context controls	% annual changein VCs investing venture capital	0.988		0.987		0.984		0.984		0.988		0.988		0.989		0.988		0.990	
	% annual changein ventures receiving biotech venture capital	0.998		1.000		1.000		1.000		1.000		1.000		0.999		0.999		0.999	
	% annual changein total venture capital raised	1.000		1.000		1.003		1.003		1.002		1.003		1.003		1.003		1.002	
	Dummy for period 1996-2000 (1=yes)	1.371		1.384		0.857		0.877		0.875		0.791		0.782		0.794		0.755	
VC controls	VC true private equity investor dummy (1=yes)			0.855		0.897		0.941		0.919		0.964		0.971		0.994		1.001	
	VC from US dummy (1=yes)			1.000		1.148		1.093		1.138		1.180		1.184		1.146		1.154	
	VC % prev. syndicated biotech deals			1.010	***	1.010	***	1.011	***	1.011	***	1.012	***	1.012	***	1.012	***	1.013	***
Finance controls	Deal size ($Mio)					1.128	***	1.136	***	1.132	***	1.137	***	1.138	***	1.136	***	1.143	***
	Ratio deal size to avg. prev. investment size in biotech					1.080	***	1.069	***	1.072	***	1.069	***	1.068	***	1.069	***	1.066	***
Venture controls	Venture 1st round investment dummy (1=yes)							0.609	*	0.615	*	0.603	*	0.601	*	0.593	*	0.570	**
	Venture start-up/seed/early-stage dummy (1=yes)							2.145	***	2.067	***	2.089	***	2.077	***	2.037	***	2.427	***
	1st investment by VC in venture dummy (1=yes)							1.389		1.435		1.404		1.403		1.389		1.341	
	VC and company from different nation dummy (1=yes)							1.171		1.161		1.232		1.229		1.175		1.146	
VC knowledge	VC age 'experience'									0.978	**								
	Non-biotech experience											0.998	***						
	Total non-/biotech experience													0.998	***				
	Biotech expertise															0.991	***		
	Biotech-stage expertise																	0.927	***
	Constant	24.782	***	12.478	***	3.980		2.632		2.483		1.852		1.821		2.105		1.781	
Omnibus Tests	Step chi-2	8.28	*	25.83	***	159.36	***	15.62	***	6.38	**	9.49	***	10.08	***	6.76	***	16.17	***
	Block chi-2	8.28	*	25.83	***	159.36	***	15.62	***	6.38	**	9.49	***	10.08	***	6.76	***	16.17	***
	Model chi-2	8.28	*	34.11	***	193.46	***	209.08	***	215.46	***	218.57	***	219.16	***	215.84	***	225.25	***
Model Summary	-2 Log likelihood	917.52		891.69		732.34		716.72		710.34		707.23		706.64		709.96		700.55	
	Cox & Snell R Square	0.007		0.030		0.159		0.170		0.175		0.177		0.178		0.175		0.182	
	Nagelkerke R Square	0.013		0.053		0.282		0.303		0.311		0.315		0.316		0.312		0.324	
	Hosmer and Lemeshow chi-2	4.35		13.83	*	228.93	***	110.67	***	108.80	***	114.93	***	114.73	***	108.58	***	123.81	***

J.VII. Tables Chapter G

Table G-3: Hypotheses 2- Descriptive statistics

Panel A: Main analysis on all rounds (N=2873)

Panel A: All rounds (N=2,837)		Summary statistics					Correlations																								
		Mean (%)	Median	SD	Min.	Max.		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
DV	Round length [days]	445.34	313.0	534.0	90.0	7,185.00	(1)	1.000																							
	Round length [log]	2.47	2.5	0.4	2.0	3.86	(2)	0.762	1.000																						
CV - Context	Annual change in VCs investing venture capital	115.32	117.0	22.0	81.8	149.00	(3)	0.001	0.054	1.000																					
	Annual change in ventures receiving biotech venture capital	118.07	110.2	29.1	81.5	350.00	(4)	0.083	0.062	0.426	1.000																				
	Annual change in total venture capital raised	133.67	121.9	59.8	6.1	1,641.73	(5)	0.034	0.069	0.608	0.377	1.000																			
	Round in 1996-2000 dummy [1=yes]	(37.26)	0.0	0.5	0.0	1.00	(6)	-0.048	0.015	0.701	0.205	0.435	1.000																		
CV - Venture	1st round investment [1=yes]	(25.41)	0.0	0.4	0.0	1.00	(7)	0.095	0.142	0.059	0.116	0.053	0.011	1.000																	
	Venture from US dummy [1=yes]	(88.33)	1.0	0.3	0.0	1.00	(8)	0.003	-0.018	-0.102	-0.045	-0.019	-0.181	-0.141	1.000																
	Venture sector 41 dummy [1=yes]	(62.85)	1.0	0.5	0.0	1.00	(9)	0.000	-0.003	-0.036	-0.063	-0.007	-0.050	-0.062	0.059	1.000															
	Venture start-up/seed/early-stage dummy [1=yes]	(59.43)	1.0	0.5	0.0	1.00	(10)	-0.001	0.050	-0.055	0.037	-0.003	-0.094	0.294	0.091	0.026	1.000														
	Venture age at round [years]	3.69	3.0	3.5	0.0	50.53	(11)	0.056	-0.040	0.016	-0.013	0.013	0.044	-0.317	0.054	-0.017	-0.396	1.000													
CV - Finance	Deal size [$Mio]	5.54	2.5	13.4	0.1	550.00	(12)	0.033	0.070	0.099	0.035	0.046	0.134	-0.036	-0.099	0.002	-0.110	0.054	1.000												
CV - VCs	Syndicated deal dummy [1=yes]	(67.64)	1.0	0.5	0.0	1.00	(13)	0.020	0.076	0.039	0.043	0.020	0.080	-0.019	-0.005	0.003	0.067	-0.085	0.179	1.000											
	% Independent private equity VCs in round	0.65	0.7	0.3	0.0	1.00	(14)	-0.055	-0.078	-0.083	-0.070	-0.038	-0.098	-0.018	0.006	0.068	0.006	-0.057	-0.075	-0.178	1.000										
	% VCs in round that come from same country as venture	0.79	1.0	0.3	0.0	1.00	(15)	-0.019	-0.033	-0.102	-0.032	-0.016	-0.150	-0.052	0.492	0.078	0.012	0.034	-0.140	-0.269	0.261	1.000									
IV - Avg. Knowledge	Avg. age of VCs[years]	10.84	10.0	8.6	0.1	127.00	(16)	-0.020	-0.030	0.118	-0.049	0.022	0.166	-0.088	-0.023	0.011	-0.070	0.060	0.068	0.027	0.020	-0.007	1.000								
(syndicate)	Avg. non-biotech experience of VCs	133.59	75.0	174.0	0.0	1,934.00	(17)	-0.056	-0.068	-0.003	-0.092	-0.011	0.035	-0.142	0.094	0.089	-0.089	0.068	0.031	-0.038	0.074	0.074	0.326	1.000							
	Avg. total [non-/biotech] experience of VCs	150.85	86.2	191.4	0.0	2,088.00	(18)	-0.061	-0.075	-0.001	-0.094	-0.013	0.040	-0.147	0.086	0.088	-0.098	0.074	0.032	-0.037	0.079	0.066	0.333	0.997	1.000						
	Avg. biotech expertise of VCs	24.14	12.0	38.9	0.0	378.00	(19)	-0.092	-0.126	0.045	-0.072	-0.009	0.077	-0.121	0.061	0.040	-0.096	0.048	0.001	-0.074	0.157	0.050	0.204	0.522	0.517	1.000					
	Avg. biotech-stage expertise of VCs	5.99	3.0	10.0	0.0	115.00	(20)	-0.100	-0.112	0.011	-0.090	-0.029	0.046	-0.072	0.050	0.043	0.144	-0.040	-0.009	-0.045	0.144	0.020	0.198	0.465	0.462	0.873	1.000				
IV - Max. Knowledge	Max. age of VCs [years]	16.50	14.0	15.4	0.1	131.00	(21)	-0.014	0.003	0.113	-0.024	0.037	0.172	-0.111	-0.055	0.049	-0.068	0.046	0.174	0.269	-0.005	-0.022	0.740	0.178	0.183	0.080	0.078	1.000			
('lead' VC)	Max. non-biotech experience of VCs	225.06	121.0	277.5	0.0	1,934.00	(22)	-0.045	-0.028	0.043	-0.070	0.014	0.085	-0.173	0.084	0.089	-0.112	0.042	0.141	0.204	0.041	0.072	0.292	0.811	0.812	0.404	0.348	0.325	1.000		
	Max. total [non-/biotech] experience of VCs	251.44	141.0	305.9	0.0	2,088.00	(23)	-0.049	-0.035	0.047	-0.072	0.014	0.091	-0.176	0.077	0.089	-0.119	0.046	0.141	0.205	0.045	0.065	0.297	0.807	0.812	0.402	0.346	0.328	0.998	1.000	
	Max. biotech expertise of VCs	39.48	20.0	55.8	0.0	378.00	(24)	-0.082	-0.085	0.083	-0.066	0.012	0.128	-0.156	0.054	0.054	-0.120	0.033	0.104	0.139	0.123	0.041	0.211	0.462	0.461	0.837	0.720	0.207	0.569	0.572	1.000
	Max. biotech-stage expertise of VCs	9.79	5.0	14.3	0.0	121.00	(25)	-0.091	-0.074	0.040	-0.084	-0.008	0.077	-0.103	0.051	0.057	0.155	-0.057	0.077	0.152	0.115	0.019	0.206	0.417	0.416	0.729	0.855	0.200	0.494	0.495	0.841

(continued) Table G-3: Hypotheses 2- Descriptive statistics

Panel B: Additional analyses on first rounds only (N=721)

Panel B: 1st rounds (N=721)		Summary statistics					Correlations																								
		Mean	Median	SD	Min.	Max.		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
DV	Round length [days]	532.63	395.0	628.5	30.0	7,185.00	(1)	1.000																							
	Round length [log]	2.56	2.6	0.4	2.0	3.86	(2)	0.758	1.000																						
CV - Context	Annual change in VCs investing venture capital	117.55	124.3	21.8	81.8	149.00	(3)	0.004	0.064	1.000																					
	Annual change in ventures receiving biotech venture capital	123.86	117.1	35.7	81.5	350.00	(4)	0.156	0.119	0.409	1.000																				
	Annual change in total venture capital raised	139.08	126.4	78.7	17.4	1,641.73	(5)	0.068	0.096	0.400	0.242	1.000																			
	Round in 1996-2000 dummy [1=yes]	(38.14)	0.0	0.5	0.0	1.00	(6)	-0.069	-0.005	0.639	0.080	0.301	1.000																		
CV - Venture	1st round investment [1=yes]	(100.00)	1.0	0.0	1.0	1.00	(7)																								
	Venture from US dummy [1=yes]	(80.58)	1.0	0.4	0.0	1.00	(8)	0.000	-0.049	-0.162	0.036	-0.044	-0.322	.	1.000																
	Venture sector 41 dummy [1=yes]	(57.70)	1.0	0.5	0.0	1.00	(9)	-0.007	-0.026	-0.070	-0.055	0.008	-0.102	.	0.013	1.000															
	Venture start-up/seed/early-stage dummy [1=yes]	(84.19)	1.0	0.4	0.0	1.00	(10)	-0.054	-0.057	-0.079	0.077	-0.017	-0.114	.	0.210	0.098	1.000														
	Venture age at round [years]	1.81	0.8	3.4	0.0	50.53	(11)	0.063	0.036	0.068	0.014	0.045	0.124	.	-0.076	-0.113	-0.287	1.000													
CV - Finance	Deal size [$Mio]	4.71	1.8	21.8	0.0	550.00	(12)	0.025	0.050	0.004	-0.031	-0.005	0.019	.	-0.109	-0.054	-0.134	0.008	1.000												
CV - VCs	Syndicated deal dummy [1=yes]	(66.16)	1.0	0.5	0.0	1.00	(13)	0.019	0.081	-0.026	0.020	-0.019	0.043	.	0.042	-0.019	0.052	0.014	0.091	1.000											
	% Independent private equity VCs in round	0.64	0.7	0.4	0.0	1.00	(14)	-0.085	-0.100	-0.048	-0.021	0.014	-0.050	.	0.067	0.076	0.111	-0.099	-0.048	-0.230	1.000										
	% VCs in round that come from same country as venture	0.77	1.0	0.3	0.0	1.00	(15)	-0.005	-0.066	-0.059	0.066	0.016	-0.157	.	0.419	0.073	0.137	-0.038	-0.133	-0.274	0.281	1.000									
IV - Avg. Knowledge	Avg. age of VCs[years]	9.55	8.0	9.3	0.1	126.00	(16)	-0.035	-0.050	0.052	-0.084	0.009	0.075	.	0.026	-0.031	-0.069	0.061	0.053	0.038	-0.003	-0.001	1.000								
(syndicate)	Avg. non-biotech experience of VCs	91.24	32.5	136.9	0.0	931.00	(17)	-0.102	-0.110	-0.084	-0.116	-0.025	0.029	.	0.122	0.058	0.011	-0.026	0.001	0.059	0.118	0.029	0.377	1.000							
	Avg. total [non-/biotech] experience of VCs	102.53	41.5	151.4	0.0	1,108.00	(18)	-0.105	-0.113	-0.080	-0.117	-0.026	0.039	.	0.110	0.056	0.014	-0.029	0.003	0.064	0.121	0.016	0.378	0.997	1.000						
	Avg. biotech expertise of VCs	16.11	5.0	35.4	0.0	354.00	(19)	-0.109	-0.144	-0.024	-0.054	-0.029	0.081	.	0.062	-0.019	0.037	-0.062	0.001	0.022	0.122	-0.028	0.203	0.543	0.534	1.000					
	Avg. biotech-stage expertise of VCs	4.75	1.3	9.9	0.0	115.00	(20)	-0.119	-0.149	-0.064	-0.071	-0.046	0.042	.	0.087	0.018	0.140	-0.107	-0.001	0.027	0.131	-0.009	0.215	0.563	0.560	0.929	1.000				
IV - Max. Knowledge	Max. age of VCs [years]	13.57	11.0	13.8	0.1	128.00	(21)	-0.021	-0.004	0.042	-0.070	0.011	0.077	.	-0.008	0.016	-0.034	0.089	0.081	0.233	0.012	-0.001	0.818	0.286	0.288	0.132	0.140	1.000			
('lead' VC)	Max. non-biotech experience of VCs	142.80	55.0	212.8	0.0	1,621.00	(22)	-0.082	-0.078	-0.075	-0.107	-0.022	0.035	.	0.121	0.059	0.024	0.009	0.026	0.211	0.086	0.043	0.327	0.887	0.886	0.445	0.460	0.356	1.000		
	Max. total [non-/biotech] experience of VCs	158.99	64.0	234.9	0.0	1,757.00	(23)	-0.085	-0.082	-0.072	-0.110	-0.023	0.045	.	0.110	0.057	0.027	0.008	0.027	0.213	0.088	0.030	0.329	0.883	0.887	0.441	0.460	0.358	0.997	1.000	
	Max. biotech expertise of VCs	24.59	7.0	46.6	0.0	354.00	(24)	-0.112	-0.134	-0.035	-0.076	-0.034	0.103	.	0.053	-0.010	0.044	-0.048	0.025	0.147	0.106	-0.029	0.208	0.526	0.523	0.888	0.835	0.209	0.561	0.562	1.000
	Max. biotech-stage expertise of VCs	7.27	2.0	13.3	0.0	115.00	(25)	-0.122	-0.139	-0.081	-0.090	-0.056	0.038	.	0.085	0.039	0.157	-0.097	0.021	0.156	0.121	0.000	0.216	0.532	0.532	0.811	0.895	0.214	0.556	0.559	0.915

