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How to choose what to do? Essays on adoption of organisational routines

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DISSERTATION

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ABSTRACT

Organisational routines i.e. firms specific, path dependent, repeated patterns of collective behaviour are at the heart of the capabilities-based perspective of building competitive advantage. It is therefore not surprising to see a large body of scholarly work on the impact of organisational routines on performance of firms. However, in contrast to the number of studies on the impact of organisational routines, there are far fewer studies on the mechanisms by which organisations filter through alternatives before adopting routines. The three essays in this dissertation contribute to our understanding of what influences organisational choices in adopting routines i.e. how to choose what to do?

Building on the concepts in evolutionary economics, behavioural theory of the firm, and attention-based theory of strategic decision making, we argue that performance is not just a function of availability of resources and capabilities, but it is also guided by structural constraints that act as *attention-focusing mechanism* and influence choices in allocating limited resources. We propose that these mechanisms operate across macro- and micro-levels and that the observed behaviour of the macro-system is the aggregated result of the heterogeneous choices made by agents at the micro-level under these attention-focusing mechanisms.

The three essays in the dissertation contribute to our understanding of how three different attention focusing mechanism namely organisational mandates, competitive pressure under constraints, and multipoint competition focus the attention of decision makers on some opportunities more than others. These attention-focusing mechanisms help decision makers to filter through alternatives and make micro-level choices to adopt or not to adopt routines that influence innovation performance at a macro-level.

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I would like to thank the members of my dissertation committee Prof Benson Honig, Dr Susan Hill, and Dr Elena Novelli and the members of my transfer panel committee Prof Feng Li and Dr Santi Furnari. I would also like to acknowledge the support of Ms Malla Pratt and Mr Abdul Momin from the PhD office at Cass Business School.

I dedicate this work to my family, particularly to my wife Divya who has been a constant source of inspiration on this journey.

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1. INTRODUCTION

Roughly speaking, rationality is concerned with the selection of preferred behavior alternatives in terms of some system of values, whereby the consequences of behavior can be evaluated.

- Herbert Simon on rational decision-making in organisations,
Administrative Behavior, 1947, p84

This dissertation started as a discussion on ‘innovation under constraints’ at the Ingenuity Conference 2011, McMaster University, Hamilton, Canada. Our aim was to build on the concept of organisational ingenuity i.e. “the ability to create innovative solutions within structural constraints using limited resources and imaginative problem solving” (Lampel, Honig, & Drori, 2014: 465) and understand how *constraints* influence innovation in firms. Over the next few months a review of the literature on the topic revealed two important threads that led to this project. In the introduction we will develop these two threads i.e. (i) the need to study innovation through the lens of adoption of routines under constraints and (ii) the need to study the causal relations between the macro- and micro-levels in strategic decision making.

First, a review of the literature on innovation under constraints with focus on the theoretical lenses dealing with theory of constraints, organisational slack, and bricolage¹, show that while multiple theoretical lenses have attempted to explain the influence of resource constraints (e.g. financial resources) on the incidence of innovation, none adequately explain the influence of other structural constraints (e.g. constraints generated by a firm’s

¹ The literature review is an excerpt from Banerjee, A. 2014. The roots of organisational ingenuity: How do qualitatively superior ideas come about? In B. Honig, J. Lampel, & I. Drori (Eds.), *Handbook of organisational and entrepreneurial ingenuity*: 15 - 33: Edward Elgar Publishing, Inc.

corporate policies). Evidence suggests that innovation performance is not just influenced by the availability of resources, but it is also guided by structural constraints that influence the development of path dependent capabilities. These capabilities are built through micro-level choices made by decision makers in the adoption or creation of new *organisational routines* i.e. firms specific, path dependent, repeated patterns of collective behaviour (Nelson & Winter, 1982; Winter, 2003). This calls for a closer look at the influence of structural constraints as *attention-focusing mechanisms* by which organisations filter through alternatives before adopting organisational routines (Ocasio, 1997).

Second, our analysis shows that to investigate how various constraints influence innovation at the macro-level we need to understand at a micro-level how constraints influence decision makers' interpretation of problems and focus their attention on benefits of adopting a routine. In essence, there is the need to connect the macro- and micro-perspectives of strategy and strategic decision. To that extent our intent is to build on the attention-based perspective of strategy formulation and contribute to the discussion on micro-foundations of strategic management research (Ocasio & Joseph, 2005)².

In the rest of the introduction we introduce the concept of organisational routines from a capabilities perspective, set the boundary conditions of studying organisational routines, and introduce the structural constraints as attention-focussing mechanisms that we study in the subsequent essays.

² . In recent years the micro-foundations agenda has become increasingly influential in strategic management research. For instance, the Strategic Management Society did a special conference on 'Micro-Foundations for Strategic Management Research: Embracing Individuals, 2014' in an attempt to give more structure to the questions of theory development, empirical measurement, data collection, and statistical implementation of micro-level strategic management research.

1.1 REVIEW OF INNOVATION UNDER CONSTRAINTS

The ability to continuously innovate is the cornerstone of growth, regeneration, and competitive advantage (Burgelman, 1983; Dosi, Teece, & Chytry, 1998; Schumpeter, 1911). Hence it is not surprising that both practitioners and researchers have tackled this topic from many perspectives. Empirical evidence in innovation studies point out that there is a clear variance in innovation outcome across firms. Variables that explain this heterogeneity include firm size (Damanpour, 1992), new entrants (Cooper & Schendel, 1976; Foster, 1986), and access to greater resources and capabilities (Methe, Swaminathan, Mitchell, & Toyama, 1997). Within the resource-based perspective some of the highly cited determinants of innovation include R&D intensity (Parthasarthy & Hammond, 2002), funding (Almus & Czarnitzki, 2003; Kortum & Lerner, 2000), annual turnover of resources (Mohr, 1969), number of employees (Rogers, 1983), and slack resources (Damanpour, 1991; Nohria & Gulati, 1996; O'Brien, 2003).

Considering the impact of internal organisational determinants of innovation, researchers have studied the impact of culture (Amabile, Conti, Coon, Lazenby, & Herron, 1996; Tellis, Prabhu, & Chandy, 2009), leadership (Elenkov, Judge, & Wright, 2005), strategic orientation of upper echelons (Hambrick, 2007; Hambrick & Mason, 1984), environment for experimentation (Anderson & West, 1998; Damanpour, 1991), tolerance to failed ideas (Madjar, Oldham, & Pratt, 2002), and risk appetite (Anderson & West, 1998; King, 1992).

Furthermore, within the process perspective the effect of learning (Ahuja & Lampert, 2001), development of employees and fostering diversity (Crossan & Hulland, 2002), knowledge (Zhang & Li, 2010), and external linkages (Atuahene-Gima, 1995) have also been studied.

From an organisational structures perspective determinants include specialization and centralization structures (Damanpour, 1991; Zaltman, Duncan, & Holbek, 1973), stratification (Kanter, 1983), matrix structures (Staw, 1990), organisational complexity and administrative intensity (Damanpour, 1991), and formalization (Anderson & West, 1998; Damanpour, 1991).

In contrast to the richness of these theoretical perspectives, the effect of constraints on innovation is under researched. In our search for answers, we review three frameworks that address innovation under constraints. We start with the theory of constraints that proposes ways to optimize a solution under constraints. We then review the literature on organisational slack that studies the relationship between the availability of resources and the generation of new ideas on performance, and conclude with a review of bricolage that studies value creation under resource constraints.

Our review of the empirical evidence from the existing literature on the relationship between constraints and innovation indicates that the focus within this stream has overwhelmingly been on resources constraints (e.g. financial or human resources) as opposed to structural constraints (e.g. rules or processes). We find that there is a need to study innovation through the lens of adoption of organisational routines that build capabilities as a response to structural constraints. This analysis point us towards a capabilities-based argument for search and innovation (Cyert & March, 1963; Nelson & Winter, 1982; Teece, Pisano, & Shuen, 1997; Winter, 2003).

1.1.1 THEORY OF CONSTRAINTS

Pioneered by E.M. Goldratt (Goldratt, 1987) in the 1980s, the theory of constraints looks at how constraints limit the ability of achieving higher levels of performance relative to the goal (Aryanezhad, Badri, & Komijan, 2010). Rooted in the operations management literature, it builds on the principles of continuous improvement, but its point of departure from such theories is that it takes a systems perspective (Dettmer, 1997). For instance a standard continuous improvement methodology would prescribe that all components of a process must be optimized to their full potential to achieve the best performance, whereas the theory of constraints would highlight the interdependence of the processes and their links with constraints to prescribe ways to exploit constraints i.e. get the most out of the system as a whole under constraints. Goldratt's central premise is that organisations exist as systems of interacting and not independent processes.

The theory of constraints is not so much a management theory devised to explain innovation under constraint but a theory aimed at optimization of a solution in an iterative process. As Dettmer (1997) notes, it is a collection of "system principles and tools, or methods for solving the problem of improving overall system performance". Since its introduction, the theory has been steadily enriched by a wide range of tools and techniques applicable in diverse settings; from accounting to operations research. The theory is fairly broad in its consideration of constraints like resources such as equipment and people and to structural constraints like policy.

Its main limitation with regards to studying innovation is that it does not provide a theoretical basis to understand how inventions come up in the first place. Moving away from an 'optimization' perspective to understand if constraints can 'trigger' the invention process we turn our attention to other two concepts namely, organisational slack and bricolage.

1.1.2 ORGANISATIONAL SLACK

Researchers have often used organisational slack to understand the effect of availability of resources on innovation. Nohria and Gulati (1996) define slack as resources that are in excess of the necessary minimum amount required to run the operations of a firm. While it is recognized that by nature slack resources can be diverted or redeployed for the achievement of organisational goals (George, 2005), scholars have also noted that some type of slack resources are more easily redeployed than others. Therefore, the slack construct is often studied as a contrast between slack that is easy to recover (i.e. high-discretion or unabsorbed slack) or slack that is not easy to recover (i.e. low-discretion or absorbed slack) (See (Nohria & Gulati, 1996; Sharfman, Wolf, Chase, & Tansik, 1988; Singh, 1986a) for further details on the type of slack). In our discussion, we are interested to understand what may be the effect of availability of slack (i.e. no resource constraints) and non-availability of slack (i.e. resource constraints) on innovation outcomes.

It has been theorized that the presence of recoverable slack in an organisation acts as a buffer that can be redistributed within the organisation depending on structural constraints. Scholars have argued that the presence of such a resource buffer can have positive as well as negative effects on performance outcomes. For instance, organisational theorists who draw parallels between the firm and an organism, view the ultimate goal of organisations as survival and growth (Cyert & March, 1963; Salancik & Pfeffer, 1978). In that context, while the organisation theorists recognize the cost of slack to the firm in the short term, they propose that it is necessary for the survival of the firm in the long term. They argue that the presence of slack resources buffers the core of the firm in times of distress (Cyert & March, 1963; Levinthal & March, 1981) and from environmental shocks (Meyer, 1982) thereby impacting long term performance.