(continued) Table G-3: Hypotheses 2- Descriptive statistics

Panel C: Additional analyses on later rounds only (N=2,116)

Panel C: Later rounds (N=2,116)		Summary statistics					Correlations																								
		Mean	Median	SD	Min.	Max.		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
DV	Round length [days]	415.60	285.5	494.5	1.0	6,839.00	(1)	1.000																							
	Round length [log]	2.43	2.5	0.4	2.0	3.83	(2)	0.771	1.000																						
CV - Context	Annual change in VCs investing venture capital	114.57	112.8	22.0	81.8	149.00	(3)	-0.008	0.041	1.000																					
	Annual change in ventures receiving biotech venture capital	116.10	110.2	26.2	81.5	350.00	(4)	0.024	0.017	0.436	1.000																				
	Annual change in total venture capital raised	131.83	121.9	51.7	6.1	285.03	(5)	0.003	0.049	0.733	0.467	1.000																			
	Round in 1996-2000 dummy [1=yes]	(36.96)	0.0	0.5	0.0	1.00	(6)	-0.041	0.019	0.723	0.266	0.518	1.000																		
CV - Venture	1st round investment [1=yes]	(0.00)	0.0	0.0	0.0	0.00	(7)	.	.	.	.	.	.	.																	
	Venture from US dummy [1=yes]	(90.97)	1.0	0.3	0.0	1.00	(8)	0.026	0.024	-0.065	-0.072	0.011	-0.118	.	1.000																
	Venture sector 41 dummy [1=yes]	(64.60)	1.0	0.5	0.0	1.00	(9)	0.012	0.016	-0.019	-0.058	-0.010	-0.031	.	0.070	1.000															
	Venture start-up/seed/early-stage dummy [1=yes]	(50.99)	1.0	0.5	0.0	1.00	(10)	-0.025	0.024	-0.076	-0.023	-0.022	-0.099	.	0.123	0.033	1.000														
	Venture age at round [years]	4.33	3.7	3.2	0.0	48.20	(11)	0.104	-0.005	0.025	0.032	0.025	0.023	.	0.053	-0.011	-0.352	1.000													
CV - Finance	Deal size [$Mio]	5.83	2.7	9.0	0.0	150.00	(12)	0.054	0.112	0.200	0.123	0.117	0.255	.	-0.109	0.046	-0.116	0.086	1.000												
CV - VCs	Syndicated deal dummy [1=yes]	(68.15)	1.0	0.5	0.0	1.00	(13)	0.023	0.079	0.063	0.058	0.043	0.093	.	-0.031	0.009	0.083	-0.137	0.285	1.000											
	% Independent private equity VCs in round	0.65	0.7	0.3	0.0	1.00	(14)	-0.040	-0.069	-0.094	-0.092	-0.066	-0.115	.	-0.028	0.063	-0.014	-0.054	-0.113	-0.160	1.000										
	% VCs in round that come from same country as venture	0.80	1.0	0.3	0.0	1.00	(15)	-0.019	-0.013	-0.114	-0.073	-0.030	-0.147	.	0.532	0.076	0.000	0.041	-0.172	-0.269	0.253	1.000									
IV - Avg. Knowledge	Avg. age of VCs[years]	11.28	10.3	8.2	0.1	127.00	(16)	-0.001	-0.006	0.152	-0.015	0.037	0.204	.	-0.069	0.020	-0.041	0.023	0.087	0.021	0.027	-0.016	1.000								
(syndicate)	Avg. non-biotech experience of VCs	148.02	89.1	182.8	0.0	1,934.00	(17)	-0.025	-0.034	0.028	-0.067	0.004	0.039	.	0.063	0.089	-0.062	0.039	0.049	-0.067	0.061	0.079	0.307	1.000							
	Avg. total [non-/biotech] experience of VCs	167.31	103.2	200.6	0.0	2,088.00	(18)	-0.030	-0.041	0.031	-0.068	0.002	0.043	.	0.054	0.088	-0.072	0.045	0.050	-0.067	0.066	0.073	0.315	0.997	1.000						
	Avg. biotech expertise of VCs	26.88	14.6	39.6	0.0	378.00	(19)	-0.072	-0.102	0.076	-0.063	0.009	0.079	.	0.038	0.050	-0.086	0.034	-0.008	-0.107	0.167	0.068	0.194	0.508	0.504	1.000					
	Avg. biotech-stage expertise of VCs	6.41	3.3	10.0	0.0	115.00	(20)	-0.084	-0.089	0.042	-0.089	-0.016	0.049	.	0.020	0.045	0.183	-0.052	-0.023	-0.071	0.147	0.025	0.185	0.438	0.434	0.858	1.000				
IV - Max. Knowledge	Max. age of VCs [years]	17.49	15.0	15.8	0.1	131.00	(21)	0.003	0.025	0.143	0.012	0.060	0.204	.	-0.100	0.051	-0.038	-0.014	0.276	0.280	-0.013	-0.038	0.717	0.138	0.143	0.050	0.050	1.000			
('lead' VC)	Max. non-biotech experience of VCs	253.08	148.0	291.1	0.0	1,934.00	(22)	-0.013	0.013	0.086	-0.034	0.043	0.103	.	0.043	0.086	-0.081	-0.019	0.242	0.205	0.026	0.071	0.276	0.792	0.793	0.382	0.315	0.304	1.000		
	Max. total [non-/biotech] experience of VCs	282.94	169.0	320.6	0.0	2,088.00	(23)	-0.018	0.007	0.091	-0.036	0.043	0.107	.	0.037	0.086	-0.090	-0.016	0.241	0.205	0.031	0.064	0.281	0.788	0.793	0.380	0.312	0.307	0.998	1.000	
	Max. biotech expertise of VCs	44.55	26.0	57.8	0.0	378.00	(24)	-0.055	-0.047	0.129	-0.041	0.045	0.139	.	0.026	0.061	-0.104	-0.008	0.175	0.136	0.127	0.053	0.201	0.434	0.433	0.821	0.692	0.189	0.557	0.560	1.000
	Max. biotech-stage expertise of VCs	10.66	6.0	14.6	0.0	121.00	(25)	-0.068	-0.038	0.086	-0.067	0.022	0.091	.	0.017	0.055	0.204	-0.095	0.129	0.150	0.112	0.018	0.194	0.382	0.380	0.702	0.842	0.184	0.472	0.472	0.822

Table G-4: Hypotheses 2 – Multiple regression results

Shown are the results for the analyses of Hypotheses 2a and 2b. The dependent variable is the log of the round-length (in days) ('***': p<.01; '**': p<.05; '*': p<.1).

Panels A: main analyses on all rounds (N=2,837)
Panel A-1: baseline model
Panel A-2: full models for the lead VCs
Panel A-3: full models for the syndicates

Panel A-1: Baseline all rounds	Model 0-1			Model 0-2			Model 0-3			Model 0-4		
N = 2,837												
	B	SE		B	SE		B	SE		B	SE	
Constant	2.301	0.053	***	2.292	0.059	***	2.277	0.059	***	2.292	0.064	***
Annual change in VCs investing venture capital	0.001	0.001		0.001	0.001		0.001	0.001		0.001	0.001	
Annual change in ventures receiving biotech venture capital	0.000	0.000	*	0.000	0.000		0.000	0.000		0.000	0.000	
Annual change in total venture capital raised	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**
Round in 1996-2000 dummy (1=yes)	-0.033	0.022		-0.028	0.022		-0.035	0.022		-0.044	0.022	**
Venture from US dummy (1=yes)				-0.003	0.024		0.005	0.024		-0.007	0.028	
Venture sector 41 dummy (1=yes)				0.005	0.015		0.004	0.015		0.007	0.015	
Venture age at round [years]				0.001	0.002		0.001	0.002		0.001	0.002	
Venture start-up/seed/early-stage dummy (1=yes)				0.009	0.017		0.014	0.017		0.010	0.017	
1st round investment (1=yes)				0.123	0.019	***	0.125	0.019	***	0.126	0.019	***
Deal size [$Mio]							0.002	0.001	***	0.002	0.001	***
Syndicated deal dummy (1=yes)										0.052	0.017	***
% Independent private equity VCs in round										-0.073	0.023	***
% VCs in round that come from same country as venture										0.019	0.033	
Adjusted R Square	0.006			0.022			0.028			0.035		
SE of the Estimate	0.399			0.395			0.394			0.393		
R Square Change	0.007			0.018			0.006			0.008		
F Change	5.108			10.517			16.658			7.808		
Sig. F Change	0.000			0.000			0.000			0.000		

Panel A-2: Lead VC's knowledge all rounds	Model 1-1			Model 1-2			Model 1-3			Model 1-4			Model 1-5		
N = 2,837															
	B	SE		B	SE		B	SE		B	SE		B	SE	
Constant	2.293	0.064	***	2.293	0.064	***	2.294	0.064	***	2.292	0.064	***	2.289	0.064	***
Annual change in VCs investing venture capital	0.001	0.001		0.001	0.001		0.001	0.001		0.001	0.001		0.001	0.001	
Annual change in ventures receiving biotech venture capital	0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000	
Annual change in total venture capital raised	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**
Round in 1996-2000 dummy (1=yes)	-0.043	0.022	*	-0.042	0.022	*	-0.042	0.022	*	-0.037	0.022	*	-0.039	0.022	*
Venture from US dummy (1=yes)	-0.007	0.028		-0.005	0.028		-0.005	0.028		-0.001	0.028		-0.004	0.028	
Venture sector 41 dummy (1=yes)	0.007	0.015		0.008	0.015		0.008	0.015		0.009	0.015		0.009	0.015	
Venture age at round [years]	0.001	0.002		0.001	0.002		0.001	0.002		0.001	0.002		0.001	0.002	
Venture start-up/seed/early-stage dummy (1=yes)	0.010	0.017		0.008	0.017		0.008	0.017		0.005	0.017		0.022	0.017	
1st round investment (1=yes)	0.126	0.019	***	0.124	0.019	***	0.123	0.019	***	0.119	0.019	***	0.117	0.019	***
Deal size [$Mio]	0.002	0.001	***	0.002	0.001	***	0.002	0.001	***	0.002	0.001	***	0.002	0.001	***
Syndicated deal dummy (1=yes)	0.054	0.018	***	0.056	0.017	***	0.057	0.017	***	0.062	0.017	***	0.061	0.017	***
% Independent private equity VCs in round	-0.073	0.023	***	-0.072	0.023	***	-0.071	0.023	***	-0.061	0.023	***	-0.062	0.023	***
% VCs in round that come from same country as venture	0.021	0.033		0.023	0.033		0.024	0.033		0.024	0.033		0.022	0.033	
Lead VC age [years]	0.000	0.001													
Lead VC non-biotech experience				0.000	0.000										
Lead VC total (non-/biotech) experience							0.000	0.000							
Lead VC biotech expertise										-0.001	0.000	***			
Lead VC biotech-stage expertise													-0.002	0.001	***
Adjusted R Square	0.034			0.035			0.035			0.039			0.039		
SE of the Estimate	0.393			0.393			0.393			0.392			0.392		
R Square Change	0.000			0.000			0.001			0.005			0.005		
F Change	0.122			1.350			2.145			14.292			13.656		
Sig. F Change	0.727			0.245			0.143			0.000			0.000		

Panel A-3: Syndicate's knowledge all rounds	Model 2-1			Model 2-2			Model 2-3			Model 2-4			Model 2-5		
N = 2,837															
	B	SE		B	SE		B	SE		B	SE		B	SE	
Constant	2.299	0.064	***	2.304	0.064	***	2.306	0.064	***	2.306	0.064	***	2.305	0.064	***
Annual change in VCs investing venture capital	0.001	0.001		0.001	0.001		0.001	0.001		0.001	0.001		0.001	0.001	
Annual change in ventures receiving biotech venture capital	0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000	
Annual change in total venture capital raised	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**
Round in 1996-2000 dummy (1=yes)	-0.042	0.022	*	-0.041	0.022	*	-0.041	0.022	*	-0.036	0.022		-0.036	0.022	*
Venture from US dummy (1=yes)	-0.007	0.028		-0.002	0.028		-0.001	0.028		0.005	0.028		0.001	0.028	
Venture sector 41 dummy (1=yes)	0.007	0.015		0.009	0.015		0.010	0.015		0.009	0.015		0.008	0.015	
Venture age at round [years]	0.001	0.002		0.001	0.002		0.001	0.002		0.001	0.002		0.001	0.002	
Venture start-up/seed/early-stage dummy (1=yes)	0.010	0.017		0.008	0.017		0.008	0.017		0.005	0.017		0.024	0.017	
1st round investment (1=yes)	0.125	0.019	***	0.122	0.019	***	0.122	0.019	***	0.119	0.019	***	0.117	0.019	***
Deal size [$Mio]	0.002	0.001	***	0.002	0.001	***	0.002	0.001	***	0.002	0.001	***	0.002	0.001	***
Syndicated deal dummy (1=yes)	0.052	0.017	***	0.051	0.017	***	0.051	0.017	***	0.047	0.017	***	0.048	0.017	***
% Independent private equity VCs in round	-0.073	0.023	***	-0.070	0.023	***	-0.069	0.023	***	-0.055	0.023	**	-0.057	0.023	**
% VCs in round that come from same country as venture	0.020	0.033		0.020	0.033		0.019	0.033		0.014	0.033		0.012	0.033	
Avg. syndicate age	-0.001	0.001													
Avg. syndicate non-biotech experience				0.000	0.000	**									
Avg. syndicate total (non-/biotech) experience							0.000	0.000	**						
Avg. syndicate biotech expertise										-0.001	0.000	***			
Avg. syndicate biotech-stage expertise													-0.004	0.001	***
Adjusted R Square	0.035			0.036			0.036			0.043			0.042		
SE of the Estimate	0.393			0.393			0.392			0.391			0.391		
R Square Change	0.000			0.002			0.002			0.009			0.008		
F Change	0.976			5.018			6.464			26.244			23.940		
Sig. F Change	0.323			0.025			0.011			0.000			0.000		

(continued) Table G-4: Hypotheses 2 – Multiple regression results

Shown are the results for the analyses of Hypotheses 2a and 2b. The dependent variable is the log of the round-length (in days) ('***': p<.01; '**': p<.05; '*': p<.1).

Panels B: additional analyses on first rounds only (N=721)
Panel B-1: baseline model
Panel B-2: full models for the lead VCs
Panel B-3: full models for the syndicates

Panel B-1: Baseline 1st rounds	Model 0-1			Model 0-2			Model 0-3			Model 0-4		
N = 721												
	B	SE		B	SE		B	SE		B	SE	
Constant	2.351	0.090	***	2.445	0.101	***	2.432	0.102	***	2.449	0.110	***
Annual change in VCs investing venture capital	0.001	0.001		0.000	0.001		0.000	0.001		0.001	0.001	
Annual change in ventures receiving biotech venture capital	0.001	0.000	**	0.001	0.000	**	0.001	0.000	**	0.001	0.000	
Annual change in total venture capital raised	0.000	0.000	*	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**
Round in 1996-2000 dummy (1=yes)	-0.042	0.038		-0.065	0.040		-0.064	0.040		-0.072	0.040	**
Venture from US dummy (1=yes)				-0.056	0.037		-0.053	0.038		-0.048	0.041	
Venture sector 41 dummy (1=yes)				-0.015	0.028		-0.014	0.028		-0.010	0.028	
Venture age at round [years]				0.002	0.004		0.002	0.004		0.001	0.004	
Venture start-up/seed/early-stage dummy (1=yes)				-0.052	0.040		-0.047	0.041		-0.045	0.041	
1st round investment (1=yes)												
Deal size [$Mio]							0.001	0.001	***	0.001	0.001	***
Syndicated deal dummy (1=yes)										0.052	0.031	***
% Independent private equity VCs in round										-0.073	0.041	***
% VCs in round that come from same country as venture										-0.020	0.055	
Adjusted R Square	0.015			0.018			0.018			0.027		
SE of the Estimate	0.370			0.369			0.369			0.367		
R Square Change	0.021			0.008			0.002			0.013		
F Change	3.767			1.521			1.257			3.096		
Sig. F Change	0.005			0.194			0.263			0.026		

Panel B-2: Lead VC's knowledge 1st rounds	Model 1-1			Model 1-2			Model 1-3			Model 1-4			Model 1-5		
N = 721															
	B	SE		B	SE		B	SE		B	SE		B	SE	
Constant	2.450	0.110		2.460	0.110	***	2.461	0.110	***	2.477	0.110	***	2.468	0.109	***
Annual change in VCs investing venture capital	0.001	0.001		0.000	0.001		0.000	0.001		0.000	0.001		0.000	0.001	
Annual change in ventures receiving biotech venture capital	0.001	0.000	**	0.001	0.000	**	0.001	0.000	**	0.001	0.000	**	0.001	0.000	**
Annual change in total venture capital raised	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**
Round in 1996-2000 dummy (1=yes)	-0.072	0.040	*	-0.064	0.040		-0.064	0.040		-0.051	0.040		-0.056	0.040	
Venture from US dummy (1=yes)	-0.049	0.041		-0.040	0.041		-0.040	0.041		-0.036	0.041		-0.038	0.041	
Venture sector 41 dummy (1=yes)	-0.009	0.028		-0.007	0.028		-0.007	0.028		-0.010	0.028		-0.007	0.028	
Venture age at round [years]	0.002	0.004		0.002	0.004		0.002	0.004		0.001	0.004		0.001	0.004	
Venture start-up/seed/early-stage dummy (1=yes)	-0.046	0.041		-0.046	0.041		-0.046	0.041		-0.044	0.041		-0.031	0.041	
1st round investment (1=yes)															
Deal size [$Mio]	0.001	0.001		0.001	0.001		0.001	0.001		0.001	0.001		0.001	0.001	
Syndicated deal dummy (1=yes)	0.055	0.032	*	0.064	0.032	**	0.065	0.032	**	0.066	0.031	**	0.067	0.032	**
% Independent private equity VCs in round	-0.072	0.041	*	-0.065	0.041		-0.064	0.041		-0.055	0.041		-0.055	0.041	
% VCs in round that come from same country as venture	-0.018	0.055		-0.016	0.055		-0.016	0.055		-0.026	0.054		-0.023	0.054	
Lead VC age [years]	0.000	0.001													
Lead VC non-biotech experience				0.000	0.000	*									
Lead VC total (non-/biotech) experience							0.000	0.000	*						
Lead VC biotech expertise										-0.001	0.000	***			
Lead VC biotech-stage expertise													-0.003	0.001	***
Adjusted R Square	0.026			0.030			0.030			0.039			0.039		
SE of the Estimate	0.368			0.367			0.367			0.365			0.365		
R Square Change	0.000			0.004			0.005			0.013			0.013		
F Change	0.121			3.006			3.364			10.050			9.850		
Sig. F Change	0.728			0.083			0.067			0.002			0.002		

Panel B-3: Syndicate's knowledge 1s rounds	Model 2-1			Model 2-2			Model 2-3			Model 2-4			Model 2-5		
N = 721															
	B	SE		B	SE		B	SE		B	SE		B	SE	
Constant	2.463	0.111		2.478	0.110	***	2.480	0.110	***	2.482	0.110	***	2.478	0.110	***
Annual change in VCs investing venture capital	0.001	0.001		0.000	0.001		0.000	0.001		0.000	0.001		0.000	0.001	
Annual change in ventures receiving biotech venture capital	0.001	0.000	**	0.001	0.000	**	0.001	0.000	**	0.001	0.000	**	0.001	0.000	**
Annual change in total venture capital raised	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**	0.000	0.000	**
Round in 1996-2000 dummy (1=yes)	-0.071	0.040	*	-0.061	0.040		-0.060	0.040		-0.054	0.040		-0.055	0.040	
Venture from US dummy (1=yes)	-0.045	0.041		-0.035	0.041		-0.035	0.041		-0.033	0.041		-0.034	0.041	
Venture sector 41 dummy (1=yes)	-0.010	0.028		-0.006	0.028		-0.006	0.028		-0.011	0.028		-0.009	0.028	
Venture age at round [years]	0.002	0.004		0.001	0.004		0.001	0.004		0.001	0.004		0.001	0.004	
Venture start-up/seed/early-stage dummy (1=yes)	-0.048	0.041		-0.048	0.041		-0.048	0.041		-0.045	0.041		-0.032	0.041	
1st round investment (1=yes)															
Deal size [$Mio]	0.001	0.001		0.001	0.001		0.001	0.001		0.001	0.001		0.001	0.001	
Syndicated deal dummy (1=yes)	0.053	0.031	*	0.056	0.031	*	0.057	0.031	*	0.053	0.031	***	0.053	0.031	*
% Independent private equity VCs in round	-0.073	0.041	*	-0.062	0.041		-0.061	0.041		-0.055	0.041		-0.056	0.041	
% VCs in round that come from same country as venture	-0.019	0.055		-0.023	0.054		-0.024	0.054		-0.034	0.054		-0.033	0.054	
Avg. syndicate age	-0.002	0.001													
Avg. syndicate non-biotech experience				0.000	0.000	**									
Avg. syndicate total (non-/biotech) experience							0.000	0.000	**						
Avg. syndicate biotech expertise										-0.001	0.000	***			
Avg. syndicate biotech-stage expertise													-0.005	0.001	***
Adjusted R Square	0.028			0.032			0.033			0.040			0.039		
SE of the Estimate	0.367			0.366			0.366			0.365			0.365		
R Square Change	0.002			0.007			0.007			0.014			0.014		
F Change	1.525			4.972			5.259			10.576			10.238		
Sig. F Change	0.217			0.026			0.022			0.001			0.001		

(continued) Table G-4: Hypotheses 2 – Multiple regression results

Shown are the results for the analyses of Hypotheses 2a and 2b. The dependent variable is the log of the round-length (in days) ('***': p<.01; '**': p<.05; '*': p<.1).

Panels C: additional analyses on later rounds only (N=2,116)
Panel C-1: baseline model
Panel C-2: full models for the lead VCs
Panel C-3: full models for the syndicates

Panel C-1: Baseline 2nd/later rounds	Model 0-1			Model 0-2			Model 0-3			Model 0-4		
N = 2,116												
	B	SE		B	SE		B	SE		B	SE	
Constant	2.353	0.067	***	2.306	0.076	***	2.295	0.075	***	2.315	0.081	***
Annual change in VCs investing venture capital	0.001	0.001		0.001	0.001		0.000	0.001		0.001	0.001	
Annual change in ventures receiving biotech venture capital	0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000	
Annual change in total venture capital raised	0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000	
Round in 1996-2000 dummy (1=yes)	-0.019	0.026		-0.014	0.027		-0.037	0.027		-0.042	0.027	
Venture from US dummy (1=yes)				0.027	0.031		0.040	0.031		0.022	0.038	
Venture sector 41 dummy (1=yes)				0.012	0.018		0.005	0.018		0.008	0.018	
Venture age at round [years]				0.000	0.003		-0.001	0.003		0.000	0.003	
Venture start-up/seed/early-stage dummy (1=yes)				0.018	0.019		0.024	0.019		0.021	0.019	
1st round investment (1=yes)												
Deal size [$Mio]							0.005	0.001	***	0.005	0.001	***
Syndicated deal dummy (1=yes)										0.039	0.021	*
% Independent private equity VCs in round										-0.067	0.027	*
% VCs in round that come from same country as venture										0.027	0.041	
Adjusted R Square	0.001			0.000			0.013			0.017		
SE of the Estimate	0.403			0.404			0.401			0.400		
R Square Change	0.003			0.001			0.013			0.005		
F Change	1.485			0.633			28.728			3.518		
Sig. F Change	0.204			0.639			0.000			0.015		

Panel C-2: Lead VC's knowledge 2nd/later rounds	Model 1-1			Model 1-2			Model 1-3			Model 1-4			Model 1-5		
N = 2,116															
	B	SE		B	SE		B	SE		B	SE		B	SE	
Constant	2.317	0.081	***	2.315	0.081	***	2.315	0.081	***	2.306	0.081	***	2.306	0.081	***
Annual change in VCs investing venture capital	0.001	0.001		0.001	0.001		0.001	0.001		0.001	0.001		0.001	0.001	
Annual change in ventures receiving biotech venture capital	0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000	
Annual change in total venture capital raised	0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000	
Round in 1996-2000 dummy (1=yes)	-0.040	0.027		-0.041	0.027		-0.041	0.027		-0.038	0.027		-0.039	0.027	
Venture from US dummy (1=yes)	0.020	0.038		0.022	0.038		0.022	0.038		0.025	0.038		0.021	0.038	
Venture sector 41 dummy (1=yes)	0.008	0.018		0.009	0.018		0.009	0.018		0.010	0.018		0.009	0.018	
Venture age at round [years]	0.000	0.003		-0.001	0.003		-0.001	0.003		-0.001	0.003		0.000	0.003	
Venture start-up/seed/early-stage dummy (1=yes)	0.021	0.019		0.019	0.019		0.018	0.019		0.015	0.019		0.033	0.019	*
1st round investment (1=yes)															
Deal size [$Mio]	0.005	0.001	***	0.005	0.001	***	0.005	0.001	***	0.005	0.001	***	0.005	0.001	***
Syndicated deal dummy (1=yes)	0.042	0.021	**	0.043	0.021	**	0.044	0.021	**	0.048	0.021	**	0.047	0.021	**
% Independent private equity VCs in round	-0.067	0.027	**	-0.066	0.027	**	-0.065	0.027	**	-0.054	0.028	**	-0.056	0.028	**
% VCs in round that come from same country as venture	0.030	0.041		0.032	0.041		0.033	0.041		0.035	0.041		0.033	0.041	
Lead VC age [years]	0.000	0.001													
Lead VC non-biotech experience				0.000	0.000										
Lead VC total (non-/biotech) experience							0.000	0.000							
Lead VC biotech expertise										0.000	0.000	***			
Lead VC biotech-stage expertise													-0.002	0.001	***
Adjusted R Square	0.016			0.017			0.017			0.021			0.020		
SE of the Estimate	0.400			0.400			0.400			0.399			0.399		
R Square Change	0.000			0.000			0.001			0.004			0.004		
F Change	0.330			1.060			1.701			9.564			8.431		
Sig. F Change	0.566			0.303			0.192			0.002			0.004		

Panel C-3: Syndicate's knowledge 2nd/later rounds	Model 2-1			Model 2-2			Model 2-3			Model 2-4			Model 2-5		
N = 2,116															
	B	SE		B	SE		B	SE		B	SE		B	SE	
Constant	2.318	0.082	***	2.323	0.081	***	2.325	0.081	***	2.319	0.081	***	2.320	0.081	***
Annual change in VCs investing venture capital	0.001	0.001		0.001	0.001		0.001	0.001		0.001	0.001		0.001	0.001	
Annual change in ventures receiving biotech venture capital	0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000	
Annual change in total venture capital raised	0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000		0.000	0.000	
Round in 1996-2000 dummy (1=yes)	-0.041	0.027		-0.041	0.027		-0.041	0.027		-0.037	0.027		-0.037	0.027	
Venture from US dummy (1=yes)	0.021	0.038		0.025	0.038		0.025	0.038		0.031	0.038		0.025	0.038	
Venture sector 41 dummy (1=yes)	0.008	0.018		0.010	0.018		0.010	0.018		0.011	0.018		0.010	0.018	
Venture age at round [years]	0.000	0.003		0.000	0.003		0.000	0.003		0.000	0.003		0.000	0.003	
Venture start-up/seed/early-stage dummy (1=yes)	0.021	0.019		0.019	0.019		0.019	0.019		0.015	0.019		0.036	0.019	*
1st round investment (1=yes)															
Deal size [$Mio]	0.005	0.001	***	0.005	0.001	***	0.005	0.001	***	0.005	0.001	***	0.005	0.001	***
Syndicated deal dummy (1=yes)	0.039	0.021	*	0.037	0.021	*	0.037	0.021	*	0.032	0.021		0.033	0.021	
% Independent private equity VCs in round	-0.066	0.027	**	-0.065	0.027	**	-0.064	0.027	**	-0.049	0.028	*	-0.051	0.028	*
% VCs in round that come from same country as venture	0.028	0.041		0.029	0.041		0.028	0.041		0.025	0.041		0.023	0.041	
Avg. syndicate age	0.000	0.001													
Avg. syndicate non-biotech experience				0.000	0.000	*									
Avg. syndicate total (non-/biotech) experience							0.000	0.000	*						
Avg. syndicate biotech expertise										-0.001	0.000	***			
Avg. syndicate biotech-stage expertise													-0.004	0.001	***
Adjusted R Square	0.016			0.018			0.018			0.024			0.023		
SE of the Estimate	0.400			0.400			0.400			0.399			0.399		
R Square Change	0.000			0.001			0.002			0.008			0.007		
F Change	0.170			2.760			3.783			17.435			15.374		
Sig. F Change	0.680			0.097			0.052			0.000			0.000		

Table G-5: Hypotheses 2 - Multiple regression results (additional analysis)

Shown are the results for the additional analysis of pre-1998 rounds only (N=1,938) ('*': p<0.1; '**': p<0.05; '***': p<0.01).