In contrast to this view, agency theorists consider the firm as a nexus of contracts between principals and agents (Fama, 1980). Therefore agency theory explicitly rejects the notion of the firm as an organisation and in the words of Davis and Stout (1992) turns the organisation theory perspective 'upside down'. The agency argument is that managers acting as agents inherently have a set of goals that are not always aligned with the principals (For example pursuit of power, prestige, money, and job security). Managers may use slack to engage in excessive diversification, empire-building, and on the job shirking (Tan & Peng, 2003). These agency theorists go on to claim that slack is in fact the source of the agency problems, i.e. firms are inefficient in allocation of resources termed as 'X-inefficiency' (Leibenstein, 1980). From this perspective the presence of excess slack resources has also been found to diminish competitiveness in organisations (Davis & Stout, 1992).

Building on this tension between organisational theory and agency theory, researchers have therefore proposed a curvilinear i.e. an inverted U relationship between organisational slack and innovation outcome (Nohria & Gulati, 1996). To summarize the implications of slack, we find that while resources are necessary for innovation too few or too many resources constraints are not conducive to produce new solutions. Based on this discussion, we can infer that depending on the level of slack in the organisation, an increase in constraints may indeed improve performance³.

The main limitation of the theory is that, while it can potentially explain the relation between resource constraints and incidence of innovation, it does not shed light on the influence of the structural constraints that influences how resources are distributed for innovation. For example how does corporate innovation strategy that introduces structural constraints on how resources are distributed influence innovation?

³ See table 8.1 for a summary of the highly cited literature on slack and the corresponding variables used.

1.1.3 BRICOLAGE

Another body of literature cited in this context of innovation under constraints is that of bricolage. Originally proposed by Levi-Strauss in his seminal book in 1962, 'La pensée sauvage' (English version published in 1966 as 'The Savage Mind') in the field of anthropology, it later gained popularity in management literature in various contexts like innovation research and organisation theory (Duymedjian & Rüling, 2010)⁴.

Our interest is to understand how the concept of bricolage is used in the context of innovation. We find that there are two ways to look at this literature i.e. from the perspective of the central actor called the *bricoleur* (For example the entrepreneur or the artist) or from the process perspective (For example resource mobilization). In Levi-Strauss's original conceptualization the artisan or *bricoleur* plays a central role in bringing together seemingly redundant artefacts in order to compose something meaningful. Therefore, it is not surprising that many scholars such as Miner, Bassoff, and Moorman (2001) and Garud and Karnøe (2003) have highlighted the characteristics of the involved actors, most notably their resourcefulness and ability to improvise.

Bricolage is understood as a process of resource mobilization when the usual resources to meet an objective are not available (Desa, 2012). Such resource mobilization can lead to novel solutions and entrepreneurial ventures as noted by Baker and Nelson (2005) definition, "making do by applying combinations of resources already at hand to new problems and opportunities". This view is close to 'improvisation' and therefore the two constructs have often been studied in close association (Moorman & Miner, 1998; Weick,

⁴ This emergence in management theory is fairly recent as Boxenbaum, E., & Rouleau, L. 2011. New knowledge products as bricolage: Metaphors and scripts in organisational theory. *Academy of Management Review*, 36(2): 272-296. note, of all the papers published in the database ABI/ INFORM between 1992 and 2009 with the keyword Bricolage, 87 % were published after the year 2000.

1998). However, as Baker notes “While bricolage may imply improvisation, bricolage also occurs in the absence of improvisation, and that it is therefore important to recognize that they are separate constructs” (Baker, 2007). For example, improvisation has been consistently observed in many creative disciplines where constraints are not observed like musical improvisation (Chase & Portney-Chase, 1988; Kernfeld, 1997), theatre (Knapp, 1985; Spolin, 1999) and sports (Bjurwill, 1993). In summary, the central difference between bricolage and improvisation as a process is that improvisation can happen without constraints whereas the central theme of bricolage is ‘scavenging’ for resources by the bricoleur⁵.

We find that while bricolage is a powerful theory, it however looks at value creation in general i.e. creating something from nothing (Baker & Nelson, 2005) as opposed to a specific case of problem solving or innovation. Therefore, while the theory of bricolage at best provides a basis to understand value creation in resource constrained environments (often termed as frugal innovation or *Jugaad* (Radjou, Prabhu, & Ahuja, 2012), it does not address goal-oriented problem solving and the search for superior innovation outcomes.

1.2 STRUCTURAL CONSTRAINTS AS ATTENTION FOCUSING MECHANISMS

From the brief review of the three frameworks that are commonly cited in the context of innovation under constraints (i.e. theory of constraints, organisational slack and bricolage), we found only a partial explanation for the emergence of innovation under structural constraints. Essentially these frameworks cannot help us understand how constraints and particularly structural constraints influence the innovation search process.

Behavioural theorists propose that the search for innovation is triggered by a mismatch of aspiration and performance (Cyert & March, 1963), which leads us to ask - Do

⁵ Table 8.2 lists the central theme of some of the cited studies on bricolage in the context of entrepreneurial bricolage and social bricolage.

structural constraints influence aspiration? Can the behavioural theory of the firm help us understand the influence of structural constraints on focusing the aspiration of decision makers? This points toward a need to understand the link between structural constraints and aspiration. Aspiration, defined as the smallest outcome that would be deemed satisfactory by the decision maker (Schneider, 1992), is a central construct that is argued to trigger innovation search when it is more than expected performance (Cyert & March, 1963). Put differently our intent is therefore to use the foundations of the behavioural theory of the firm to understand how structural constraints might focus the attention of decision makers on certain aspiration that influence the search for innovation⁶.

We know from the central postulates that make up the cognitive foundations of the behavioural theory, that individuals do not maximize, they *satisfice*. This implies that as the knowledge of possible solutions is limited and as there is a cost of acquiring new knowledge; decision makers, within the limits of their knowledge are likely to seek a solution that meets their aspiration – and not necessarily seek the universally best solution for a problem. However, if performance falls below aspiration, it triggers changes in these rules such as triggering organisational search behaviour. This leads to problemistic search – Implying that search for new solutions is motivated by the objective to achieve goals that are set within the system of values that focus the attention of decision makers on specific aspiration⁷. There is

⁶ For a detailed review of research on the behavioural theory of the firm see Argote, L., & Greve, H. R. 2007. A Behavioral Theory of the Firm--40 Years and Counting: Introduction and Impact. *Organisation Science*, 18(3): 337-349, Gavetti, G., Greve, H. R., Levinthal, D. A., & Ocasio, W. 2012. The Behavioral Theory of the Firm: Assessment and Prospects. *Academy of Management Annals*, 6(1): 1-40.

⁷ At the same time a behavioural theory based explanation of innovation from problemistic search does not preclude the role of slack based search or from acquiring solutions available in the environment. Therefore a firm may build a solution stock using slack resources or by acquiring knowledge from the environment Greve, H. R. 2003. A behavioral theory of R&D expenditures and innovations: Evidence from shipbuilding. *Academy of Management Journal*, 46(6): 685-702..

strong empirical evidence to show that firms indeed trigger problemistic search when performance falls below aspiration, for example, we know that firms tend to invest more in R&D (Antonelli, 1989; Hundley, Jacobson, & Park, 1996), as well as seek new R&D processes (Bolton, 1993) when their performance is below aspiration levels.

The behavioural theory of the firm suggests that aspiration are set as a result of certain value based objectives defined by the organisation (Simon, 1947). Structural constraints define the value system within which performance can be assessed. For instance past (historical) and social (peer) performances focus the attention of decision makers on specific performance aspiration (Greve, 2008). Aspiration can also be set by the strategic intent of the organisation (Hamel & Prahalad, 1989).

Simultaneously, the processes involved in searching are governed by *organisational routines* which are built on past experiences i.e. path dependent. As a result of the cycle of aspirations, performance, and problemistic search the organisation builds capabilities by adopting new routines in response to how the decision makers' attention is focused on certain priorities more than others. In such a context, we propose that the introduction of structural constraints will focus the attention of decision makers on internal routines and guide the adoption of routines in line with the structural constraints that set priorities. Therefore structural constraints influence organisational choices in adopting routines.

1.3 ROUTINES IN EVOLUTIONARY ECONOMICS

In *An evolutionary theory of economic change*, Nelson and Winter (1982) bring the concept of organisational routines i.e. firm specific, path dependent, repeated patterns of collective behaviour to the forefront of the discussion on organisational capabilities. They define capabilities as the “range of things a firm can do at any time” (52) and propose that organisational routines that build capabilities, include characteristics “that range from well-specified technical routines for producing things, through procedures for hiring and firing, ordering new inventory, or stepping up production of items in high demand, to policies regarding investments, research and development (R&D) or advertising, and business strategies about product diversification and overseas investment” (14).

They go on to categorize routines as those that are related to knowing the answer to ‘how to do’ questions (e.g., production or implementation) and those related to knowing the answers to ‘how to choose’ questions (e.g., deliberation or planning). Even though Nelson and Winter note the conceptual distinction between routines that make up the ‘choice set’ and ‘choosing’ i.e. between the availability of different production techniques and deciding to adopt a production technique, they see strong similarities between the two categories and treat them similarly.

In this dissertation we propose that this distinction between routines that make up the ‘choice set’ and routines that involve ‘choosing’, is a useful one and needs to be explored further. Specifically, we argue that the act of choosing an option from the choice set is essentially a behavioural act and is subject to the decision makers’ cognitive limitations. How a decision maker chooses what to do, is influenced by mechanisms that firms use to focus and distribute the *attention* of its decision makers (Ocasio, 1997; Ocasio & Joseph, 2005). This calls for a closer look into the causal influence between the availability of capabilities and the

performance of firms at the macro-level, by investigating the micro-level choices made by decision makers under the influence of attention-focusing mechanisms i.e. structural constraints.