(N=1938)	Model 1-1	Model 1-2	Model 1-3	Model 1-4	Model 1-5	Model 2-1	Model 2-2	Model 2-3	Model 2-4	Model 2-5
	beta	beta	beta	beta	beta	beta	beta	beta	beta	beta
(Constant)	2.499 ***	2.494 ***	2.494 ***	2.481 ***	2.479 ***	2.508 ***	2.508 ***	2.510 ***	2.495 ***	2.493 ***
Annual change in VCs investing venture capital	(0.000)	(0.000)	(0.000)	0.000	(0.000)	(0.000)	(0.000)	(0.000)	0.000	(0.000)
Annual change in ventures receiving biotech venture capital	0.001 **	0.001 *	0.001 *	0.001	0.001	0.001 *	0.001 *	0.001 *	0.001	0.001
Annual change in total venture capital raised	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Round in 1996-2000 dummy (1=yes)	(0.021)	(0.020)	(0.020)	(0.014)	(0.018)	(0.019)	(0.020)	(0.019)	(0.016)	(0.016)
Venture from US dummy (1=yes)	(0.040)	(0.044)	(0.045)	(0.038)	(0.042)	(0.039)	(0.041)	(0.041)	(0.026)	(0.031)
Venture sector 41 dummy (1=yes)	(0.019)	(0.015)	(0.015)	(0.009)	(0.013)	(0.020)	(0.015)	(0.014)	(0.008)	(0.011)
Venture age at round	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004
Venture start-up/seed/early-stage dummy (1=yes)	(0.018)	(0.020)	(0.021)	(0.027)	0.004	(0.018)	(0.019)	(0.020)	(0.027)	0.007
1st round investment	0.152 ***	0.144 ***	0.143 ***	0.138 ***	0.137 ***	0.152 ***	0.144 ***	0.144 ***	0.139 ***	0.136 ***
Deal size ($Mio)	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***
Syndicated deal dummy (1=yes)	0.043 *	0.048 **	0.049 **	0.056 **	0.052 **	0.039 *	0.036	0.035	0.031	0.031
% true private equity VCs in round	(0.108) ***	(0.102) ***	(0.101) ***	(0.086) ***	(0.091) ***	(0.108) ***	(0.102) ***	(0.101) ***	(0.081) ***	(0.083) ***
% VCs in round that come from same country as venture	(0.020)	(0.012)	(0.011)	(0.017)	(0.019)	(0.022)	(0.019)	(0.019)	(0.031)	(0.035)
Lead VC age	(0.001)									
Lead VC non-biotech experience		(0.000) *								
Lead VC total experience			(0.000) *							
Lead VC biotech expertise				(0.001) ***						
Lead VC biotech-stage expertise					(0.003) ***					
Avg. syndicate age						(0.002)				
Avg. syndicate non-biotech experience							(0.000) **			
Avg. syndicate total experience								(0.000) **		
Avg. syndicate biotech expertise									(0.002) ***	
Avg. syndicate botech-stage expertise										(0.006) ***
Adjusted R Square	0.037	0.036	0.037	0.044	0.042	0.037	0.037	0.038	0.047	0.046
SE of estimate	0.433	0.433	0.433	0.432	0.432	0.433	0.433	0.433	0.431	0.431
R Square Change (over baseline model)	0.000	0.001	0.002	0.008	0.006	0.001	0.002	0.003	0.011	0.010
F Change	0.599	2.995 *	3.724 *	16.044 ***	12.488 ***	2.007	4.792 **	5.602 **	21.651 ***	20.339 ***

Table G-6: Hypotheses 2 - t-test

Shown are the results for the t-test that serves as an additional analysis to compare the not-/included first rounds ('*': p<0.1; '**': p<0.05; '***': p<0.01).

Panel A: all first rounds (N-included=729; N-not-included=310)
Panel B: pre-1998 first rounds (N-included=477; N-not-included=55)

Panel A: all 1st rounds	Included in analysis (N=729)			Not included in analysis (N=310)				
	Mean	SD	SE	Mean	SD	SE	t	Sig. (2-tail.)
Annual change in VCs investing venture capital	117.5	21.8	0.8	103.5	27.3	1.6	8.0	0.000 ***
Annual change in ventures receiving biotech venture capital	123.6	35.6	1.3	110.3	32.9	1.9	5.8	0.000 ***
Annual change in total venture capital raised	138.9	78.5	2.9	92.9	71.7	4.1	9.2	0.000 ***
Round in 1996-2000 dummy (1=yes)	0.4	0.5	0.0	0.3	0.5	0.0	2.3	0.022 **
Venture from US dummy (1=yes)	0.8	0.4	0.0	0.5	0.5	0.0	10.1	0.000 ***
Venture sector 41 dummy (1=yes)	0.6	0.5	0.0	0.5	0.5	0.0	2.8	0.006 ***
Venture age at round	1.8	3.4	0.1	3.9	8.7	0.5	-4.0	0.000 ***
Venture start-up/seed/early-stage dummy (1=yes)	0.8	0.4	0.0	0.7	0.5	0.0	5.2	0.000 ***
Deal size ($Mio)	4.7	21.7	0.8	5.9	14.0	0.8	-1.1	0.275
Syndicated deal dummy (1=yes)	0.7	0.5	0.0	0.6	0.5	0.0	2.1	0.033 **
% VCs from US in round	0.7	0.3	0.0	0.4	0.4	0.0	10.2	0.000 ***
% true private equity VCs in round	0.6	0.4	0.0	0.6	0.4	0.0	2.5	0.013 **
% VCs in round that come from same country as venture	0.8	0.3	0.0	0.7	0.3	0.0	1.0	0.315
Lead VC age	13.6	13.8	0.5	12.4	12.0	0.7	1.4	0.153
Lead VC non-biotech experience	143.0	212.1	7.9	97.7	225.1	12.8	3.0	0.003 ***
Lead VC total experience	159.2	233.9	8.7	112.3	247.6	14.1	2.8	0.005 ***
Lead VC biotech expertise	25.1	47.6	1.8	18.3	38.3	2.2	2.4	0.015 **
Lead VC biotech-stage expertise	7.4	13.4	0.5	5.5	11.3	0.6	2.3	0.022 **
Avg. syndicate age	9.6	9.4	0.3	9.2	8.6	0.5	0.7	0.513
Avg. syndicate non-biotech experience	91.5	136.7	5.1	56.8	112.7	6.4	4.3	0.000 ***
Avg. syndicate total experience	102.9	151.3	5.6	67.2	124.7	7.1	4.0	0.000 ***
Avg. syndicate biotech expertise	16.4	35.7	1.3	11.4	21.5	1.2	2.8	0.005 ***
Avg. syndicate botech-stage expertise	4.8	9.9	0.4	3.5	6.7	0.4	2.4	0.015 **
Round Year	1,993.0	6.7	0.2	1,999.0	5.0	0.3	-15.8	0.000 ***

Panel B: pre-1998 1st rounds	Included in analysis (N=477)			Not included in analysis (N=55)				
	Mean	SD	SE	Mean	SD	SE	t	Sig. (2-tail.)
Annual change in VCs investing venture capital	113.2	18.1	0.8	108.9	17.6	2.4	1.7	0.092 *
Annual change in ventures receiving biotech venture capital	124.0	37.1	1.7	121.6	26.5	3.6	0.6	0.535
Annual change in total venture capital raised	137.5	84.3	3.9	133.0	43.5	5.9	0.6	0.522
Round in 1996-2000 dummy (1=yes)	0.2	0.4	0.0	0.2	0.4	0.1	-0.7	0.497
Venture from US dummy (1=yes)	0.9	0.3	0.0	0.9	0.4	0.0	1.4	0.162
Venture sector 41 dummy (1=yes)	0.6	0.5	0.0	0.6	0.5	0.1	0.7	0.461
Venture age at round	1.6	3.5	0.2	3.6	5.3	0.7	-2.7	0.009 ***
Venture start-up/seed/early-stage dummy (1=yes)	0.9	0.3	0.0	0.7	0.5	0.1	2.5	0.015 **
Deal size ($Mio)	4.0	25.5	1.2	3.3	13.4	1.8	0.3	0.741
Syndicated deal dummy (1=yes)	0.6	0.5	0.0	0.3	0.5	0.1	4.7	0.000 ***
% VCs from US in round	0.8	0.3	0.0	0.8	0.3	0.0	0.6	0.561
% true private equity VCs in round	0.7	0.4	0.0	0.7	0.4	0.1	-0.6	0.548
% VCs in round that come from same country as venture	0.8	0.3	0.0	0.8	0.3	0.0	0.2	0.830
Lead VC age	14.1	14.5	0.7	9.7	8.4	1.1	3.3	0.001 ***
Lead VC non-biotech experience	149.4	191.2	8.8	74.9	136.7	18.4	3.6	0.000 ***
Lead VC total experience	163.8	210.9	9.7	86.1	157.4	21.2	3.3	0.001 ***
Lead VC biotech expertise	20.8	35.6	1.6	11.2	24.6	3.3	2.6	0.011 **
Lead VC biotech-stage expertise	6.6	11.0	0.5	2.7	5.0	0.7	4.6	0.000 ***
Avg. syndicate age	10.0	10.2	0.5	9.1	8.1	1.1	0.7	0.469
Avg. syndicate non-biotech experience	97.7	132.7	6.1	63.0	93.2	12.6	2.5	0.015 **
Avg. syndicate total experience	108.1	146.7	6.7	71.9	103.7	14.0	2.3	0.022 **
Avg. syndicate biotech expertise	13.5	24.5	1.1	8.8	15.6	2.1	1.9	0.056 *
Avg. syndicate botech-stage expertise	4.2	7.3	0.3	2.3	3.8	0.5	3.1	0.002 ***
Round Year	1,989.5	5.6	0.3	1,989.6	5.1	0.7	-0.1	0.888

J.VIII. Tables Chapter H

Table H-2: Hypotheses 3 - Summary statistics (continued)

Shown are the detailed summary statistics for the 'core sample' of all/non-public/public ventures founded before 1994 ('core sample' raw data, used for the main analysis of H3a), including the results of a t-test comparing the mean values of the examined variables for non-public and public ventures ('***': p<.01; '**': p<.05; '*': p<.1). Also shown are (in the last five columns) the summary statistics for the sample used for the main analysis of H3b.

Summary statistics			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			All ventures founded before 1994													All ventures founded before March 2003				
			All ventures					Non-public ventures			Public ventures			t-test non-/public		All ventures				
			Mean	SD	Min	Max.	N	Mean	SD	N	Mean	SD	N	Sig.(*)		Mean	SD	Min.	Max.	N
1	All VCs' knowledge - all rounds	Avg. age of all VCs invested in venture	**10.33**	10.05	0.10	126.50	568	**10.47**	10.41	330	**10.13**	9.56	238	0.693		**10.60**	10.57	0.10	129.00	1602
2		Avg. experience of all VCs invested in venture	**123.92**	148.45	0.00	1,020.00	567	**118.52**	157.68	330	**131.43**	134.51	237	0.307		**104.66**	149.07	0.00	1,273.00	1594
3		Avg. non-biotech experience of all VCs invested in venture	**111.15**	137.16	0.00	961.00	567	**105.72**	146.49	330	**118.72**	122.91	237	0.266		**91.16**	134.48	0.00	1,081.00	1594
4		Avg. biotech expertise of all VCs invested in venture	**14.95**	19.48	0.00	194.62	567	**13.63**	16.55	330	**16.79**	22.85	237	0.057	*	**16.68**	32.47	0.00	407.00	1597
5		Avg. biotech-stage expertise of all VCs invested in venture	**3.87**	5.10	0.00	47.18	567	**3.50**	4.45	330	**4.38**	5.87	237	0.043	**	**4.35**	7.34	0.00	95.33	1597
6		Avg. biotech-sector expertise of all VCs invested in venture	**7.56**	12.18	0.00	117.74	567	**6.24**	9.81	330	**9.39**	14.68	237	0.002	***	**7.05**	13.22	0.00	125.75	1597
7	Lead VCs' knowledge - all rounds	Avg. age of lead VCs invested in venture	**14.35**	12.88	0.10	126.50	568	**13.63**	12.61	330	**15.35**	13.21	238	0.118		**14.68**	13.71	0.10	129.00	1602
8		Avg. experience of lead VCs invested in venture	**190.63**	226.93	0.00	1,488.00	567	**175.71**	234.70	330	**211.40**	214.41	237	0.065	*	**172.17**	251.75	0.00	2,088.00	1594
9		Avg. non-biotech experience of lead VCs invested in venture	**172.16**	207.55	0.00	1,364.00	567	**157.92**	215.26	330	**191.99**	195.02	237	0.054	*	**152.31**	228.13	0.00	1,934.00	1594
10		Avg. biotech expertise of lead VCs invested in venture	**23.33**	31.14	0.00	264.67	567	**20.42**	27.48	330	**27.39**	35.27	237	0.008	***	**26.45**	45.60	0.00	407.00	1597
11		Avg. biotech-stage expertise of lead VCs invested in venture	**6.13**	8.41	0.00	69.00	567	**5.22**	7.08	330	**7.39**	9.85	237	0.002	***	**6.92**	11.04	0.00	121.00	1597
12		Avg. biotech-sector expertise of lead VCs invested in venture	**11.81**	19.32	0.00	166.67	567	**9.51**	16.29	330	**15.02**	22.54	237	0.001	***	**11.44**	21.70	0.00	244.00	1597
13	All VCs' knowledge - 1st rounds	Avg. age of all VCs in 1st round	**9.39**	10.69	0.10	126.00	554	**9.72**	11.02	322	**8.94**	10.23	232	0.401		**9.91**	11.45	0.10	129.00	1541
14		Avg. experience of all VCs in 1st round	**94.59**	137.57	0.00	1,020.00	551	**89.35**	135.38	322	**101.96**	140.55	229	0.289		**87.11**	150.89	0.00	1,273.00	1531
15		Avg. non-biotech experience of all VCs in 1st round	**85.83**	127.59	0.00	961.00	551	**80.45**	125.74	322	**93.41**	130.05	229	0.240		**76.26**	135.60	0.00	1,081.00	1531
16		Avg. biotech expertise of all VCs in 1st round	**10.38**	17.95	0.00	199.00	555	**9.30**	12.97	323	**11.90**	23.11	232	0.093	*	**13.83**	32.47	0.00	407.00	1538
17		Avg. biotech-stage expertise of all VCs in 1st round	**3.25**	5.42	0.00	44.00	555	**2.88**	4.43	323	**3.75**	6.53	232	0.065	*	**4.05**	8.74	0.00	115.00	1538
18		Avg. biotech-sector expertise of all VCs in 1st round	**4.85**	10.73	0.00	137.00	555	**3.98**	7.25	323	**6.06**	14.15	232	0.024	**	**5.44**	13.85	0.00	231.00	1538
19	Lead VCs' knowledge - 1st rounds	Age of lead VCs in 1st round	**12.71**	14.47	0.10	128.00	554	**12.90**	14.83	322	**12.43**	13.97	232	0.705		**12.94**	14.23	0.10	129.00	1541
20		Avg. experience of lead VCs in 1st round	**139.75**	207.10	0.00	1,488.00	551	**132.81**	211.30	322	**149.52**	201.09	229	0.351		**130.24**	232.91	0.00	2,088.00	1531
21		Avg. non-biotech expertise of lead VCs in 1st round	**127.85**	191.27	0.00	1,364.00	551	**120.65**	195.59	322	**137.97**	184.97	229	0.295		**115.52**	211.07	0.00	1,934.00	1531
22		Avg. biotech expertise of lead VCs in 1st round	**15.14**	24.44	0.00	199.00	555	**14.12**	20.98	323	**16.56**	28.56	232	0.246		**20.07**	42.40	0.00	407.00	1538
23		Avg. biotech-stage expertise of lead VCs in 1st round	**4.91**	8.17	0.00	61.00	555	**4.41**	7.23	323	**5.59**	9.29	232	0.093	*	**5.90**	11.81	0.00	121.00	1538
24		Avg. biotech-sector expertise of lead VCs in 1st round	**7.08**	14.14	0.00	137.00	555	**5.98**	11.00	323	**8.61**	17.51	232	0.031	**	**8.06**	19.69	0.00	240.00	1538
25	All VCs' knowledge - 2nd/later rounds	Avg. age of all VCs in 2nd/later round	**11.20**	8.41	0.10	127.00	430	**11.21**	7.05	207	**11.19**	9.52	223	0.979		**11.77**	9.19	0.10	128.00	945
26		Avg. total experience of all VCs in 2nd/later round	**138.95**	145.40	0.00	961.00	430	**135.86**	157.92	207	**141.82**	133.01	223	0.674		**125.84**	142.51	0.00	961.00	945
27		Avg. non-biotech experience of all VCs in 2nd/later round	**156.35**	158.54	0.00	1,020.00	430	**153.45**	169.85	207	**159.04**	147.61	223	0.717		**144.22**	156.84	0.00	1,020.00	945
28		Avg. biotech expertise of all VCs in 2nd/later round	**21.56**	23.17	0.00	157.35	430	**19.02**	19.18	207	**23.92**	26.16	223	0.026	**	**23.97**	36.70	0.00	378.00	948
29		Avg. biotech-stage expertise of all VCs in 2nd/later round	**4.97**	5.51	0.00	39.06	430	**4.62**	4.89	207	**5.29**	6.02	223	0.206		**5.69**	7.61	0.00	85.50	948
30		Avg. biotech-sector expertise of all VCs in 2nd/later round	**11.45**	15.18	0.00	108.29	430	**9.08**	12.09	207	**13.65**	17.30	223	0.002	***	**10.71**	14.89	0.00	108.29	948
31	Lead VCs' knowledge - 2nd/later rounds	Avg. age of lead VCs in 2nd/later round	**16.02**	12.64	0.10	130.00	430	**15.59**	10.56	207	**16.42**	14.32	223	0.492		**17.53**	14.31	0.10	130.00	945
32		Avg. total experience of lead VCs in 2nd/later round	**215.25**	218.63	0.00	1,364.00	430	**213.75**	237.26	207	**216.64**	200.32	223	0.892		**219.88**	260.92	0.00	2,041.00	945
33		Avg. non-biotech expertise of lead VCs in 2nd/later round	**240.04**	240.74	0.00	1,488.00	430	**238.88**	259.89	207	**241.11**	222.08	223	0.924		**248.15**	286.77	0.00	2,207.00	945
34		Avg. biotech expertise of lead VCs in 2nd/later round	**32.76**	36.36	0.00	226.00	430	**29.52**	33.19	207	**35.78**	38.91	223	0.073	*	**39.33**	53.44	0.00	378.00	948
35		Avg. biotech-stage expertise of lead VCs in 2nd/later round	**7.78**	8.97	0.00	60.40	430	**7.15**	7.98	207	**8.36**	9.78	223	0.161		**9.54**	12.17	0.00	121.00	948
36		Avg. biotech-sector expertise of lead VCs in 2nd/later round	**17.35**	23.89	0.00	156.80	430	**14.35**	20.87	207	**20.13**	26.12	223	0.011	**	**17.92**	26.32	0.00	246.00	948

(continued) Table H-2: Hypotheses 3 - Summary statistics

Shown are the detailed summary statistics for the 'core sample' of all/non-public/public ventures founded before 1994 ('core sample' raw data, used for the main analysis of H3a), including the results of a t-test comparing the mean values of the examined variables for non-public and public ventures ('***': p<.01; '**': p<.05; '*': p<.1). Also shown are (in the last five columns) the summary statistics for the sample used for the main analysis of H3b.

	Summary statistics		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			All ventures founded before 1994													All ventures founded before March 2003				
			All ventures					Non-public ventures			Public ventures			t-test non-/public		All ventures				
			Mean	SD	Min	Max.	N	Mean	SD	N	Mean	SD	N	Sig.(*)		Mean	SD	Min.	Max.	N
37	Venture-related control variables	Round amount at 1st round	**3.05**	8.16	0.00	148.20	522	**3.18**	10.06	285	**2.90**	5.01	237	0.698		**4.86**	17.95	0.00	550.00	1394
38		Venture amount received before IPO or until last round	**16.78**	22.71	0.01	150.50	529	**16.42**	22.00	296	**17.24**	23.62	233	0.681		**17.02**	28.04	0.00	550.00	1461
39		Venture from US dummy (1=yes)	**0.84**	0.37	0.00	1.00	613	**0.78**	0.41	343	**0.91**	0.28	270	0.000	***	**0.63**	0.48	0.00	1.00	1712
40		Venture stage start-up/seed or early at 1st round	**0.77**	0.42	0.00	1.00	613	**0.74**	0.44	343	**0.80**	0.40	270	0.106		**0.74**	0.44	0.00	1.00	1712
41		Venture 1st round syndicated	**0.50**	0.50	0.00	1.00	613	**0.50**	0.50	343	**0.49**	0.50	270	0.884		**0.49**	0.50	0.00	1.00	1712
42		Length of 1st round (adjusted for IPOs or acquisitions as last rounds)	**631.88**	781.56	11.00	7,185.00	472	**619.77**	589.27	225	**642.91**	923.63	247	0.744		**537.39**	616.92	1.00	7,185.00	1019
43	Context-related control variables - 1st round	Annual change in DJI in year of 1st round	**112.04**	12.94	90.54	134.87	599	**111.08**	12.61	338	**113.28**	13.27	261	0.039	**	**109.09**	13.33	81.27	134.87	1609
44		Annual change in no. of biotech VC-backed IPOs in year of 1st round	**183.10**	222.86	8.82	1,000.00	591	**172.29**	215.86	335	**197.24**	231.36	256	0.178		**176.90**	216.91	8.82	1,000.00	1642
45		Annual change in venture capital raised in year of 1st round	**132.67**	80.22	17.44	1,641.73	602	**125.34**	51.11	339	**142.13**	105.98	263	0.011	**	**125.35**	75.41	17.44	1,641.73	1658
46		Annual change in no. of VCs providing venture capital in year of 1st round	**109.13**	19.11	73.87	149.00	602	**108.34**	19.81	339	**110.13**	18.15	263	0.255		**114.00**	24.82	73.87	149.00	1658
47		Annual change in no. of ventures receiving biotech venture capital in year of 1st round	**122.29**	34.83	76.71	350.00	602	**119.39**	31.78	339	**126.02**	38.15	263	0.020	**	**118.84**	33.40	76.71	350.00	1656
48	Context-related control variables - last round/IPO	Annual change in DJI in year of last round/IPO	**114.29**	12.61	90.54	134.87	603	**112.01**	12.76	333	**117.11**	11.84	270	0.000	***	**105.84**	13.70	90.54	134.87	1585
49		Annual change in no. of biotech VC-backed IPOs in year of last round/IPO	**234.02**	279.54	8.82	1,000.00	608	**177.49**	235.48	338	**304.79**	312.77	270	0.000	***	**192.54**	244.24	8.82	1,000.00	1669
50		Annual change in venture capital raised in year of last round/IPO	**126.23**	53.67	17.44	220.64	609	**118.82**	55.07	339	**135.52**	50.44	270	0.000	***	**104.63**	71.61	17.44	478.71	1673
51		Annual change in no. of VCs providing venture capital in year of last round/IPO	**110.58**	21.20	73.87	149.00	609	**108.19**	22.32	339	**113.58**	19.32	270	0.001	***	**107.46**	26.40	73.87	149.00	1673
52		Annual change in no. of ventures receiving biotech venture capital in year of last round/IPO	**116.53**	24.47	76.71	215.79	609	**112.89**	24.93	339	**121.10**	23.13	270	0.000	***	**112.40**	30.97	76.71	215.79	1671
53	Variables not used for analysis	Venture no. of rounds until last round or IPO (where relevant)	**3.80**	3.08	1.00	19.00	613	**3.51**	3.08	343	**4.16**	3.04	270	0.010	**	**2.78**	2.49	1.00	19.00	1712
54		Venture foundation year	**1,986.79**	4.52	1,974.00	1,993.00	557	**1,987.27**	4.36	296	**1,986.26**	4.64	261	0.008	***	**1,992.75**	8.66	1,902.00	2,003.00	1354
55		Venture age at 1st round	**3.00**	4.32	-3.25	24.01	545	**3.77**	4.95	291	**2.13**	3.25	254	0.000	***	**2.61**	6.36	-8.59	96.12	1331
56		Venture age at last update	**15.55**	4.40	8.26	29.29	556	**15.11**	4.29	296	**16.06**	4.49	260	0.011	**	**9.77**	8.56	0.02	101.15	1352

Table H-3: Hypotheses 3 - Correlations

Shown are the correlations for the variables in the 'core sample' of ventures founded before 1994.

		1	2	3	4	5	6	7	8	9	10	11	12
1	Avg. age of 1st round VCs	1.000											
2	Avg. total experience of 1st round VCs		1.000										
3	Avg. non-biotech experience of 1st round VCs		0.998	1.000									
4	Avg. biotech expertise of 1st round VCs	0.125	0.588	0.573	1.000								
5	Avg. biotech-stage expertise of 1st round VCs	0.103	0.547	0.526	0.808	1.000							
6	Avg. biotech-sector expertise of 1st round VCs	0.088	0.435	0.425	0.878	0.703	1.000						
7	Max. age of 1st round VC	0.819	0.220	0.221	0.097	0.089	0.086	1.000					
8	Max. total experience of 1st round VC	0.224	0.878	0.873	0.526	0.509	0.375	0.299	1.000				
9	Max. non-biotech expertise of 1st round VC	0.224	0.879	0.877	0.515	0.494	0.368	0.302	0.999	1.000			
10	Max. biotech expertise of 1st round VC	0.127	0.587	0.570	0.883	0.754	0.757	0.180	0.689	0.673	1.000		
11	Max. biotech-stage expertise of 1st round VC	0.105	0.507	0.487	0.680	0.865	0.591	0.176	0.639	0.623	0.849	1.000	
12	Max. biotech-sector expertise of 1st round VC	0.109	0.440	0.427	0.784	0.677	0.903	0.182	0.488	0.475	0.849	0.746	1.000
13	Avg. age of all VCs invested in venture	0.941	0.243	0.243	0.149	0.136	0.102	0.755	0.204	0.204	0.147	0.130	0.120
14	Avg. total experience of all VCs invested in venture	0.218	0.824	0.823	0.495	0.452	0.355	0.199	0.750	0.751	0.522	0.461	0.389
15	Avg. non-biotech experience of all VCs invested in venture	0.220	0.825	0.827	0.482	0.433	0.346	0.197	0.746	0.750	0.506	0.442	0.376
16	Avg. biotech expertise of all VCs invested in venture	0.087	0.485	0.471	0.836	0.668	0.744	0.094	0.457	0.447	0.766	0.601	0.690
17	Avg. biotech-stage expertise of all VCs invested in venture	0.062	0.456	0.440	0.779	0.775	0.715	0.063	0.433	0.422	0.725	0.701	0.677
18	Avg. biotech-sector expertise of all VCs invested in venture	0.053	0.355	0.346	0.730	0.621	0.837	0.091	0.340	0.333	0.662	0.561	0.792
19	Avg. max. age of VCs invested in venture	0.807	0.216	0.216	0.132	0.144	0.108	0.831	0.256	0.256	0.183	0.190	0.175
20	Avg. max. total experience of VCs invested in venture	0.176	0.750	0.744	0.476	0.467	0.346	0.234	0.851	0.849	0.631	0.599	0.461
21	Avg. max. non-biotech experience of VCs invested in venture	0.178	0.754	0.751	0.470	0.454	0.341	0.235	0.852	0.853	0.619	0.584	0.450
22	Avg. max. biotech expertise of VCs invested in venture	0.077	0.462	0.447	0.772	0.653	0.692	0.131	0.545	0.532	0.851	0.725	0.753
23	Avg. max. biotech-stage expertise of VCs invested in venture	0.060	0.438	0.423	0.718	0.727	0.664	0.114	0.530	0.517	0.807	0.814	0.737
24	Avg. max. biotech-sector exprtise of VCs invested in venture	0.063	0.352	0.342	0.696	0.622	0.792	0.135	0.409	0.400	0.743	0.675	0.859
25	Annual change in DJI in year of 1st round	0.023	0.036	0.038	0.025	-0.001	0.003	0.086	0.064	0.068	0.044	0.032	0.010
26	Annual change in total no. of biotech VC-backed IPOs in year of 1st round	-0.054	0.040	0.042	-0.018	0.000	-0.018	-0.036	-0.008	-0.004	-0.065	-0.045	-0.053
27	Annual change in total venture capital raised in year of 1st round	0.025	-0.016	-0.014	-0.001	-0.017	0.012	0.008	-0.012	-0.011	0.002	-0.015	0.015
28	Annual change in total no. of VCs providing venture capital in year of 1st round	0.032	-0.178	-0.171	-0.129	-0.210	-0.100	0.020	-0.153	-0.149	-0.133	-0.197	-0.115
29	Annual change in total no. of ventures receiving biotech venture capital in year of 1st round	-0.063	-0.192	-0.184	-0.184	-0.196	-0.144	-0.052	-0.186	-0.179	-0.197	-0.193	-0.153
30	Round amount at 1st round	0.117	0.034	0.034	0.015	0.006	-0.015	0.175	0.119	0.119	0.093	0.077	0.039
31	Venture total amount received before IPO or until last round	0.034	0.023	0.028	-0.030	-0.010	-0.033	0.061	0.009	0.015	-0.053	-0.031	-0.054
32	Venture total no. of rounds until last round or IPO (where relevant)	-0.040	0.055	0.053	0.148	0.199	0.157	0.104	0.103	0.105	0.176	0.221	0.184
33	Venture from US dummy (1=yes)	-0.059	0.042	0.046	0.034	0.084	0.067	-0.019	0.072	0.077	0.063	0.099	0.079
34	Venture age at 1st round	0.190	-0.003	-0.003	-0.017	-0.099	-0.052	0.158	0.021	0.020	-0.018	-0.084	-0.066
35	Venture stage start-up/seed or early at 1st round	-0.108	-0.009	-0.010	-0.040	0.167	0.014	-0.048	0.027	0.027	0.003	0.176	0.050
36	Venture foundation year	0.173	0.306	0.294	0.322	0.331	0.280	0.139	0.287	0.276	0.353	0.340	0.327
37	Venture age at last update	-0.159	-0.298	-0.286	-0.315	-0.330	-0.277	-0.130	-0.278	-0.267	-0.348	-0.337	-0.326