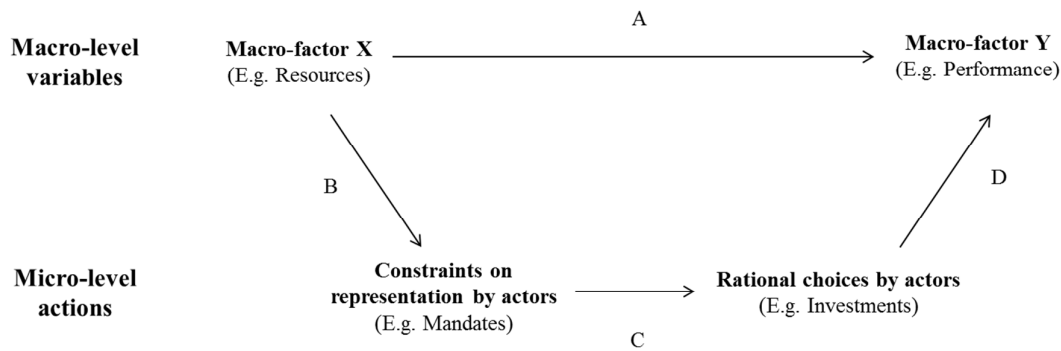
1.4 A FRAMEWORK TO STUDY ADOPTION OF ROUTINES UNDER CONSTRAINTS

Our aim is to build on the attention-based perspective of strategy formulation and contribute to the discussion connecting the macro- and micro-perspectives on strategy and strategic decision making. Coleman (1994) provides an excellent basis to build the theoretical links between the macro- and micro-level of analyses. In his book *Foundations of Social Theory*, he summarizes the relation in a diagram (adaptation in fig 1.1) where the macro variables are at the top and the micro actions are at the bottom while the arrows indicate possible pathways of causal influence between the two level (Coleman, 1994: 10). This conceptualization, often referred to as "Coleman's boat", very elegantly captures the 'structural constraints' that we refer to as attention-focusing mechanisms and its influence on micro-level choices.

Coleman illustrates this idea of the influence of structural constraints with a simulation game. The game comprises of, "a set of roles that players take on, each role defining the interests or goals of the player, rules about the kinds of actions that are allowable for players in each role, as well as about the order of play, rules specifying the consequences that each player's action has for other players in the game." He goes on to argue that, "it is this structure which corresponds to the two transitions I have described: macro to micro and micro to macro. The first of these transitions is mirrored in the player's interests, given by the goal established by the rules; the constraints on action, which are imposed by other rules; the initial conditions, which provide the context within which action is taken; and after the game is in play, the new context imposed by others' actions. The second transition is mirrored by

the consequences of the player's action: how it combines with, interferes with, or in any other way interacts with the actions of other ... thus creating a new context within which the next action takes place.” (11-12).

Fig 1.1: Theorizing causal pathways that link macro-level variables through micro-level action under attention focusing constraints (Coleman, 1994)



Put differently, if we assume that the availability of capabilities lead to firm performance though the micro-level choices of decision makers then the micro-level process can be broken down into at least three steps. First, the act of representing the opportunity that is open to variation in representation based on structural constraints that operate as attention-focusing mechanisms i.e. path B, second, the act of selecting an option to maximize expected utility i.e. path C, and finally, performance as observed at the macro-level is then the result of the aggregation of results from choices made at the micro-level i.e. path D. The underlying argument is that all attentions-focusing mechanisms impose cognitive limitation on the decision maker’s ability to represent opportunities or threats. This step of how an opportunity or a problem is framed (or not framed) imposes boundaries on the subsequent process of choosing routines. Performance outcome is therefore not just a matter of availability of resources and capabilities (path A), but it is also influenced by the decision makers’

commitment of resources and capabilities to various tasks, based on how their attention is focused on some opportunities more than others (path $B \rightarrow C \rightarrow D$). In this dissertation we will ask questions about the path $B \rightarrow C \rightarrow D$ as depicted in Fig 1.1.

In the dissertation we use micro and macro to designate the relative unit of analysis in each essay. The first essay deals with the macro-micro interaction. In this essay organisational mandates operate at the macro-level and influence the choices of adopting absorptive capacity routines at the micro-level. Here macro is the level of the R&D subsidiary whereas micro is the level of the inventor. The second essay deals with the micro-micro interaction. In this essay competitive pressure focuses the attention of decision makers to trigger search for better routines. Here micro is the level of the team. Finally the third essay deals with the micro-macro interaction. In this essay micro-level choices to adopt a new routine are made by decision makers based on how their attention is focused by the adoption decision of other firms when engaged in multipoint competition. We observe the diffusion of a routine as a competitive action at the macro-level. Here micro is the level of the key decision maker in the firm and macro is the level of the industry. We will provide more details on the essays in section 1.7.

1.5 BOUNDARY CONDITIONS OF THE STUDY

Before we introduce the three essays, each employing a distinct methodological approach, on adoption of organisational routines, let us briefly outline the boundary conditions within which we propose this study. We define organisational routines as firm specific, path dependent, repeated patterns of collective behaviour that provide an organisation the potential to undertake an activity. Routines have been the subject of many excellent review articles and a handbook (e.g. (Becker, 2004, 2008; Parmigiani & Howard-Grenville, 2011)), therefore we

do not attempt to do another review on the subject; instead we will highlight the salient arguments separately in the literature review for each essay. However, given the wide variety of contexts in which routines have been studied, it is still useful to point out the three main boundary conditions of our study. First, we study organisational routines as opposed to individual routines. Second, we study the organisational routines embedded in the context of the task, the firm, or the industry and third, we focus on the adoption of routines as opposed to changes in the routine itself.

Organisational routines are distinct from individual routines. Our interest here is in organisational routines as opposed to routines of specific individuals or an individual's adoption of routines⁸. Organisational routines involve the collective activities of a team or sets of teams typically within or across functional areas. These organisational routines serve as mechanisms to control and coordinate actions between multiple actors while performing an activity (for a detailed review see Becker (2004)). Specifically we are interested in the use of organisational routines as rules, or procedures that are executed in carrying out particular objectives like a production task. In the processual sense organisational routines consist of a series of steps to carry out a task. Similar terms used in the literature include standard practices, blueprints, decision-rules, or standard operating procedures for executing an activity (Parmigiani & Howard-Grenville, 2011).

Next, in line with prior studies in the capabilities tradition, we study organisational routines specific to a context (Inkpen & Crossan, 1995; Lippman & Rumelt, 1982; Teece & Pisano, 1994). The argument for specificity is often used along multiple dimensions of which we would like to mention two i.e. task and firm/industry specificity. First, somewhat obviously, routines are specific to the context of the task or activities that they are designed to

⁸ For example individual routines would consist of heuristics or habits of individuals in decision making.

accomplish. For example routines are often designed and practiced to build absorptive capacity in organisations (Lewin, Massini, & Peeters, 2011). These routines require coordination between multiple actors across different organisational units with the objective of building firm level absorptive capacity i.e. the capability to evaluate the benefits that can be derived from external technological and market forces (Cohen & Levinthal, 1990). Routines are also specific to the organisation or industry context within which they are designed. For example, every organisation has its own way of implementing the routines to build absorptive capacity (Peeters, Massini, & Lewin, 2014) or particular set of routines may be specific to certain industries (e.g. TQM in manufacturing). We will discuss the need for context specificity in each essay separately.

Finally, our focus would be primarily on the decision to adopt an organisational routine as opposed to study the changes in the organisational routines. To that extent we treat the routines (or collection of routines) as constant over time. Throughout the three essays we are mindful that a routine may adapt with time, experience and learning (Argote, 2013) but we still make this simplifying assumption as any change in a routine is still a function of its previous state i.e. it is path dependent (Cohen et al., 1996; Levitt & March, 1988)⁹.

1.6 OVERVIEW OF THE ESSAYS

Each essay deals with a structural constraint that focuses the attention of decision makers on adopting routines. In the first essay – **Adoption of absorptive capacity routines and technological innovation: Evidence from a global R&D organisation**, we examine how

⁹ There is a rich tradition of scholarly work that deals with the changes in organisational routines from a practice perspective. For instance, scholars in this tradition have focused on understanding the role of agency and artefacts in influencing changes in routine. See Parmigiani, A., & Howard-Grenville, J. 2011. Routines revisited: Exploring the capabilities and practice perspectives. *The Academy of Management Annals*, 5(1): 413-453. for a contrast between the capabilities and practice perspectives.

corporate innovation strategy influences the adoption of Absorptive Capacity (AC) routines in different subsidiaries of a large global software R&D organisation. We argue that the innovation strategy based on dominant logic stipulates exploitative or explorative mandates to R&D subsidiaries that focus the attention of managers on some innovation opportunities more than others. We theorise that adopting an AC routine would increase or decrease the subsidiary's innovative output, depending on whether the AC routine is aligned or misaligned with the subsidiary's mandate. We test this idea using data collected from SAP, a global packaged-software firm with 14 international R&D subsidiaries that implemented six major AC routines from 2000 to 2010. We find that while the R&D organisation as a whole benefits from the introduction of AC routines, individual R&D subsidiaries benefit more when AC routines are aligned with its mandate and there is a fall in the subsidiary's innovative output when the AC routines are misaligned with its mandate. The results from this study gives us some insight into how managers at the level of an R&D subsidiary select routines, but it also opens up a relatively more micro-level question i.e. what triggers decision makers to search for *new* routines in the first place?

At the micro-level choices made by decision makers become *routinized* over time and form the basis of predictable patterns, or 'production techniques'. The use of routines in decision-making helps agents to economize on cognitive effort of searching, and focus their attention on productivity gains from increased labour effort by using the same production techniques. However, in reality these production techniques are not static, but new production techniques are always being invented by the variation, selection, and retention of underlying routines by decision makers in response to *new problems* (Nelson & Winter, 1982). Decision makers often confront new problems when there is a 'mismatch' between available resources and desired outcome. These circumstances arise when organisations face reduced resource availability, for instance due to external supply shock, or a shift in desired outcome that may

be among other things due to new regulations or changing competitive conditions. Under these circumstances, decision makers are often forced to choose between lowering their aspiration and rethinking their existing routines.

In the second essay – **Ingenuity and the creation of new routines: Evidence from laboratory experiments**, we look at the latter option. Specifically, we argue that when decision makers work under structural constraints, that neither allow them to obtain more resources, nor compromise on their aspiration, they will turn their attention to internal production and management processes. This focussing of attention on internal processes may result in attempts to pressure employees to economize on the use of existing resources or accelerate production processes. In some situations, employees may push hard to meet these targets without questioning existing methods and practices (i.e. apply more labour effort), but in others their observation and analysis of production processes may lead them to ‘see’ better ways of arriving at the desired targets (i.e. apply cognitive effort to search). Such insights are often at the origins of new practices and our aim is to understand what triggers some decision makers to search for better routines.

We theorize at the micro-level high aspiration under resource constraints focus the attention of agents to search for new and better routines to improve productivity. We argue that under normal conditions, an agent’s familiarity with the routines of a task, helps them to economize on the cognitive effort of search and focus attention on performance improvement through labour effort when such labour effort is available i.e. apply more resources using known techniques. However, under sufficiently high aspiration and resource constraints, the routines can be rendered ineffective, thereby framing agents to search for better routines through cognitive effort. We design two experiments to test the relationship between high aspiration and performance through the increase in labour effort (apply known solutions) and

cognitive effort (search for new solutions) in repeated task and a novel task. Our results show that agents are more likely to discover new routines under high aspiration and resource constraints.