		13	14	15	16	17	18	19	20	21	22	23	24
13	Avg. age of all VCs invested in venture	1.000											
14	Avg. total experience of all VCs invested in venture	0.239	1.000										
15	Avg. non-biotech experience of all VCs invested in venture	0.239	0.998	1.000									
16	Avg. biotech expertise of all VCs invested in venture	0.149	0.620	0.601	1.000								
17	Avg. biotech-stage expertise of all VCs invested in venture	0.122	0.537	0.518	0.876	1.000							
18	Avg. biotech-sector expertise of all VCs invested in venture	0.101	0.444	0.428	0.879	0.800	1.000						
19	Avg. max. age of VCs invested in venture	0.873	0.226	0.223	0.151	0.135	0.129	1.000					
20	Avg. max. total experience of VCs invested in venture	0.209	0.881	0.874	0.595	0.535	0.443	0.289	1.000				
21	Avg. max. non-biotech experience of VCs invested in venture	0.209	0.885	0.881	0.583	0.523	0.433	0.289	0.998	1.000			
22	Avg. max. biotech expertise of VCs invested in venture	0.141	0.565	0.546	0.912	0.822	0.813	0.206	0.701	0.684	1.000		
23	Avg. max. biotech-stage expertise of VCs invested in venture	0.123	0.494	0.477	0.794	0.909	0.733	0.200	0.643	0.628	0.897	1.000	
24	Avg. max. biotech-sector exprtise of VCs invested in venture	0.112	0.420	0.404	0.817	0.763	0.933	0.187	0.532	0.518	0.886	0.817	1.000
25	Annual change in DJI in year of 1st round	0.044	0.001	0.002	0.011	0.001	-0.005	0.092	0.034	0.036	0.036	0.037	0.007
26	Annual change in total no. of biotech VC-backed IPOs in year of 1st round	-0.066	0.006	0.008	-0.045	-0.035	-0.042	-0.062	-0.029	-0.026	-0.064	-0.050	-0.057
27	Annual change in total venture capital raised in year of 1st round	0.016	-0.048	-0.046	-0.033	-0.057	-0.011	0.019	-0.029	-0.027	-0.020	-0.040	-0.001
28	Annual change in total no. of VCs providing venture capital in year of 1st round	-0.001	-0.160	-0.151	-0.159	-0.195	-0.150	0.031	-0.126	-0.118	-0.142	-0.170	-0.139
29	Annual change in total no. of ventures receiving biotech venture capital in year of 1st round	-0.095	-0.162	-0.152	-0.185	-0.188	-0.156	-0.061	-0.161	-0.152	-0.182	-0.180	-0.148
30	Round amount at 1st round	0.112	0.007	0.008	-0.018	-0.031	-0.030	0.147	0.063	0.065	0.025	0.017	-0.001
31	Venture total amount received before IPO or until last round	0.012	0.005	0.009	-0.057	-0.025	-0.048	0.044	-0.002	0.002	-0.066	-0.027	-0.069
32	Venture total no. of rounds until last round or IPO (where relevant)	0.022	0.183	0.170	0.340	0.286	0.350	0.136	0.248	0.238	0.379	0.306	0.383
33	Venture from US dummy (1=yes)	-0.043	0.093	0.095	0.083	0.094	0.104	-0.032	0.111	0.114	0.096	0.108	0.102
34	Venture age at 1st round	0.151	-0.068	-0.066	-0.090	-0.129	-0.127	0.098	-0.066	-0.064	-0.106	-0.121	-0.141
35	Venture stage start-up/seed or early at 1st round	-0.092	0.054	0.052	0.030	0.138	0.073	-0.035	0.085	0.083	0.066	0.146	0.094
36	Venture foundation year	0.236	0.257	0.244	0.305	0.322	0.276	0.242	0.289	0.277	0.339	0.336	0.308
37	Venture age at last update	-0.227	-0.253	-0.240	-0.298	-0.321	-0.272	-0.237	-0.282	-0.270	-0.331	-0.332	-0.304

		25	26	27	28	29	30	31	32	33	34	35	36
25	Annual change in DJI in year of 1st round	1.000											
26	Annual change in total no. of biotech VC-backed IPOs in year of 1st round	0.357	1.000										
27	Annual change in total venture capital raised in year of 1st round	0.148	-0.109	1.000									
28	Annual change in total no. of VCs providing venture capital in year of 1st round	0.095	0.116	0.272	1.000								
29	Annual change in total no. of ventures receiving biotech venture capital in year of 1st round	0.078	0.243	0.177	0.527	1.000							
30	Round amount at 1st round	-0.026	-0.090	-0.021	0.031	-0.077	1.000						
31	Venture total amount received before IPO or until last round	-0.032	-0.059	0.058	0.088	0.020	0.021	1.000					
32	Venture total no. of rounds until last round or IPO (where relevant)	0.039	0.081	0.018	-0.079	-0.001	-0.097	-0.029	1.000				
33	Venture from US dummy (1=yes)	0.020	0.027	0.035	-0.037	0.098	-0.120	0.024	0.202	1.000			
34	Venture age at 1st round	-0.042	-0.129	-0.056	0.151	-0.162	0.261	-0.002	-0.306	-0.397	1.000		
35	Venture stage start-up/seed or early at 1st round	0.032	0.067	0.012	-0.109	0.089	-0.181	-0.041	0.322	0.382	-0.453	1.000	
36	Venture foundation year	0.049	-0.140	-0.134	-0.238	-0.417	0.123	-0.013	0.030	-0.232	-0.062	-0.165	1.000
37	Venture age at last update	-0.057	0.140	0.139	0.250	0.418	-0.117	0.016	-0.035	0.193	0.108	0.139	-0.992

Table H-4: Hypotheses 3a - Logistic regression results for main analysis on 'core sample'

Shown are the results for the main analyses of Hypothesis 3a i-iii on the 'core-sample' of ventures that had received at least two rounds of funding and that were founded before 1994 (N=310). The dependent variable is the dichotomous outcome IPO yes/no. ('***': p<.01; '**': p<.05; '*': p<.1)

Panel A: baseline model

Panel A Baseline model	1		2		3		4		5		6		7		8		9	
N = 310	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Constant	1.019		0.969		0.462	**	0.389	**	1.211		1.532	**	0.462		0.032	***	0.009	**
Round amount at 1st round	1.007																1.038	
Venture amount received before IPO or until last round			1.004														1.004	
Venture from US dummy (1=yes)					2.495	**											1.571	
Venture stage start-up/seed or early at 1st round							2.884	**									2.141	
Venture 1st round syndicated									0.777								0.643	*
Length of 1st round (adjusted for IPOs or acquisitions as last rounds)											0.999	***					0.999	**
Annual change in DJI in yr. of 1st round													1.008				1.011	
Annual change in number of biot. VC-backed IPOs in yr. of 1st round													1.000				1.000	
Annual change in venture capital raised in yr. of 1st round													1.003				1.002	
Annual change in number of VCs providing venture capital in yr. of 1st round													0.988				0.987	
Annual change in number of ventures receiving biot. venture capital in yr. of 1st round													1.007				1.005	
Annual change in DJI in yr. of last round/IPO															1.020	*	1.018	
Annual change in number of biot. VC-backed IPOs in yr. of last round/IPO															1.001	**	1.001	*
Annual change in venture capital raised in yr. of last round/IPO															1.005		1.005	
Annual change in number of VCs providing venture capital in yr. of last round/IPO															0.990		0.989	
Annual change in number of ventures receiving biot. venture capital in yr. of last round/IPO															1.012	*	1.015	**
VC Knowledge																		
-2 Log likelihood	446.206		445.604		439.696		440.403		445.058		437.516		440.764		422.191		402.098	
Cox & Snell R Square	0.000		0.002		0.020		0.018		0.004		0.027		0.017		0.072		0.128	
Nagelkerke R Square	0.000		0.003		0.027		0.024		0.005		0.036		0.023		0.096		0.171	
Omnibus Tests of Model Coefficients	Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2	
Block	0.069		0.671		6.579	**	5.871	**	1.216		8.759	***	5.511		24.084	***	44.177	***
Model	0.069		0.671		6.579	**	5.871	**	1.216		8.759	***	5.511		24.084	***	44.177	***
Hosmer and Lemeshow Test	8.072		12.727		0.000	.	0.000	.	0.000	.	4.775		5.605		9.695		13.539	*

(continued) Table H-4: Hypotheses 3a - Logistic regression results for main analysis on 'core sample'

Shown are the results for the main analyses of Hypothesis 3a i-iii on the 'core-sample' of ventures that had received at least two rounds of funding and that were founded before 1994 (N=310). The dependent variable is the dichotomous outcome IPO yes/no. ('***': p<.01; '**': p<.05; '*': p<.1)

Panel B: full models for the lead VCs (B1) and the syndicates (B2) in all rounds

Panel B	B-I: Syndicates' knowledge												B-II: 'Lead' VCs' knowledge											
All rounds	1		2		3		4		5		6		1		2		3		4		5		6	
N = 310	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Constant	0.011	**	0.013	**	0.013	**	0.008	**	0.008	**	0.006	**	0.011	**	0.011	**	0.011	**	0.008	**	0.009	**	0.007	**
Round amount at 1st round	1.037		1.037		1.037		1.037		1.038		1.036		1.028		1.036		1.036		1.037		1.037		1.034	
Venture amount received before IPO or until last round	1.004		1.004		1.004		1.004		1.004		1.005		1.004		1.004		1.004		1.005		1.004		1.005	
Venture from US dummy (1=yes)	1.615		1.611		1.610		1.688		1.606		1.704		1.509		1.597		1.597		1.655		1.523		1.623	
Venture stage start-up/seed or early at 1st round	1.891		1.911		1.913		1.838		1.826		1.731		1.994		1.889		1.886		1.846		1.823		1.769	
Venture 1st round syndicated	0.660		0.654		0.655		0.681		0.696		0.687		0.643	*	0.658		0.658		0.653		0.656		0.650	
Length of 1st round (adjusted for IPOs or acquisitions as last rounds)	0.999	**	0.999	**	0.999	**	0.999	**	0.999	**	0.999	**	0.999	**	0.999	**	0.999	**	0.999	**	0.999	**	0.999	**
Annual change in DJI in yr. of 1st round	1.009		1.009		1.009		1.010		1.009		1.010		1.008		1.010		1.010		1.009		1.009		1.010	
Annual change in number of biot. VC-backed IPOs in yr. of 1st round	1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000	
Annual change in venture capital raised in yr. of 1st round	1.003		1.003		1.003		1.002		1.002		1.002		1.003		1.003		1.003		1.002		1.002		1.002	
Annual change in number of VCs providing venture capital in yr. of 1st round	0.987		0.987		0.987		0.989		0.989		0.990		0.986		0.988		0.988		0.989		0.990		0.990	
Annual change in number of ventures receiving biot. venture capital in yr. of 1st round	1.005		1.004		1.004		1.005		1.005		1.005		1.005		1.005		1.005		1.005		1.005		1.005	
Annual change in DJI in yr. of last round/IPO	1.018		1.017		1.017		1.019		1.018		1.019		1.019		1.018		1.018		1.019		1.019		1.019	
Annual change in number of biot. VC-backed IPOs in yr. of last round/IPO	1.001	*	1.001	*	1.001	*	1.001	*	1.001	*	1.001	**	1.001	*	1.001	*	1.001	*	1.001	*	1.001	*	1.001	**
Annual change in venture capital raised in yr. of last round/IPO	1.005		1.005		1.005		1.005		1.006		1.005		1.005		1.005		1.005		1.006		1.006		1.006	
Annual change in number of VCs providing venture capital in yr. of last round/IPO	0.988		0.988		0.988		0.987		0.986		0.986		0.987		0.988		0.988		0.985		0.984		0.984	
Annual change in number of ventures receiving biot. venture capital in yr. of last round/IPO	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**
VC Knowledge																								
Syndicate's/'lead' VC's age	**0.998**												**1.015**											
Syndicate's/'lead' VC's non-biot. experience			**1.000**												**1.000**									
Syndicate's/'lead' VC's total experience					**1.000**												**1.000**							
Syndicate's/'lead' VC's biotech expertise							**1.006**												**1.006**	*				
Syndicate's/'lead' VC's biot.-stage expertise									**1.041**												**1.038**	**		
Syndicate's/'lead' VC's biot.-subsector expertise											**1.021**	**											**1.015**	**
-2 Log likelihood	398.401		398.172		398.220		397.248		395.539		393.560		396.851		398.324		398.315		395.425		392.044		392.314	
Cox & Snell R Square	0.128		0.129		0.129		0.131		0.136		0.141		0.132		0.128		0.128		0.136		0.145		0.145	
Nagelkerke R Square	0.171		0.172		0.172		0.175		0.181		0.188		0.177		0.171		0.171		0.182		0.194		0.193	
Omnibus Tests of Model Coefficients	Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2	
Block	0.011		0.239		0.192		1.164		2.873	*	4.852	**	1.561		0.088		0.097		2.987	*	6.368	**	6.098	**
Model	43.749	***	43.977	***	43.930	***	44.902	***	46.611	***	48.589	***	45.299	***	43.826	***	43.834	***	46.725	***	50.106	***	49.836	***
Hosmer and Lemeshow Test	14.379	*	14.042	*	16.006	**	8.113		8.663		10.943		12.631		13.176		12.341		9.260		11.207		9.081	

(continued) Table H-4: Hypotheses 3a - Logistic regression results for main analysis on 'core sample'

Shown are the results for the main analyses of Hypothesis 3a i-iii on the 'core-sample' of ventures that had received at least two rounds of funding and that were founded before 1994 (N=310). The dependent variable is the dichotomous outcome IPO yes/no. ('***': p<.01; '**': p<.05; '*': p<.1)

Panel C: full models for the lead VCs (C1) and the syndicates (C2) in the first round only