In the third essay – **Choosing which battles to fight: An attention-based argument for the diffusion of routines as a competitive action**, we pick-up on the micro to macro transition i.e. what drives the diffusion of a routine? We know that a routine diffuses in a population as decision makers have access to information about the benefits of the routine and have the resources necessary to adopt the routine. We theorize that as firms engage in competition across multiple markets and business domains, they allocate more attention to the information from some competitors more than others. Put differently, a firm is likely to allocate more attention to the decisions of its primary competitor than to the same decision made by a firm that is not a major competitor. Based on this argument, we build an agent-based simulation model to estimate how an attention-based mechanism would govern the adoption of routines as a competitive response to rivals' decisions to adopt or not adopt new routines in an industry. Using this model, we predict the characteristics of early adopters in a diffusion pattern. We illustrate this theory using data from the adoption of Software-as-a-Service amongst the top 50 global packaged software firms between 2002 and 2012. Table 1.3 summarizes the research questions, the methods and data, key findings, and the theoretical implications from each essay.

Table 1.1 Overview of the three essays

Essay	Research question	Data & methods	Key findings	Theoretical implications
1. Adoption of absorptive capacity (AC) routines and technological innovation: Evidence from a global R&D organisation	Does organisational mandate influence the adoption and effectiveness of absorptive capacity routines in corporate R&D units?	Quantitative analysis on panel data (2000 – 2010) collected from 14 global R&D subsidiaries of a single large MNC in the packaged-software industry	(i) Technological innovation is positively related with the introduction of AC routines (ii) R&D subsidiaries benefit when AC routines are aligned with the innovation mandate, but there is a fall in the subsidiary's innovative output when the AC routines are misaligned with the mandate	(i) Organisational mandates influence micro-level choices in adopting and benefiting from AC routines (ii) Research in global R&D needs to be more cognizant of variation in location mandates
2. Ingenuity and the creation of new routines: Evidence from laboratory experiments	Does high aspiration under resource constraints induce agents to apply increased cognitive effort to search for better routines to improve performance?	Laboratory experiments in teams using a: (i) repeated task (ii) novel task Where aspiration is manipulated using competitive pressures	(i) Agents show a preference to improve performance though increased labour effort under low aspiration. (ii) High aspiration under constraints can trigger increased cognitive effort when labour effort is not sufficient to meet high aspiration	(i) Competitive pressure under resources constraints focus attention of decision makers on search for better routines

<p>3. Choosing which battles to fight: An attention-based argument for the diffusion of routines as a competitive action</p>	<p>Does an attention-based model explain the diffusion of a routine as a competitive action when firms are engaged in multipoint competition?</p> <p>What would be the characteristics of the early adopters of routines in such a system?</p>	<p>Agent-based simulation model to estimate diffusion pattern of routines. Illustration of the pattern using data from the adoption of SaaS as a new software delivery capability amongst the top 50 packaged software firms between 2002 and 2012</p>	<p>(i) Early adopters of a new routine are more likely to be firms with a small reference group and high competitive rivalry</p> <p>(ii) Firms with large reference groups and low competitive rivalry are least likely to be early adopters</p>	<p>(i) Firms engaged in multipoint competition prioritize their competitive response based on how their attention is focused by the moves of competitors</p>
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2. ADOPTION OF ABSORPTIVE CAPACITY ROUTINES AND TECHNOLOGICAL INNOVATION:
EVIDENCE FROM A GLOBAL R&D ORGANISATION

*Knowledge is of two kinds. We know a subject ourselves, or we know where we can
find information upon it.*

- Samuel Johnson

From Boswell's "The Life of Samuel Johnson, LL.D" (1791)

This essay looks at how corporate innovation strategy influences the effectiveness of Absorptive Capacity (AC) routines by the formulation of an innovation strategy based on dominant logic that stipulates the allocation of exploitative or explorative mandates to R&D subsidiaries. Extant AC research suggests that maintaining a successful innovation strategy calls for striking a balance between inward- and outward-looking AC routines. In this essay we argue that adopting an AC routine would increase or decrease the subsidiary's innovative output, depending on whether the AC routine is aligned or misaligned with the subsidiary's mandate. We test this using data collected from SAP, a global packaged-software firm with 14 international R&D subsidiaries that implemented six major AC routines from 2000 to 2010. We find that R&D subsidiaries benefit when AC routines are aligned with the mandate, but there is a fall in the subsidiary's innovative output when the AC routines are misaligned with the mandate.

2.1 INTRODUCTION

Lewin et al. (2011) contend that in the twenty years that followed the introduction of ‘absorptive capacity’ (AC) by Cohen and Levinthal (1989), this seminal construct has been widely applied, but not fully understood. The main problem, argue Lewin et al. (2011: 81), is that, “with very few exceptions, the specific organisational routines and processes that constitute AC capabilities remain a black box”. A number of researchers suggest that opening the black box is best accomplished by placing AC within the wider framework of evolutionary economics as originally pioneered by Nelson and Winter (1982). As with other models in organisation theory that adopt this paradigm, the evolution of AC at the macro-level is the result of variation, selection, and retention of routines at the micro-level. To base AC development on the dynamics of routines at the micro-level, however, raises the question of path dependence. If AC development is a function of the evolution of routines, then the shape that AC takes over time will be strongly influenced by prior problems and opportunities that organisations encounter as they search for knowledge that can be transformed into commercial innovations (Zahra & George, 2002).

If AC is path dependent then organisations run the risk of possessing an AC that underperforms when the environment changes. Put differently, search routines that are modified or selected out in response to idiosyncratic problems, associated with innovating at one point in time, may actually reduce the effectiveness of AC when the organisation confronts opportunities that are unfamiliar and uncertain. To counter this trend, organisations work to align their AC development with overall R&D strategy. Ensuring this alignment can be challenging. In most organisations, R&D strategy consists of policies that top managers set for the various departments or business units. However, while policies that make up R&D strategy consist of intentions, plans, targets, and budgets that are explicitly laid out, routines

in contrast, are decision rules, standard operating procedures, and norms that are consciously followed at the micro-level (Becker, 2004; Lewin et al., 2011). Inevitably, there is a gap between the macro framework where R&D strategy is formulated, and the complex set of routines that make up AC. The question that we wish to address in this essay is how the two levels interact? More specifically, what impact does R&D strategy, as articulated by the top management team, have on the routines that make AC?

We start with a review of routine-based view of AC with particular emphasis on the role of internal vs. external AC routines. We then examine how firms use ‘mandates’ to direct the activities of their R&D units. We argue that the constraints of directing the operations of R&D in detail often lead managers to rely on ‘dominant logic’, which aligns the attention of managers with the firm’s R&D objectives. This in turn suggests that AC routines that are not aligned with the mandate of the unit will either have no impact or even have a negative impact on the unit’s R&D output. We then introduce our research site, SAP, a global packaged-software producer with more than US\$15 billion in revenues as of 2010 (end of the study period). Like most large technology firms, R&D at SAP is globalised and managed out of 14 international R&D subsidiaries. Using the subsidiary as the unit of analysis, we develop and test four hypotheses on the interaction of AC routines and organisational mandates on the subsidiary’s innovative output. We conclude by drawing implications for theory, practice, and future directions of research.

2.2 THEORY

2.2.1 ROUTINE-BASED VIEW OF ABSORPTIVE CAPACITY

Technological innovation is at the heart of growth and renewal of firms in R&D intensive industries (Dosi, 1988). Levinthal and March (1993) argue that technological innovations entail organisational innovation search processes which are triggered when an organisation's performance falls short of its aspiration (Cyert & March, 1963). Complementing this view, Cohen and Levinthal (1990) argue that search processes are not only triggered by retrospective assessment of firm performance, but they are also activated by perceived opportunities. Opportunity perception, however, depends on the capacity of the organisation to evaluate the benefits that can be derived from external technological and market forces. Cohen and Levinthal (1990) called this 'absorptive capacity'. They argued that this capability has two distinct dimensions: 'outward-looking', AC that enables the capture of external knowledge, and 'inward-looking', AC that enables organisations to assimilate knowledge from other units within the organisation.

Although AC as a construct was rapidly and widely adopted by organisational researchers, questions remained about how organisations constitute AC in the first place. Increasingly, scholars argue that as is the case for capabilities more generally, AC also consists of organisational routines (Zahra & George, 2002). Mirroring Cohen and Levinthal's breakdown of AC into 'inward-looking' and 'outward-looking' processes, Lewin et al. (2011) propose two distinct types of routines, namely internal and external AC routines. According to Lewin et al. (2011) internal AC routines relate to the efficiency of internal communication and sharing of knowledge originating from other units within the firm. For example, many technology firms run so called 'Jam sessions' where individuals and teams from different units of the firm come together for a few days either physically i.e. in the same location, or

virtually i.e. over online video conferencing, to work on specific predefined ideas or ideas that they find interesting beyond their daily tasks. This is a typical internal AC routine that facilitates communication between different parts of the firm, thus enabling employees to share current challenges, cross pollinate ideas and solutions, and encourage management to focus attention and resources on promising innovative ideas. IBM introduced a similar internal AC routine of 'Jamming' in 2001, designed for its own specific context and priorities. In their case study of IBM's Jams, Bjelland and Wood (2008) note that in the 2006 Jam edition, which was a three-day virtual mega-event involving employees across all R&D subsidiaries, IBM was able to harvest ten new business ideas that cut across existing businesses. They also note that the IBM Jam process helped IBM innovate by identifying numerous smaller ideas (from its own employees) which complement bigger ones.

In contrast to internal AC routines, external AC routines target external knowledge that may be useful to the organisation. For instance, a common practice in many technology firms is to seek R&D alliances or co-development partnerships with firms in closely related industries. Such collaborations often lead to sharing knowledge and best practices that enable partners to learn from each other and even co-develop new products or services. Sony, which has formed various alliances since the 1990s, is one such firm. Inkpen and Dinur (1998) note that starting in 1990s Sony's management team forged new technology linkages with various computer and telecommunications firms. These linkages enabled Sony engineers, who already had considerable experience in consumer electronics, to access new external knowledge, in particular techniques to manage faster product development cycles, which at that time were more advanced in the computer industry. At Sony, the practice of alliance formation was not confined to a few experts, but involved individuals and teams across various organisational levels who engaged directly with partners. Sony clearly benefitted from these early alliances, as is evident from its own subsequent entry into personal

computers, notably the launch of the VAIO in 1996, and subsequently its entry into mobile communications via a joint venture with Ericsson in 2001.