Panel C	C-I: Syndicates' knowledge												C-II: 'Lead' VCs' knowledge											
1st rounds	1		2		3		4		5		6		1		2		3		4		5		6	
N = 310	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Constant	0.010	**	0.005	**	0.005	**	0.004	**	0.005	**	0.005	**	0.009	**	0.005	**	0.005	**	0.006	**	0.006	**	0.006	**
Round amount at 1st round	1.040		1.038		1.038		1.039		1.037		1.039		1.045		1.038		1.038		1.035		1.032		1.034	
Venture amount received before IPO or until last round	1.004		1.005		1.005		1.005		1.004		1.005		1.004		1.005		1.005		1.005		1.005		1.005	
Venture from US dummy (1=yes)	1.708		1.939		1.942		2.172		1.773		2.071		1.758		1.911		1.912		2.023		1.736		1.981	
Venture stage start-up/seed or early at 1st round	1.952		1.853		1.849		1.919		1.886		1.832		1.929		1.832		1.830		1.911		1.924		1.867	
Venture 1st round syndicated	0.646		0.653		0.653		0.640		0.636	*	0.637	*	0.665		0.642		0.641		0.601	*	0.580	**	0.596	*
Length of 1st round (adjusted for IPOs or acquisitions as last rounds)	0.999	*	0.999	*	0.999	*	0.999	*	0.999	*	0.999	*	0.999	*	0.999	**	0.999	**	0.999	*	0.999	*	0.999	*
Annual change in DJI in yr. of 1st round	1.010		1.013		1.013		1.013		1.013		1.013		1.011		1.013		1.013		1.012		1.012		1.012	
Annual change in number of biot. VC-backed IPOs in yr. of 1st round	1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000	
Annual change in venture capital raised in yr. of 1st round	1.002		1.001		1.001		1.001		1.001		1.001		1.002		1.001		1.001		1.001		1.001		1.001	
Annual change in number of VCs providing venture capital in yr. of 1st round	0.992		0.994		0.994		0.994		0.995		0.994		0.992		0.993		0.993		0.994		0.995		0.994	
Annual change in number of ventures receiving biot. venture capital in yr. of 1st round	1.004		1.004		1.004		1.005		1.005		1.005		1.003		1.004		1.004		1.004		1.005		1.005	
Annual change in DJI in yr. of last round/IPO	1.015		1.017		1.017		1.016		1.015		1.016		1.015		1.017		1.017		1.016		1.014		1.016	
Annual change in number of biot. VC-backed IPOs in yr. of last round/IPO	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**
Annual change in venture capital raised in yr. of last round/IPO	1.006		1.005		1.005		1.005		1.006		1.005		1.006		1.005		1.005		1.006		1.006		1.006	
Annual change in number of VCs providing venture capital in yr. of last round/IPO	0.988		0.989		0.989		0.987		0.987		0.987		0.988		0.989		0.989		0.987		0.987		0.987	
Annual change in number of ventures receiving biot. venture capital in yr. of last round/IPO	1.015	**	1.015	**	1.015	**	1.015	*	1.015	**	1.014	*	1.015	**	1.015	**	1.015	**	1.015	*	1.015	**	1.014	*
VC Knowledge																								
Syndicate's/'lead' VC's age	**0.997**												**0.994**											
Syndicate's/'lead' VC's non-biot. experience			**1.001**												**1.000**									
Syndicate's/'lead' VC's total experience					**1.001**												**1.000**							
Syndicate's/'lead' VC's biotech expertise							**1.012**												**1.006**					
Syndicate's/'lead' VC's biot.-stage expertise									**1.044**	*											**1.026**	*		
Syndicate's/'lead' VC's biot.-subsector expertise											**1.022**	*											**1.014**	*
-2 Log likelihood	385.912		381.363		381.340		380.966		380.700		380.340		385.546		381.606		381.596		382.741		381.211		381.007	
Cox & Snell R Square	0.124		0.131		0.131		0.138		0.139		0.140		0.126		0.130		0.130		0.133		0.138		0.138	
Nagelkerke R Square	0.166		0.174		0.174		0.185		0.186		0.187		0.167		0.173		0.173		0.178		0.184		0.184	
Omnibus Tests of Model Coefficients	Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2	
Block	40.950	***	41.927	***	41.838	***	42.809	***	41.182	***	42.542	***	41.247	***	42.304	***	42.247	***	43.212	***	42.733	0.000	43.379	***
Model	40.950	***	42.791	***	42.814	***	45.896	***	46.162	***	46.522	***	41.316	***	42.547	***	42.558	***	44.121	***	45.650	0.000	45.855	***
Hosmer and Lemeshow Test	8.929		11.173		11.549		7.453		5.824		11.137		10.102		6.989		6.996		11.751		7.169	0.519	16.419	**

(continued) Table H-4: Hypotheses 3a - Logistic regression results for main analysis on 'core sample'

Shown are the results for the main analyses of Hypothesis 3a i-iii on the 'core-sample' of ventures that had received at least two rounds of funding and that were founded before 1994 (N=310). The dependent variable is the dichotomous outcome IPO yes/no. ('***': p<.01; '**': p<.05; '*': p<.1)

Panel D: full models for the lead VCs (D1) and the syndicates (D2) in later rounds only

Panel D	D-I: Syndicates' knowledge												D-II: 'Lead' VCs' knowledge											
2nd/later rounds	1		2		3		4		5		6		1		2		3		4		5		6	
N = 310	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Constant	0.008	**	0.007	**	0.007	**	0.003	***	0.005	**	0.003	***	0.007	**	0.007	**	0.007	**	0.004	**	0.006	**	0.004	***
Round amount at 1st round	1.030		1.031		1.031		1.031		1.034		1.028		1.024		1.030		1.030		1.032		1.034		1.028	
Venture amount received before IPO or until last round	1.005		1.005		1.005		1.006		1.005		1.006		1.005		1.005		1.005		1.006		1.005		1.006	
Venture from US dummy (1=yes)	1.597		1.604		1.604		1.694		1.621		1.652		1.514		1.576		1.578		1.604		1.543		1.555	
Venture stage start-up/seed or early at 1st round	1.703		1.685		1.685		1.551		1.594		1.448		1.800		1.689		1.684		1.659		1.617		1.573	
Venture 1st round syndicated	0.641	*	0.640	*	0.640	*	0.673		0.674		0.653		0.630	*	0.633	*	0.635	*	0.625	*	0.639	*	0.615	*
Length of 1st round (adjusted for IPOs or acquisitions as last rounds)	0.999	*	0.999	*	0.999	*	0.999	*	0.999	*	0.999	*	0.999	*	0.999	*	0.999	*	0.999	*	0.999	*	0.999	*
Annual change in DJI in yr. of 1st round	1.012		1.012		1.012		1.012		1.011		1.013		1.011		1.012		1.012		1.012		1.011		1.013	
Annual change in number of biot. VC-backed IPOs in yr. of 1st round	1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000	
Annual change in venture capital raised in yr. of 1st round	1.003		1.003		1.003		1.002		1.003		1.002		1.003		1.003		1.003		1.002		1.002		1.002	
Annual change in number of VCs providing venture capital in yr. of 1st round	0.988		0.988		0.988		0.992		0.991		0.993		0.987		0.989		0.989		0.991		0.991		0.992	
Annual change in number of ventures receiving biot. venture capital in yr. of 1st round	1.004		1.004		1.004		1.005		1.005		1.005		1.005		1.004		1.004		1.005		1.005		1.005	
Annual change in DJI in yr. of last round/IPO	1.018		1.018		1.018		1.021	*	1.019		1.021	*	1.019		1.019		1.019		1.021	*	1.020		1.021	*
Annual change in number of biot. VC-backed IPOs in yr. of last round/IPO	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**	1.001	**
Annual change in venture capital raised in yr. of last round/IPO	1.005		1.005		1.005		1.005		1.006		1.005		1.005		1.005		1.005		1.006		1.006		1.006	
Annual change in number of VCs providing venture capital in yr. of last round/IPO	0.989		0.989		0.989		0.987		0.987		0.986		0.988		0.988		0.988		0.985	*	0.985	*	0.985	*
Annual change in number of ventures receiving biot. venture capital in yr. of last round/IPO	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**	1.015	**	1.016	**
VC Knowledge																								
Syndicate's/'lead' VC's age	**1.003**												**1.015**											
Syndicate's/'lead' VC's non-biot. experience			**1.000**												**1.000**									
Syndicate's/'lead' VC's total experience					**1.000**												**1.000**							
Syndicate's/'lead' VC's biotech expertise							**1.014**	**											**1.009**	**				
Syndicate's/'lead' VC's biot.-stage expertise									**1.047**	*											**1.038**	**		
Syndicate's/'lead' VC's biot.-subsector expertise											**1.033**	***											**1.019**	***
-2 Log likelihood	394.831		394.816		394.825		388.987		390.841		381.492		393.328		394.432		394 470		388.252		388.148		383.489	
Cox & Snell R Square	0.127		0.127		0.127		0.143		0.138		0.163		0.131		0.128		0.128		0.145		0.146		0.158	
Nagelkerke R Square	0.170		0.170		0.170		0.191		0.184		0.218		0.175		0.171		0.171		0.194		0.194		0.211	
Omnibus Tests of Model Coefficients	Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2		Chi2	
Block	0.027		0.042		0.033		5.871	**	4.017	**	13.366	***	1.530		0.426		0.388		6.606	*	6.710	***	11.369	***
Model	43.035	***	43.050	***	43.041	***	48.880	***	47.025	***	56.375	***	44.539	***	43.435	***	43.397	***	49.614	***	49.719	***	54.378	***
Hosmer and Lemeshow Test	8.964		8.355		7.024		10.618		10.692		8.237		8.430		9.537		11.882		13.685	*	14.749	*	7.225	

Table H-5: Hypotheses 3a - Logistic regression results for additional analysis on 'full sample'

Shown are the results for the main analyses of Hypothesis 3a i-iii on the 'full-sample' of ventures, regardless of how many rounds they had received, that were founded before 1994 (N=406). The dependent variable is the dichotomous outcome IPO yes/no. ('***': p<.01; '**': p<.05; '*': p<.1)

Panel A: full models for the lead VCs (A1) and the syndicates (A2) in all rounds

Panel A: all rounds	A-I: Syndicates' knowledge												A-II: 'Lead' VCs' knowledge											
	1		2		3		4		5		6		1		2		3		4		5		6	
N = 406	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Constant	0.002	***	0.002	***	0.002	***	0.001	***	0.001	***	0.001	***	0.002	***	0.001	***	0.001	***	0.001	***	0.001	***	0.001	***
Round amount at 1st round	1.006		1.006		1.006		1.008		1.008		1.008		1.000		1.006		1.006		1.007		1.007		1.007	
Venture amount received before IPO or until last round	1.001		1.001		1.001		1.002		1.001		1.002		1.001		1.001		1.001		1.002		1.001		1.002	
Venture stage start-up/seed or early at 1st round	1.854	*	1.851	*	1.852	*	1.886	*	1.739		1.826	*	1.789	*	1.820	*	1.822	*	1.811	*	1.616	*	1.728	
Venture from US dummy (1=yes)	2.940	**	2.935	**	2.932	**	2.748	**	2.795	**	2.588	**	2.930	**	2.874	**	2.869	**	2.722	**	2.739	**	2.631	**
Annual change in DJI in yr. of 1st round	1.007		1.008		1.008		1.008		1.008		1.009		1.005		1.008		1.008		1.008		1.008		1.009	
Annual change in number of biot. VC-backed IPOs in yr. of 1st round	1.000		1.000		1.000		1.000		1.000		1.000		1.001		1.000		1.000		1.000		1.000		1.000	
Annual change in venture capital raised in yr. of 1st round	1.002		1.002		1.002		1.002		1.002		1.002		1.002		1.002		1.002		1.002		1.002		1.001	
Annual change in number of VCs providing venture capital in yr. of 1st round	1.001		1.002		1.002		1.003		1.004		1.005		1.001		1.002		1.002		1.004		1.005		1.005	
Annual change in number of ventures receiving biot. venture capital in yr. of 1st round	0.998		0.998		0.998		0.998		0.998		0.998		0.998		0.998		0.998		0.998		0.998		0.998	
Annual change in DJI in yr. of last round/IPO	1.017	*	1.016	*	1.016	*	1.018	*	1.018	*	1.019	*	1.018	*	1.017	*	1.017	*	1.019	*	1.018	*	1.019	*
Annual change in number of biot. VC-backed IPOs in yr. of last round/IPO	1.001	***	1.001	***	1.001	***	1.001	***	1.001	***	1.001	***	1.001	***	1.001	***	1.001	***	1.001	***	1.001	***	1.001	***
Annual change in venture capital raised in yr. of last round/IPO	1.004		1.004		1.004		1.004		1.005		1.005		1.005		1.004		1.004		1.005		1.005	*	1.005	*
Annual change in number of VCs providing venture capital in yr. of last round/IPO	1.000		1.000		1.000		0.998		0.998		0.997		0.999		0.999		0.999		0.996		0.995		0.995	
Annual change in number of ventures receiving biot. venture capital in yr. of last round/IPO	1.005		1.005		1.005		1.005		1.005		1.005		1.005		1.005		1.005		1.006		1.006		1.006	
VC KNOWLEDGE																								
Syndicate's/'lead' VC's age	1.000												1.016											
Syndicate's/'lead' VC's non-biot. experience			1.000												1.000									
Syndicate's/'lead' VC's experience					1.000												1.001							
Syndicate's/'lead' VC's bitotech expertise							1.010	*											1.009	**				
Syndicate's/'lead' VC's biot.-stage expertise									1.043	*											1.043	***		
Syndicate's/'lead' VC's biot.-subsector expertise											1.027	***											1.019	***
-2 Log likelihood	516.330		514.683		514.670		511.595		510.751		506.087		513.757		513.692		513.625		508.682		505.423		503.876	
Cox & Snell R Square	0.127		0.127		0.127		0.133		0.135		0.145		0.132		0.129		0.129		0.139		0.146		0.149	
Nagelkerke R Square	0.170		0.170		0.170		0.179		0.181		0.194		0.177		0.173		0.173		0.187		0.196		0.200	
Omnibus Tests of Model Coefficients	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.
Block	0.000		0.019		0.031		3.107	0.078	3.951	**	8.614	0.003	2.573	0.109	1.010		1.077		6.019	**	9.278	0.002	10.826	0.001
Model	56.446	***	56.465	***	56.477	***	59.553	***	60.397	***	65.060	***	59.019	***	57.456	***	57.523	***	62.465	***	65.724	***	67.272	***
Hosmer and Lemeshow Test	5.648		5.373		6.928		8.334		10.070		12.567		2.566		2.831		4.555		14.530	0.069	6.776		17.671	0.024

(continued) Table H-5: Hypotheses 3a - Logistic regression results for additional analysis on 'full sample'

Shown are the results for the main analyses of Hypothesis 3a i-iii on the 'full-sample' of ventures, regardless of how many rounds they had received, that were founded before 1994 (N=406). The dependent variable is the dichotomous outcome IPO yes/no. ('***': p<.01; '**': p<.05; '*': p<.1)*continued*

Panel B: full models for the lead VCs (B1) and the syndicates (B2) in the first round only