Though partners are a key source of external knowledge through relationships like joint ventures and alliances (Dyer & Singh, 1998), collaborations with ‘lead users’ (Von Hippel, 1986), and customers (Foss, Laursen, & Pedersen, 2011) can also be sources of external knowledge. For instance, Foss et al. (2011) point out that firms develop AC by tapping user and customer knowledge. This is often done by introducing external AC routines, such as periodic interactions with customer that are designed to capture new knowledge that is shared with other units in the organisation.

To sum up, AC research argues that firms build ‘inward-looking’ AC by introducing internal AC routines, and build ‘outward-looking’ AC by introducing external AC routines. Since useful knowledge can be found both internally and externally, both inward- and outward-looking AC are potentially valuable for technological innovation, it is therefore to be inferred that both internal and external AC routines are necessary to develop AC capabilities.

2.2.2 BALANCING INWARD- AND OUTWARD-LOOKING ABSORPTIVE CAPACITY

Although AC can be expected to have both inward- and outward-looking AC routines, the question remains, how far should organisations cultivate one or the other? Cohen and Levinthal (1990) argue that that there is a trade-off between developing inward- and outward-looking AC. Organisations that pursue the advantages of inward-looking AC do so at the expense of outward-looking AC, and vice versa, organisations that tilt towards outward-looking AC do so at the expense of inward-looking AC. Pushed too far this may result in excessive dominance by inward- or outward-looking AC that is dysfunctional. The

implication is that firms do best when they achieve a balance between inward- and outward-looking AC. At the micro-level this suggests that allowing internal AC routines to dominate is more conducive to systematic exploitation of internal knowledge, but may come at the expense of external knowledge acquisition that often plays a vital role in new exploratory innovations. Likewise, allowing external AC routines to dominate may lead organisations to overlook useful knowledge that is available internally, resulting in costly ‘reinvention of the wheel’.

The conclusion that most researchers have drawn from the limits imposed by the trade-off between internal and external AC, is that a coordinated balance between the two ensures optimal search and knowledge acquisition by the organisation (Cohen & Levinthal, 1990; Lewin et al., 2011; Volberda, Foss, & Lyles, 2010). As organisations grow, product lines evolve, and competition shifts, the relative balance between internal and external AC will change. This change may be caused by a push to innovate certain technologies, the need to generate additional earnings, or may simply be a product of incremental decisions at the departmental and business levels. To maintain a balance between internal and external AC, and to counter a drift towards excessive emphasis towards one type of AC at the expense of the other, top managers will usually develop policies that directly or indirectly seek to maintain the relative influence of internal vs. external AC search routines.

2.2.3 R&D MANDATE AS DOMINANT LOGIC

Research suggests that successful corporate R&D strategy depends on developing effective search processes. However, as Laursen (2012) points out, the literature on innovation does not subscribe to a single effective search process. Instead, it draws a distinction between ‘local’ and ‘non-local’ search processes, ‘search depth’ and ‘search scope’ (Katila & Ahuja,

2002), and between ‘organisational boundary-spanning’ and ‘technological boundary-spanning’ (Rosenkopf & Nerkar, 2001). At heart, argue Laursen (2012), all these distinctions address essentially the same opposing tendencies that March (1991) captures in the distinction between exploitative and explorative search. The basic innovation dilemma that confronts organisation is how to balance the need to efficiently ‘exploit’ existing knowledge, while at the same time ‘explore’ innovations in conjunction with new market opportunities. Benner and Tushman (2003) propose that firms achieve this by distinguishing between exploitative and explorative R&D efforts. These efforts are directed by policy mandates that are formulated at the corporate level. As Benner and Tushman (2003) put it, exploitative mandate focus R&D efforts on existing technological trajectories with a view to improving products that are already in the firm’s portfolio. In contrast, explorative mandate directs R&D efforts towards a search for different technological trajectories, and potentially radically innovative products, by accessing new external knowledge. The literature on organisational ambidexterity builds on this aspect further (Duncan, 1976; Raisch, Birkinshaw, Probst, & Tushman, 2009). This stream of literature points out that both exploration and exploitation jointly influence firm’s performance in technological innovation (He & Wong, 2004; Hill & Birkinshaw, 2008).

A mandate for a particular kind of R&D effort is intended to link the organisation’s R&D objectives with activities of the business unit or department that is responsible for implementing these objectives. The key challenge facing the organisation is ensuring that mandates influence R&D activities on a day-to-day basis. The difficulty arises from the relationship between top managers as strategic decision makers and R&D actors, who usually work several levels below in specialized units. While top managers seek to maintain control over defining R&D objectives, effective implementation of these objectives depends on allowing managers that are involved in managing the R&D effort considerable latitude when

it comes to deciding how they should proceed. The problem that confronts top managers is how to ensure that R&D managers remain focused on the direction set by the mandate without controlling the process directly?

Looking at this problem more broadly in terms of the balance between corporate control and entrepreneurial flexibility led Bettis and Prahalad (1995) to suggest that corporations often achieve a balance between top-down direction and bottom-up initiative by creating what they describe as ‘dominant logic’: A shared cognitive framework that shapes assumptions and focuses attention on priorities. Dominant logic operates by structuring the business units’ attention processes (Ocasio, 1997). In practice, this means that business unit’s managers are expected to focus more attention on certain market or technological opportunities than others. The differential allocation of attention has two main consequences. In the short run, dominant logic should drive managers to filter out data that is considered as less ‘relevant’, and pay more attention to data that is consistent with dominant logic. In the long run, however, differential attention will also impact the search routines that managers use to gather and analyse data. In other words, business unit activities are more likely to use, elaborate, and improve search routines that are consistent with the dominant logic. In contrast, search routines that are not consistent with the dominant logic are less likely to be useful, and therefore more likely to be side-lined or discarded over time. Our intent in the paper is not to investigate how the dominant logic is created but instead focus on what is the dominant logic by which exploration or exploitation mandates exist at each R&D subsidiary.

To sum up, on the one hand, R&D mandates link the organisation’s R&D strategy, as formulated by top managers with the objectives at the business unit level. This dominant logic of assigning certain types of mandates to the business units is influenced by the shared cognition of local resource endowments, local conditions, and idiosyncratic business unit

contingencies. While on the other hand, managers at the business unit level work within an ensemble of AC routines that build different dimensions of AC. Inevitably, the dominant logic as set by top management, will be aligned with some of these AC dimensions, and misaligned with others. When corporations comprise multi-business units, and each unit is influenced by local conditions, what impact does alignment or misalignment of R&D dominant logic with AC routines have on innovative performance of each of these business units?

2.3 RESEARCH CONTEXT FOR THE STUDY OF ABSORPTIVE CAPACITY ROUTINES

Many scholars have pointed out that routines that build AC are unique, context specific and embedded in the organisation (Gibbons & Henderson, 2012; Lippman & Rumelt, 1982; Winter & Szulanski, 2001). Therefore, to study the impact of R&D mandate on the adoption and effectiveness of the *same* routine, we use data from multiple R&D subsidiaries of a single large packaged-software firm, SAP. Our choice of the firm was dictated to some extent by access to top management and the firm's willingness to make internal information available for research. Confining our data to one firm limits the generalizability of our findings, but it also has important advantages. To begin with, SAP operates in a single global industry i.e. it operates only in the packaged-software industry. Consequently, all of SAP's 14 R&D subsidiaries are focused on packaged-software development and maintenance. Having one firm where all R&D subsidiaries are focused on the same technology ensures that that we are looking at the same set of internal and external AC routines across units. We can track the introduction and diffusion of these routines, and examine how they interact with the mandates of different subsidiaries. The longitudinal design that we are adopting allows us to compare how mandates influence adoption and effectiveness of internal and external AC routines. This

means that our focus is *deeper* than previous research in this area, as we aim to understand the nature and impact of the *same* AC routine in different organisational units.

When it comes to allocating R&D investments to subsidiaries, we argue that top managers will set an R&D mandate and allocate resources to R&D locations based on the perceived strengths of the subsidiary. In the case of SAP, an overview of the R&D strategy reveals that the company essentially had two mandates for R&D investments, in line with the typology proposed by Benner and Tushman (2003). The R&D investments to subsidiaries were either directed towards extending or maintaining existing products and technologies, i.e. they were given an exploitative mandate, or they were directed to develop new products and technologies, i.e. they were given an explorative mandate. In the next section we will briefly review the creation of SAP's R&D organisation.

2.3.1 BRIEF OVERVIEW OF SAP'S R&D ORGANISATION

SAP is the world's largest producer of business software. Founded in 1972 in Mannheim, Germany, SAP had more than 53,000 employees in over 120 countries as of 2010. In that year, the company reported gross revenues of over US\$15 billion. Since its establishment, SAP has built a large network of software development locations around the world. These R&D centres called 'labs' employ more than 20,000 of SAP's R&D staff. In this section we will summarize the evolution of the R&D organisation in three phases, last of which is our study period.

Phase 1 Initial years till mid 1990s: Since SAP Labs Network organisation has a close association with SAP's growth and product history, we start with SAP product history. SAP, an acronym for *Systemanalyse und Programmementwicklung* ("System Analysis and

Programme Development") was founded by five software engineers from IBM, Germany. They saw an opportunity to build standardized 'real-time' business software for functions like finance and manufacturing, and in 1973 they released a financial accounting system that later formed the backbone of the flagship product called R1. Developed by a handful of software engineers (less than 25) in Mannheim, Germany, the product was still highly malleable to what the customer needed. Most of the developers were in constant contact with customer and were involved in sales as well. All the customers were European, and mostly German.

The next release SAP R/2 System in 1982 was not only a stable product it was also compatible with both the IBM and Siemens mainframes. This made the system readily acceptable in the market. Development was still quite small and limited to Germany but SAP had started attracting customers from all around the world and many from the US. By 1985, the US business had become so large that SAP set up a US sales headquarters in Wayne, Pennsylvania. By 1991, SAP had more than 2,200 customers across 31 countries including Japan, while the core development work was still done in Germany. If a piece of custom development was needed, developers from Germany would travel to the customer location. While this may seem inefficient, by keeping all the development in one location, SAP was able to create a tight coupling in the initial years, which was essential to build a stable core technology. The development organisation had also become formalized i.e. they were now separate from the sales set up. Developers would only interact with customers in highly specialised custom development projects or in requirements gathering stages.

The inflection point came in 1992 with the introduction of the SAP R/3 system based on client-server technology. This was a significant evolution from the age of R/2 based on mainframes and called for more and more network functionality from customers. The relatively small development team entirely based in Germany, was not only stretched but at

the same time somewhat cut off from innovations in the technology industry coming out of the Silicon Valley in the US. On the one hand European IT hardware vendors like Nixdorf were disappearing, while on the other hand Silicon Valley based firms like Intel, Microsoft and Oracle were beginning to dominate the technology world. It was clear that SAP needed to get external knowledge and expand its development force to meet these demands.

In 1993, SAP started its cooperation with Microsoft (the largest software producer then) to port the R/3 system to Windows NT. This collaboration was the first of its kind and also marked the setting up of a small but permanent facility in the Silicon Valley. The aim was clearly to create a doorway to let all the new technologies from the Silicon Valley into SAP. Even though the facility at Silicon Valley was a move towards a distributed setup, it was still a tightly coupled extension through which SAP could enhance the core being developed in Walldorf, Germany.

The opening of the Lab in US was also a sign of stronger commitment to the American market and soon enough large American firms responded positively to SAP. For example in 1994, when the R/3 System was released on Windows NT, IBM (a long standing SAP partner) decided to roll out R/3 globally, making IBM the then single largest SAP customer. From an organisational perspective, the expansion of development to US was driven by the sponsorship of one of the founders, Hasso Plattner. As Neumann and Srinivasan (2009) note, the initial ‘seed’ resources came from Germany and Hasso had to convince them to move. Hasso himself started spending considerable lengths of time in the Valley to set up the lab. The initial years were tough. It was not only an uphill task to get critical mass of experienced SAP developers in the Lab to do meaningful collaborative work but back in the headquarters at Walldorf, Germany, managers had to fight the perception that all the ‘cool’

development would move to the Valley while the ‘old’ maintenance work would remain in Germany.

To summarize, in this period we find that SAP’s development team was small and concentrated in Germany. The R&D organisation was flat and had started to get specialised only in custom development work as specialised sales teams had started coming up in key markets. Towards the end of this phase, the board of SAP started realising the need to globalise their R&D to (a) integrate latest technology innovations from different regions, (b) move development closer to the growing markets, and (c) source the best developers in larger numbers from around the world.

Phase 2 Emergence of the Hub & Spoke model till 2000: SAP has been consciously building the Global Labs Network since 1996 (SAP, 2004, p: 32). Before that SAP had made strategic investments in R&D only in the Silicon Valley, US. From these early experiences, the management team realised that some fundamental questions needed to be answered around the management of distributed software development. These questions were on three levels: (a) Content: What would be developed in each lab? (b) Process: How will it come together as one? (c) Organisation: How will it be managed? These questions reflect the management team’s thinking around setting up mandates for each subsidiary and the accompanying routines that would help connect each subsidiary in a network.

By 1998, SAP had made investments in other key industrial regions outside of Europe like Detroit in the US, Tokyo in Japan and Bangalore in India (SAP, 1998, p: 43). While the purpose of the lab in Tokyo was clearly oriented towards targeting the Japanese market, the reason for the lab in Bangalore in 1998 was to tap into the Indian talent market (Neumann & Srinivasan, 2009, p: 28). Not surprisingly these locations have significantly evolved from the initial design. In fact, by 2006 SAP had focused the work at the Tokyo facility only on

custom development for specific customers or partner oriented projects as opposed to core product development (SAP, 2007, p: 31), whereas with the growth in the Indian information technology services industry SAP set up the Co-Innovation Lab (COIL) in Bangalore to increase the collaboration with Indian services partners (SAP, 2009) under the umbrella of the existing development Lab that was also doing product maintenance projects.

In this phase the SAP Labs network cautiously increased its footprint to Moscow, Tokyo, Bangalore, Sofia-Antipolis and key locations in the US apart from Palo Alto. All these centres were small and served somewhat different organisational needs. At the same time the SAP was also firming up its distributed development practices around content, process and organisation.

In 1998 a board sponsored SAP Labs project recommended a 'Hub & Spoke' model for content management. SAP development in Walldorf would remain the main development hub and delegate responsibilities to other labs around the world. Each lab would develop a specialty around a research lab, development centre, ABAP factory (ABAP is the SAP proprietary coding language) or a test centre. Each lab was also assigned a board sponsor to ensure executive sponsorship for the location. The minimum number of developers in a location for it to be viable was estimated to be 100 with an ideal manager to developer ratio of 1:10.

From a process perspective, in the mid-1990s, SAP introduced a formal software development framework called HORIZON. This focused on the core development process from specification gathering to testing. Responding to the growing need of internationalization of the product, the next process evolution was the Solution Development Lifecycle (SDLC), which included product level planning and processes to support market introduction. The SDLC was introduced in 2000. These detailed process guidelines while on

the one hand increased the bureaucracy in the development process but at the same time created the much needed standardisation to run a globally distributed development network.

The organisational setup relied heavily on the early experiences in the US. Apart from the development teams (Lines of Business), each lab location has its own suitable setup to run the operations smoothly. From an organisational perspective, this would include a Managing Director with other support functions like onsite human resources, finance & controlling management, and facilities management, and from a legal point of view these units were fully owned local subsidiaries of SAP AG. The lines of businesses and the managing directors report into global functional heads, most of whom were located in Walldorf, Germany.

To summarize, in this phase we find that SAP consciously decided to expand its R&D network to keep pace with the growing needs from the success of R/3. This expansion was driven by some fundamental design principles around the content, process, and organisation. We find that as the R&D footprint was growing, SAP had to build formalisation (Specialisation of tasks), standardisation (Common documentation of development processes) and centralisation (Hub and spoke model) in its organisation structure.

Phase 3 Building a network 2000 to 2010: In 1999, SAP launched the new ambitious mySAP.com strategy, which was a significant shift in its product strategy. This coupled with the tremendous success of R/3 created an even greater demand to expand the development network. More and more developers and senior managers were being added outside of Germany. In 2001, SAP acquired a portals company called Top Tier to boost its mySAP.com strategy (SAP, 2001). This was one of the largest product acquisitions that SAP had made till date and with it, the firm also acquired senior executives who owned complete product delivery but were not based in Germany. At the same time based on the learning from the investments in Palo Alto, Bangalore, Montreal and other lab locations, the board was more

confident to either expand existing operations by giving them more autonomy or replicate the organisational configuration in new locations based on need.

Just like the previous set up, the post 2000 labs also have different histories and play a distinct role in the overall SAP development strategy. For example, SAP Labs Brazil was set up ‘organically’ (as opposed to an acquisition) in São Leopoldo in 2006 for two primary reasons; to target the growth opportunity in fast growth market like Brazil and to provide same time zone service and support to the US customers (SAP, 2011a). This lab is more aligned in its organisational practices with the US Lab and market than Germany. Whereas SAP Labs in Sofia, Bulgaria, that was also set up organically in 2000, focuses on only specific technology development (SAP, 2011b) and augments the capacity in Walldorf. Sofia is close to the headquarters in Walldorf, it is in the same time zone and significantly more cost-effective. Hence, we find that there is significantly higher alignment between Walldorf and Sofia.

From an organisational design perspective, we find that in the 2000s the SAP Labs setup had moved from a ‘Hub & Spoke’ model to a network of labs. This is particularly visible with the evolution of the bigger locations in Palo Alto, Walldorf, Bangalore and Shanghai where SAP also had ambitious growth plans. During this period, we find two important developments that also make this case an ideal context to study the interaction of AC based on routines and innovation strategy. First, the management team introduced six major organisational routines (discussed in the data section) as enablers in the creation of a global R&D organisation. To ensure that the locations have a ‘one SAP’ culture, the management team ensured that the *same* routine was replicated across locations. Second, given the portfolio of locations, the headquarters set out to craft an R&D strategy to answer the question: what kind of development work should be done where? This gave rise to clear

mandate being assigned to different locations. Once again we will discuss the mandates in more detail when we discuss the data.

2.4 HYPOTHESES DEVELOPMENT

In general, we hypothesize that R&D subsidiaries are more likely to adopt and benefit from AC routines that are consistent with the mandate. As noted earlier, we are looking at the adoption of internal and external AC routines in subsidiaries with explorative and exploitative R&D mandates.

Impact of adoption of internal AC routines: In the context of a multi-unit organisation, internal AC routines facilitate internal communication and knowledge flow from different parts of the organisation. For instance, setting up of cross functional teams (Freeman, 1987), establishing common development methodologies (Wheelwright & Clark, 1992), and creating common technological infrastructure and protocols for knowledge management systems (Davenport, David, & Beers, 1998), are routines that enable organisational units to share and access knowledge from other parts of the organisation more freely and efficiently.

Units that operate under an exploitative mandate focus their attention on developing deep technical understanding of existing products, filling gaps in the product line, and pursuing opportunities that incrementally extend products that have an established customer base. Efficiency and control are central to the execution of an exploitative mandate. These units usually have clear delivery goals, and execute projects within strict project management guidelines of time, cost and quality. In general, subsidiaries with exploitative mandate are developed as extensions of the primary R&D hub to tap into unique locational advantages such as availability of a large pool of cost effective talent. This has been a prime consideration for many multinational companies that have built R&D subsidiaries in India.

The presence of large, highly skilled, but cost effective talent pool has motivated the decision to offshore development and refinement of products that are relatively more mature and hence, more technologically stable in their product lifecycle.

An exploitative mandate leads R&D units to focus on searching for opportunities near existing products and technological trajectories (Benner & Tushman, 2003). These units are often ‘users of knowledge’ from other units (Gupta & Govindarajan, 2000), and are more likely to benefit from the adoption of internal AC routines that enable them to access internal knowledge. We therefore have the following hypothesis:

Hypothesis 1(a): The adoption of internal AC routines in units with exploitative R&D mandate is positively associated with innovative output.

In contrast to units that operate under exploitative mandate, units that operate under an explorative mandate are encouraged to search for new technologies and markets. Execution of an exploratory mandate requires flexibility, autonomy, and experimentation. This tends to be consistent with research on new technological trajectories, building proof-of-concepts and prototypes, and market testing of new products and services. In general, subsidiaries with explorative mandate are built in locations that can provide access to an ecosystem of key partners, customers and research institutes. For example, many multinational companies in technology based industries have built subsidiaries in the Silicon Valley to benefit from the knowledge in this unique ecosystem (Almeida, 1996; Frost, 2001).

Having an explorative mandate focuses the unit’s attention on seeking external knowledge that is new to the firm, but at the same time the unit is also expected to serve as a ‘provider of knowledge’ to the rest of the organisation (Gupta & Govindarajan, 2000). Thus, even though internal AC routines are not aligned with the exploratory objective of the unit, their adoption is nevertheless essential for the unit to efficiently disseminate knowledge to the

rest of the organisation. For this reason, the corporate HQ is often insistent that all units adopt common internal AC routines, even when they may have different mandates. But forcing R&D units with explorative mandates to adopt internal AC routines may constrain their ability to capture new external knowledge. When corporate HQ embarks on a systematic attempt to introduce internal AC routines across all units, regardless of their primary mandate, this may lead to *excessive standardisation of process* in the case of R&D units with an explorative mandate. We therefore have the following hypothesis:

Hypothesis 1(b): The adoption of internal AC routines in units with explorative R&D mandate is negatively associated with innovative output.