Panel B: 1st rounds only	B-I: Syndicates' knowledge												B-II: 'Lead' VCs' knowledge											
	1		2		3		4		5		6		1		2		3		4		5		6	
N = 406	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Constant	0.002	***	0.001	***	0.001	***	0.001	***	0.001	***	0.001	***	0.002	***	0.001	***	0.001	***	0.001	***	0.001	***	0.001	***
Round amount at 1st round	1.007		1.007		1.007		1.007		1.006		1.007		1.007		1.006		1.006		1.005		1.004		1.005	
Venture amount received before IPO or until last round	1.001		1.002		1.002		1.001		1.001		1.002		1.002		1.002		1.002		1.002		1.001		1.002	
Venture stage start-up/seed or early at 1st round	1.877	**	2.046	**	2.050	**	2.154	**	1.840	*	2.054	**	1.892	*	2.016	**	2.018	**	2.065	**	1.805	*	1.982	**
Venture from US dummy (1=yes)	2.974	**	2.847	**	2.844	**	2.783	**	2.834	**	2.702	**	2.983	**	2.830	**	2.824	**	2.806	**	2.853	**	2.736	**
Annual change in DJI in yr. of 1st round	1.009		1.011		1.011		1.011		1.011		1.011		1.009		1.011		1.011		1.010		1.010		1.011	
Annual change in number of biot. VC-backed IPOs in yr. of 1st round	1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000		1.000	
Annual change in venture capital raised in yr. of 1st round	1.001		1.001		1.001		1.001		1.000		1.000		1.001		1.001		1.001		1.001		1.001		1.000	
Annual change in number of VCs providing venture capital in yr. of 1st round	1.005		1.007		1.007		1.008		1.008		1.007		1.005		1.007		1.007		1.007		1.008		1.007	
Annual change in number of ventures receiving biot. venture capital in yr. of 1st round	0.997		0.998		0.998		0.999		0.999		0.999		0.997		0.998		0.998		0.998		0.999		0.999	
Annual change in DJI in yr. of last round/IPO	1.015		1.015		1.015		1.015		1.014		1.015		1.015		1.015		1.015		1.014		1.014		1.015	
Annual change in number of biot. VC-backed IPOs in yr. of last round/IPO	1.002	***	1.002	***	1.002	***	1.002	***	1.002	***	1.002	***	1.002	***	1.002	***	1.002	***	1.002	***	1.002	***	1.002	***
Annual change in venture capital raised in yr. of last round/IPO	1.005		1.004		1.004		1.005		1.005		1.005		1.005		1.004		1.004		1.005		1.005		1.005	
Annual change in number of VCs providing venture capital in yr. of last round/IPO	1.000		1.000		1.000		0.998		0.998		0.998		1.000		1.000		1.000		0.998		0.997		0.998	
Annual change in number of ventures receiving biot. venture capital in yr. of last round/IPO	1.004		1.004		1.005		1.004		1.004		1.004		1.004		1.004		1.004		1.004		1.005		1.004	
VC KNOWLEDGE																								
Syndicate's/'lead' VC's age	0.996												0.997											
Syndicate's/'lead' VC's non-biot. experience			1.001												1.000									
Syndicate's/'lead' VC's experience					1.001												1.000							
Syndicate's/'lead' VC's bitotech expertise							1.012	*											1.006					
Syndicate's/'lead' VC's biot.-stage expertise									1.042	*											1.027	*		
Syndicate's/'lead' VC's biot.-subsector expertise											1.024	**											1.016	**
-2 Log likelihood	501.475		494.748		494.670		495.431		495.509		494.198		501.438		495.179		495.104		497.352		495.737		494.710	
Cox & Snell R Square	0.129		0.134		0.134		0.139		0.139		0.141		0.129		0.133		0.133		0.135		0.138		0.140	
Nagelkerke R Square	0.173		0.179		0.180		0.186		0.186		0.190		0.173		0.178		0.178		0.181		0.185		0.188	
Omnibus Tests of Model Coefficients	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.	Chi2	Sig.
Block	0.114		0.877		0.955		3.992	**	3.914	**	5.224	**	0.152		0.446		0.521		2.071		3.686	*	4.712	**
Model	56.138	***	57.956	***	58.034	***	60.552	***	60.473	***	61.784	***	56.175	***	57.525	***	57.600	***	58.630	***	60.246	***	61.272	***
Hosmer and Lemeshow Test	5.046		14.075	*	16.106	**	18.751	**	14.682	*	13.705	*	5.254		11.362		14.119	*	18.456	**	15.923	**	9.421	

Table H-6: Hypotheses 3b - Cox regression results

Shown are the results for the analyses of Hypothesis 3b i-ii. The dependent variable is the hazard rate of experiencing an IPO' ('***': p<.01; '**': p<.05; '*': p<.1).

Panel A: Main analyses on ventures founded before 2003 (N=1232)
Panel A-I: baseline models
Panel A-II: full models for the syndicates
Panel A-III: full models for the lead VCs

Panel A: ventures founded before March 2003	A-I - Baseline model									
	1		2		3		4		5	
N=1232 (IPO=251; censored=981)	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Round amount at 1st round	1.003								1.000	**
Venture stage start-up/seed or early at 1st round			1.671	****					1.237	
Venture from US dummy (1=yes)					2.876	****			2.585	****
Annual change in DJI in yr. of 1st round							1.015	****	1.010	**
Annual change in number of biot. VC-backed IPOs in yr. of 1st round							1.000		1.000	
Annual change in venture capital raised in yr. of 1st round							1.002		1.002	
Annual change in number of VCs providing venture capital in yr. of 1st round							0.987	****	0.990	**
Annual change in number of ventures receiving biot. venture capital in yr. of 1st round							1.008	****	1.005	**
VC KNOWLEDGE										
Syndicate's/'lead' VC's age										
Syndicate's/'lead' VC's non-biot. experience										
Syndicate's/'lead' VC's total experience										
Syndicate's/'lead' VC's biotech expertise										
Syndicate's/'lead' VC's biot.-stage expertise										
Syndicate's/'lead' VC's biot.-subsector expertise										
-2 Log Likelihood baseline	3,294.1		3,294.1		3,294.1		3,294.0		3,294.0	
-2 Log Likelihood model	3,293.0		3,284.9		3,261.2		3,271.9		3,242.1	
Change from previous block										
Chi2	1.1		9.2	***	32.8	***	22.2	***	22.2	***
df	1		1		1		5		8	
R2'	0.001		0.007		0.026		0.018		0.041	

Panel A: ventures founded before March 2003	A-II - 1st round syndicates' knowledge											
	1		2		3		4		5		6	
N=1232 (IPO=251; censored=981)	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Round amount at 1st round	1.005	**	1.006	***	1.005	***	1.005	***	1.005	***	1.006	***
Venture stage start-up/seed or early at 1st round	1.239		1.271		1.269		1.273		1.256		1.272	
Venture from US dummy (1=yes)	2.585	****	2.450	****	2.459	****	2.512	****	2.510	****	2.465	***
Annual change in DJI in yr. of 1st round	1.010	**	1.011	**	1.011	**	1.011	**	1.011	**	1.012	**
Annual change in number of biot. VC-backed IPOs in yr. of 1st round	1.000		1.000		1.000		1.000		1.000		1.000	
Annual change in venture capital raised in yr. of 1st round	1.002		1.001		1.001		1.002		1.002		1.002	
Annual change in number of VCs providing venture capital in yr. of 1st round	0.990	**	0.991	**	0.991	**	0.991	**	0.991	**	0.991	**
Annual change in number of ventures receiving biot. venture capital in yr. of 1st round	1.006	**	1.006	**	1.006	**	1.006	**	1.006	**	1.006	**
VC KNOWLEDGE												
Syndicate's/'lead' VC's age	1.001											
Syndicate's/'lead' VC's non-biot. experience			1.001									
Syndicate's/'lead' VC's total experience					1.000							
Syndicate's/'lead' VC's biotech expertise							**1.001**					
Syndicate's/'lead' VC's biot.-stage expertise									1.005			
Syndicate's/'lead' VC's biot.-subsector expertise											1.006	*
-2 Log Likelihood baseline	3,272.8		3,229.4		3,229.4		3,269.6		3,269.6		3,269.6	
-2 Log Likelihood model	3,219.0		3,173.5		3,174.0		3,215.7		3,215.6		3,213.6	
Change from previous block												
Chi2	0.0		2.1		1.7		0.2		0.4		2.5	
df	1		1		1		1		1		1	
R2'	0.043		0.044		0.044		0.043		0.043		0.044	

Panel A: ventures founded before March 2003	A-III- 1st round 'lead' VCs' knowledge											
	1		2		3		4		5		6	
N=1232 (IPO=251; censored=981)	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Round amount at 1st round	1.005	**	1.005	**	1.005	**	1.005	***	1.005	***	1.005	***
Venture stage start-up/seed or early at 1st round	1.240		1.261		1.261		1.270		1.236		1.260	
Venture from US dummy (1=yes)	2.584	***	2.449	***	2.443	***	2.513	***	2.494	***	2.466	***
Annual change in DJI in yr. of 1st round	1.010	*	1.012	**	1.012	**	1.011	**	1.011	**	1.012	**
Annual change in number of biot. VC-backed IPOs in yr. of 1st round	1.000		1.000		1.000		1.000		1.000		1.000	
Annual change in venture capital raised in yr. of 1st round	1.002		1.001		1.001		1.002		1.002		1.002	
Annual change in number of VCs providing venture capital in yr. of 1st round	0.990	**	0.991	**	0.991	**	0.991	**	0.991	**	0.991	**
Annual change in number of ventures receiving biot. venture capital in yr. of 1st round	1.006	**	1.006	**	1.006	**	1.006	**	1.006	**	1.006	**
VC KNOWLEDGE												
Syndicate's/'lead' VC's age	1.003											
Syndicate's/'lead' VC's non-biot. experience			1.000									
Syndicate's/'lead' VC's total experience					1.000							
Syndicate's/'lead' VC's biotech expertise							1.001					
Syndicate's/'lead' VC's biot.-stage expertise									1.006			
Syndicate's/'lead' VC's biot.-subsector expertise											1.005	*
-2 Log Likelihood baseline	3,272.8		3,229.4		3,229.4		3,269.6		3,269.6		3,269.6	
-2 Log Likelihood model	3,218.4		3,173.0		3,172.7		3,215.4		3,214.2		3,213.0	
Change from previous block												
Chi2	0.3		2.2		2.4		0.3		1.2		2.9	*
df	1		1		1		1		1		1	
R2'	0.043		0.045		0.045		0.043		0.044		0.045	

Table H-6: Hypotheses 3b - Cox regression results

Shown are the results for the analyses of Hypothesis 3b i-ii. The dependent variable is the hazard rate of experiencing an IPO' ('***': p<.01; '**': p<.05; '*': p<.1).

Panel B: Additional analyses on ventures founded before 1994 (N=470)
Panel B-I: baseline models
Panel B-II: full models for the syndicates
Panel B-III: full models for the lead VCs

Panel B: ventures founded before 1994	B-I - Baseline model									
	1		2		3		4		5	
N=470 (IPO=201; censored=269)	Exp(B)		Exp(B)		Exp(B)		Exp(B)		Exp(B)	
Round amount at 1st round	0.997								1.006	
Venture stage start-up/seed or early at 1st round			1.757	**					1.491	
Venture from US dummy (1=yes)					2.452	***			2.193	**
Annual change in DJI in yr. of 1st round							1.003		1.002	
Annual change in number of biot. VC-backed IPOs in yr. of 1st round							1.000		1.000	
Annual change in venture capital raised in yr. of 1st round							1.003		1.003	
Annual change in number of VCs providing venture capital in yr. of 1st round							1.003		1.006	
Annual change in number of ventures receiving biot. venture capital in yr. of 1st round							1.001		0.999	
VC KNOWLEDGE										
Syndicate's/'lead' VC's age										
Syndicate's/'lead' VC's non-biot. experience										
Syndicate's/'lead' VC's total experience										
Syndicate's/'lead' VC's biotech expertise										
Syndicate's/'lead' VC's biot.-stage expertise										
Syndicate's/'lead' VC's biot.-subsector expertise										
-2 Log Likelihood baseline	2,376.6		2,376.6		2,376.6		2,376.6		2,376.6	
-2 Log Likelihood	2,376.4		2,369.4		2,364.7		2,368.3		2,353.0	
Change from previous block										
Chi2	0.112		7.187		11.878		8.272		9.206	
df	1.0		1.0	***	1.0		5.0		8.0	
R2'	0.000		0.015		0.025		0.017		0.049	

Panel B: ventures founded before 1994	B-II - 1st round syndicates' knowledge											
	1		2		3		4		5		6	
N=470 (IPO=201; censored=269)	Exp(B)		Exp(B)		Exp(B)		Exp(B)		Exp(B)		Exp(B)	
Round amount at 1st round	1.006		1.007		1.007		1.008		1.007		1.008	
Venture stage start-up/seed or early at 1st round	1.490		1.583	*	1.580	*	1.638	*	1.464		1.621	*
Venture from US dummy (1=yes)	2.196	**	2.088	**	2.092	**	2.064	**	2.110	**	2.060	**
Annual change in DJI in yr. of 1st round	1.001		1.003		1.003		1.003		1.003		1.003	
Annual change in number of biot. VC-backed IPOs in yr. of 1st round	1.000		1.000		1.000		1.000		1.000		1.000	
Annual change in venture capital raised in yr. of 1st round	1.003		1.002		1.002		1.002		1.002		1.002	
Annual change in number of VCs providing venture capital in yr. of 1st round	1.006		1.008		1.007		1.006		1.007		1.006	
Annual change in number of ventures receiving biot. venture capital in yr. of 1st round	0.999		1.000		1.000		1.000		1.000		1.000	
VC KNOWLEDGE												
Syndicate's/'lead' VC's age	**1.002**											
Syndicate's/'lead' VC's non-biot. experience			**1.001**									
Syndicate's/'lead' VC's total experience					**1.001**							
Syndicate's/'lead' VC's biotech expertise							**1.007**	**				
Syndicate's/'lead' VC's biot.-stage expertise									1.022	*		
Syndicate's/'lead' VC's biot.-subsector expertise											**1.013**	***
-2 Log Likelihood baseline	2,356.1		2,319.0		2,319.0		2,356.8		2,356.8		2,356.8	
-2 Log Likelihood	2,329.6		2,289.5		2,289.7		2,326.0		2,327.2		2,325.9	
Change from previous block												
Chi2	0.056		1.564		1.385		4.125	**	2.989	*	5.192	**
df	1.0		1.0		1.0		1.0		1.0		1.0	
R2'	0.055		0.061		0.060		0.063		0.061		0.064	

Panel B: ventures founded before 1994	B-III- 1st round 'lead' VCs' knowledge											
	1		2		3		4		5		6	
N=470 (IPO=201; censored=269)	Exp(B)		Exp(B)		Exp(B)		Exp(B)		Exp(B)		Exp(B)	
Round amount at 1st round	1.006		1.006		1.006		1.006		1.006		1.006	
Venture stage start-up/seed or early at 1st round	1.490		1.563	*	1.565	*	1.589	*	1.457		1.568	*
Venture from US dummy (1=yes)	2.193	**	2.090	**	2.085	**	2.080	**	2.108		2.082	**
Annual change in DJI in yr. of 1st round	1.002		1.003		1.003		1.002		1.003		1.003	
Annual change in number of biot. VC-backed IPOs in yr. of 1st round	1.000		1.000		1.000		1.000		1.000		1.000	
Annual change in venture capital raised in yr. of 1st round	1.003		1.002		1.002		1.002		1.002		1.002	
Annual change in number of VCs providing venture capital in yr. of 1st round	1.006		1.007		1.007		1.006		1.007		1.006	
Annual change in number of ventures receiving biot. venture capital in yr. of 1st round	0.999		1.000		1.000		1.000		1.000		1.000	
VC KNOWLEDGE												
Syndicate's/'lead' VC's age	**1.000**											
Syndicate's/'lead' VC's non-biot. experience			**1.000**									
Syndicate's/'lead' VC's total experience					1.000							
Syndicate's/'lead' VC's biotech expertise							**1.004**					
Syndicate's/'lead' VC's biot.-stage expertise									1.014	*		
Syndicate's/'lead' VC's biot.-subsector expertise											**1.010**	**
-2 Log Likelihood baseline	2,356.1		2,319.0		2,319.0		2,356.8		2,356.8		2,356.8	
-2 Log Likelihood	2,329.8		2,289.9		2,289.7		2,327.0		2,326.4		2,325.5	
Change from previous block												
Chi2	0.002		0.849		0.963		2.257		2.713	*	5.154	**
df	1.0		1.0		1.0		1.0		1.0		1.0	
R2'	0.054		0.060		0.060		0.061		0.063		0.064	