Impact of adoption of external AC routines: Since the external environment can be an important source of new knowledge, technology firms often take steps to ensure that they have access to external sources of knowledge that are up-to-date. As mentioned earlier, this has led many multinational companies in the packaged-software industry to open subsidiaries near, or in, knowledge clusters with the intention of benefiting from knowledge spillovers (Almeida & Phene, 2004). The external AC routines that organisations use to capture knowledge from these external sources, run the gamut from basic surveys that solicit end user feedback to knowledge gained from long-term co-development of new products and services. Broadly speaking, these routines facilitate learning from partners, suppliers, customers and research institutes. For instance, many technology firms develop routines to reach out to ‘lead users’ (Von Hippel, 1986) in order to better understand future needs in fast changing markets. Collaborating with scientific institutions is another area where firms have sought to gain knowledge. Many software firms like Google and Microsoft have developed structured collaborative programmes with universities that allow them to scan academic research for new developments that may have significant commercial potential.

When subsidiaries have an exploitative mandate, their attention is focused on innovating ‘near’ existing products and technologies. The need for efficiency and control in such subsidiaries often leads to a well-defined scope and detailed project management plans. While an exploitative mandate encourages business units to develop and adopt internal AC routines, translating the mandate into practice is left in the hands of the local R&D managers. Local R&D managers may often resist strict implementation of only internal AC routines for exploitative R&D because this denies their unit the prestige and influence that usually accompany explorative research. Therefore, managers will seek to expand the scope of the exploitative mandate by pursuing more R&D responsibilities from the HQ (Bouquet & Birkinshaw, 2008). They may argue, for instance, that they must engage in what essentially amount to explorative research because customers’ demand of support for products or technologies require wider knowledge search. In other cases, managers will adopt external AC routines that are employed by subsidiaries that have an explorative mandate, as a way of legitimising a push for greater explorative responsibility from the HQ. However, by adopting external AC routines that are not aligned with the focus of their exploitative mandate, units not only waste valuable resources in a search for external knowledge with little or no relevance to their mandate, but they also run the risk of *excessive diversification of search scope*. This leads us to the following hypothesis:

Hypothesis 2(a): The adoption of external AC routines in units with exploitative R&D mandate is negatively associated with innovative output.

In contrast to subsidiaries that work under exploitative mandate, but seek to adopt external AC routines in order to engage in explorative research, subsidiaries that work under explorative mandate clearly benefit from the adoption of external AC routines. In the case of these subsidiaries, adoption of external AC routines facilitates the subsidiary’s ability to tap

into external knowledge sources. Specifically, such external AC routines provide various actors in the units the opportunity to effectively and efficiently engage with the external environment. This leads to our last hypothesis.

Hypothesis 2(b): The adoption of external AC routines in units with explorative R&D mandate is positively associated innovative output.

Based on these hypotheses, we propose the following ‘interaction-model’ of the effect of AC routines and organisational mandates on innovative output.

Fig 2.1: The interaction of AC routines and R&D mandates

Dimensions of AC routines	Internal	H1 (a): Positive effect	H1 (b): Negative effect ----- <i>Excessive standardization of processes</i>
	External	H2 (a): Negative effect ----- <i>Excessive diversification of scope</i>	H2 (b): Positive effect
		Exploitative	Explorative
		Dimensions of R&D Mandate	

2.5 EMPIRICAL ANALYSIS

2.5.1 METHODS AND DATA

Data: Our data were collected from SAP, a large packaged-software firm with more than US\$15 billion in annual revenues as of 2010. The firm has 14 international R&D subsidiaries apart from its HQ. While there is R&D activity at HQ, it is not clearly demarcated from other

corporate functions like marketing & communications, nor is it subject to a clear R&D mandate. We, therefore, decided to exclude the HQ from our analysis.

We collected in-depth longitudinal data about the implementation of six major AC routines and subsidiary mandates for all 14 global R&D subsidiaries for the period 2000 to 2010. There were three sources of data. First, we conducted detailed semi-structured interviews with 17 senior executives including the executive board member responsible for R&D for the entire organisation, the senior vice president heading the R&D centres, five managing directors of different R&D locations, and various vice presidents of R&D based at the headquarters as well as from different locations. These executives were identified by the senior vice president heading the R&D centres, and collectively they were responsible for charting out SAP's R&D strategy. Second, we were given access to more than 200 pages of internal reports, numerous presentations, and we had more than 50 email correspondences with various managers clarifying and detailing the evolution of the R&D network and the implementation of various internally and externally-focused organisational practices. Third, we collected all publicly available information about the firm and its subsidiaries. This includes patent applications (from European Patent Office (EPO)), acquisition records (from Factiva and SDC Platinum), press coverage on external practices (from Factiva), and key announcements like launching of new projects or significant investments in R&D (from Factiva).

2.5.2 MEASURES

Dependent variable: Subsidiary's innovative output. We use the count of patent applications made by employees of a subsidiary as the innovative output for each subsidiary in each year. Although our use of patent count as a direct measure of innovative output is in line with past studies of innovation, we are mindful that of the biases that may result: Clearly, not all R&D

leads to patents, and not all inventions are patented. To avoid this bias, it is important to understand and take into account the strategic context in which patents are created (Gittelman, 2008).

In the packaged-software industry, as in any technology intensive industry, a patent is considered as the grant of a property right to an inventor or a group of inventors for an invention. Patents represent new knowledge created by the organisational unit (Jaffe, Trajtenberg, & Henderson, 1993) and are regularly used as a measure of a firm's innovative output (Ahuja & Lampert, 2001; Kotha, Zheng, & George, 2011). In this industry, managers file patent applications as part of their efforts to protect what they consider to be novel and valuable ideas (Corrocher, Malerba, & Montobbio, 2007). SAP's approach to patenting conforms to this industry practice. Within SAP, the patenting process is managed by a global intellectual property (IP) team. As part of the process, any employee can initiate an application but to move forward they need the support of the global IP team and an approval of the group's VP. In other words, SAP will not invest resources in pursuing the patent application without first evaluating the content of the patent in terms of market and commercial potential.

Independent variables: Count of internal & external AC routines. First, as part of our preliminary interview, the senior vice president heading the R&D centres helped us identify an initial list of practices that may have had an impact on accessing internal and external knowledge. Then as part of our interviews, we asked the executives to single out the most important 'standard practices', or routines, that had a significant impact on the ability of R&D teams to access internal or external sources of knowledge. To control for retrospective biases, we asked the executives to focus on specific parts of the study period and corroborated the responses across interviewees as well as with documentary evidence where

available, to precisely track the introduction of the practice and any changes thereafter. From an initial list of five internal and three external practices, we had to drop two internal practices. In one case the practice was adopted in only one location before it was abandoned, and in the other it was adopted for less than a year and then abandoned. We were left with three internal and three external practices that were singled out as having had significant impact by the management team. Table 2.1 provides a description of the routines and how they relate to similar routines discussed in the AC literature. In the organisational context, these routines are interchangeably called standard operating procedures, best practices or simply standard practice.

We identified the year in which a particular routine was rolled-out in each subsidiary. In a few cases a routine was withdrawn (e.g. withdrawal of the co-location policy) from some locations, while in a few cases there was a time lag between the initial roll-out and the full adoption of a routine. These cases were identified by managers with specific knowledge of such cases and were excluded from the active routine count. Subsequently, we created a record to count the number of active internal and external routines for each subsidiary-year.¹⁰

¹⁰ Our study site is SAP that is a German firm with a global R&D organization. Scholars have argued that firm culture is a key determinant of the inventive activities. While we have not taken into consideration the culture at SAP or more precisely if there is a variation in the culture across the subsidiaries, we believe that it may not have a huge impact on our empirical analysis. First as this is a single case study we can assume that there is a ‘SAP Culture’ that is common across all subsidiaries. Next we expect that there would be a location specific culture, for instance the subsidiary in Israel is likely to have a different culture compared to the subsidiary in China. However, we assume that the culture variable in each subsidiary is time invariant and so a fixed effects model would adequately take into consideration any subsidiary specific culture effects on inventive activities.

Table 2.1: List of Absorptive Capacity Routines

Routine	Nature of the routine	Description	Similar routines in AC literature
Standard development methodology [Standard X]	Internal AC	<p>A common standard of how the firm aims to invent, produce, and manage products throughout the entire lifecycle i.e. from design to maintenance across multiple versions, teams and locations. It contains specific guidelines on all aspects of development most notably documentation and knowledge management, software security, testing, and production standards.</p> <p>The Standard X methodology was rolled-out across all locations in the period 2004 – 2006. During this time, all developers underwent training relevant to their role on how to adopt these standards. This common development standard is considered to be a significant enabler in the globalisation of R&D. As one of the development heads pointed out -</p>	<p>Standardisation of processes to ensure efficiency. For example, Szulanski (2000) notes how the ‘copy exact’ principle is used by organisations to leverage optimisation of processes across different units. A standardised development methodology is known to create the basis for interoperability and interchangeability of pieces of large projects (Kanigel, 2005; Wheelwright & Clark, 1992)</p> <p>In their review of AC routines</p>

		<p><i>“I have teams in Germany, China and India ... these standards ensure that we are all on the same plane of reference. It ensures that all our products are developed to the same highest standards wherever its developed”</i></p>	Lewin et al. (2011) also note that routines that share superior practices and knowledge, are key internal AC routines.
Co-location programmes	Internal AC	<p>A programme in which a group of expatriates are sent to a location to achieve a specific objective like setting up a new R&D centre, new team, or participate in long term intense development activities. The co-location programme is separate from short term travel (which is common). As part of this practice the group of developers are given long term (usually more than 12 months) expatriate contracts. If more than 1 % of the employees of a location are on expatriate contracts, then the host location is said to have an active co-location programme.</p> <p>Such programmes are estimated to be quite expensive for the firm and require approval from a board level executive. This routine was introduced and practiced in some locations between the years 2002 –</p>	<p>The use of practices involving expatriate to facilitate internal knowledge flows is well documented. (Chang, Gong, & Peng, 2012; Mäkelä, 2007)</p>

		<p>2007, but discontinued mostly due to cost reasons. A development head notes the importance of this initiative in the early stages of development of a project -</p> <p><i>“Three [locations] is not a very good number from a coordination perspective... they are crying for co-location sessions! They believe that co-location would benefit and focus now [early stages]”</i></p>	
Mandatory setting up of cross-functional teams	Internal AC	<p>The R&D organisation had built teams of specialists who were not necessarily part of the core development team. For example, specialists in user interface (UI) design or quality management were included in an actual development project only at the behest of the development head.</p> <p>In 2008, the R&D organisation introduced mandatory policy of setting up cross-functional teams as part of a major reorganisation. This practice was subsequently implemented across locations in a phased manner. Such routines enable development teams to identify new opportunities as they plan and develop, as opposed to discovering opportunities on completion of development – when it might be too</p>	<p>In the technology management literature, the internal routines for setting up of cross-functional teams, has been known to promote the generation of new ideas (Freeman, 1987; Sethi, Smith, & Park, 2001; Wheelwright & Clark, 1992)</p>

		late or too expensive to implement. A development head pointed this out as - <i>“Experts can contribute early on in the development cycle ... quality managers can work with the developers to fix bugs as they appear ... [so that] the developer would not do the same error again”</i>	
Links to the local developers’ community	External AC	<p>The firm introduced two standard routines to establish connections with the local developers’ community. As part of both the programmes, the local subsidiary organizes 2-3 day events where members of the community are invited to participate in various activities like showcasing new ideas, demonstration of prototypes and products, and co-development projects. These events target freelance developers and individuals from partners firms and universities.</p> <p>This routine not only provides a gateway to establish connections with the local developers’ community, it also serves as a multiplier. For example, the head of a local community development programme notes –</p>	<p>Routines that enable the development of local networks with partner organisations, universities and research institutions are known to improve the firm’s ability to learn from external knowledge (Koch & Strotmann, 2008).</p>

			<p>“When a partner sees a demo of an exciting new product that was developed with another partner, they want to do the same with us... [This event] makes our ecosystem grow.”</p>	
Alliance with local partners	External AC	<p>The firm introduced a formal standardised programme of collaboration with local partners in co-development mode within the research centre. As part of this routine, developers co-locate to the R&D centre of the firm to pursue a common objective. The infrastructure is jointly sponsored by the firm and the partners. Before commencing on such collaborations, an alliance agreement is signed between the involved parties. Partners bring in their expertise and new knowledge into these collaborations. The development head of this initiative notes –</p> <p>“We and our partners bring the latest generation hardware and software [as part of this programme] ... we hope that this collaboration will lead to prototypes that can meet the most pressing challenges and opportunities”</p>	<p>Routines that build different types of long term relationships with partners can be a source of new knowledge for the firm. These routines can be co-development relationships (Dyer & Singh, 1998) , R&D partnerships (Tether, 2002), or strategic alliances (Joshi & Nerkar, 2011)</p>	
Collaborating	External	<p>The firm introduced a standardised programme in which teams of</p>	Customer engagement and lead	

with local customers	AC	<p>developers from an R&D subsidiary work with early adopters of technology in the local market. As part of this initiative, developers get feedback directly from the end user of the prototype. This often leads to fine-tuning of the product's features, release dates etc. These collaborative engagements are usually setup with important long term customers and are bound by confidentiality agreements.</p> <p>Customers and end user feedback during the early stages of the product lifecycle can provide valuable insights. For example, a development head notes that –</p> <p><i>“One of our largest customer wanted [a new application] seamlessly integrated with ... We set up a project with the customers to prototype this new app ... now it is a standard feature”</i></p>	<p>user engagement programmes are known to be a source of new opportunities for innovation. (Foss et al., 2011; Von Hippel, 1986, 2009)</p>
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Exploitative and Explorative Organisational Mandates: Bettis and Prahalad (1995)

note that the views of top managers, preferably obtained by first-hand interviews, are suitable source of data for determining the dominant organisation logic. The coding for mandate was done on the basis of semi-structured interviews with 17 senior executives in R&D. The interviews lasted between one and two hours, and were recorded and transcribed. At least two researchers were present at all interviews. We followed an interview protocol for the semi-structured interviews (Yin, 2003) (See appendix 1). Table 2.2 lists the basis for the coding of the mandate. In general, subsidiaries with an explorative mandate are engaged in ‘blue sky’ projects without anticipated payoff horizon, or product or technology research projects that are in an early stage. In contrast, subsidiaries with an exploitative mandate have relatively more mature and stable projects, relating to existing products and technology. Based on our interviews with top managers at SAP, we coded the mandate for each subsidiary-year as two dichotomous variables i.e. presence of exploitative R&D mandate, and presence of explorative R&D mandate.

Table 2.2: Overview of the subsidiary mandates

Mandate	Project attributes	Location attributes	Typical performance indicators	Typical quotes from executives
Exploitative	<p>Presence of R&D topics that were initially developed in other subsidiaries and were subsequently relocated. Key terms used in this context are hand-over, localisation, integrations, and building on core/stable products, and maintenance.</p> <p>These topics were described to have strict delivery road maps, characterised by long periods of knowledge transfer, quality management, testing or maintenance.</p>	<p>The subsidiary was set up organically (as opposed to an acquisition) and the reasons of founding were observed as availability of low cost talent in large numbers, overlap of normal working hours with the HQ, or common communication language.</p>	<p>The subsidiary's performance is likely to be measured by the following metrics: fully loaded cost per developer, attrition/turnover, project delivery timelines, and quality of products.</p>	<p><i>“The entire [Product P] is now developed from this location”</i></p> <p>Product P is a mature and stable product. Its largest market is the US. It was conceived and initially developed in other subsidiaries and the responsibility for future incremental releases and maintenance was later transferred to this subsidiary.</p>

Explorative	<p>Presence of topics that are at the early stages of research, including prototyping and market testing.</p> <p>Key terms used in this context are next generation, design, prototypes, demos, and future technology.</p> <p>These topics also have delivery timelines but the focus is more on building the ‘latest’ and ‘greatest’ products for the future rather than sticking to a deadline.</p>	<p>The subsidiary was acquired and the reasons for founding were observed as presence of partners, key customers or specific technical experts (start-ups) or academic research centres.</p> <p>The subsidiary was established in spite of it relatively high cost. Typically 3–4 times more than exploitative subsidiaries.</p>	<p>The subsidiary’s performance is likely to be measured by the following metrics:</p> <p>Innovations in the development of new products, technologies, design that generates new revenue opportunities, and product launches.</p>	<p><i>“We want to build the latest and greatest cutting edge technology”</i></p> <p>The team was working on a new UI technology that would be used by other teams in the future.</p> <p><i>“We are in investment mode now. It’s not revenue generating – yet!”</i></p> <p>Indicates that this project is in an early stage of research.</p>
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While the mandate of a subsidiary remained mostly constant in our study period, in a few cases we observed a change in the mandate. This happened for two reasons. First, due to acquisitions that had substantial impact on the company. For example, a Canadian acquisition that was eight times the size (by headcount) of the existing local subsidiary led to the introduction of new exploratory projects. Second, management concluding that changes in the external local environment of the subsidiary required mandate change. Modification in a subsidiary's mandate due to external environment was coded when the firm set up a special programme to initiate the change. For example, the firm introduced an exploration mandate in the R&D centre in China by announcing a multimillion dollar investment package to develop products in China for the Chinese market, by outlining its intention of working closely with local partners.

Control variables: We collected data on the following four control variables: size, collaboration with HQ, number of acquisitions, and age of the subsidiary.

Size: Previous research suggests that organisational size strongly influences innovation (Damanpour, 1992). We, therefore, used the size of the subsidiary as a control variable. The size of the subsidiary was measured by the average number of employees involved in R&D work in each subsidiary-year. Development headcount is a better estimate than R&D cost (which is often used in similar studies), as we found that the average cost per developer in a high cost location (e.g. US or Germany) can be up to four times the average cost per developer in a low cost location (e.g. Hungary or India).

Collaboration with the HQ: Scholars such as Hansen (1999) and Tsai (2001) have proposed that a unit's position and ties with the key source of internal knowledge may also influence its access to knowledge and therefore its innovative output. In a multinational R&D Network, the HQ is the primary source of internal knowledge and a tradition of collaboration

with the HQ is likely to give the subsidiary more access to the HQ's knowledge pool. The collaboration with the HQ was measured as the percentage of joint patent applications between the subsidiary and the HQ. A higher percentage of joint patent applications indicate a stronger link with the HQ.

Number of acquisitions: Acquisitions can be a major source of new knowledge in a subsidiary. We count the number instances for each subsidiary-year where an acquisition valued over US\$100 million was integrated.

Age of the subsidiary: Scholars such as Autio, Sapienza, and Almeida (2000) have suggested that age is a key determinant of an unit's ability to acquire knowledge. Therefore, we introduce age; measured as the number of years a subsidiary has been operational, as a control variable.

2.5.3 ANALYSIS

Since our dependent variable is a count of patent applications, we use a panel negative binomial regression model with fixed effects (Cameron & Trivedi, 2013). A negative binomial model is suitable for count data as it ensures that the zero values of the dependent variables are not truncated. Furthermore, the negative binomial regression model is better than a Poisson regression model in this context as the variance of the dependent variable is more than the mean. Such a technique is common for patent count studies (Lahiri, 2010). A panel data model within the same organisation enables us to effectively study variables that change over time but remain the same across subsidiaries. In our model, we assume that something (unobserved) within the subsidiary may impact or bias the dependent variables and we need to control for this. A fixed effect model removes the effect of those time-invariant characteristics so we can assess the independent variable's net effect.

Results: The descriptive statistics and correlation table (Table 2.3) show that as expected both internal and external AC routines are positively correlated with the innovative output of the subsidiaries. The control variables - age of the subsidiary, number of acquisitions, and the size of the subsidiary, are all positively correlated with the dependent variable. This supports our choice of controls. The correlation table also points to the relative adoption of internal and external AC routines by subsidiaries with exploitative and explorative mandate. For instance, we find that subsidiaries with a mandate for exploitative innovation are more likely to adopt internal AC practices and subsidiaries that have explorative R&D mandates are more likely to adopt external AC routines. This suggests that subsidiaries try to align AC routines to the mandate. Another interesting observation that can be seen from the descriptive statistics is that the collaboration with the HQ is positive in subsidiaries with an exploitative R&D mandate, whereas it is negative in subsidiaries with an explorative mandate.

In model 2 of the regression table (Table 2.4) we find that the introduction of internal and external AC routines improves the units' innovative output. This provides empirical evidence to show that the incidence of technological innovation is positively affected by the build-up of AC, through the introduction of AC routines. Next, we take a closer look at how this overall impact can be understood as an interaction of the AC routines and organisational mandates. In model 4 we find support for all our hypotheses of the interaction model. We find that the impact of the internal AC routine is boosted by the presence of an exploitative R&D mandate, while the introduction of internal AC routines in a unit with an explorative mandate, negatively impacts its inventive outcome. Similarly, the introduction of external AC routines in a unit with an explorative R&D mandate boosts its inventive outcome and has a negative impact when the unit has an exploitative R&D mandate. However in the full model i.e. model 5 we get support for only two of our four hypotheses for internal and external AC routines in the subsidiaries with an exploitation mandate.

Table 2.3: Descriptive statistics and correlations

	Variable	Mean	Std. Dev.	Min	Max	1	2	3	4	5	6	7	8
	Subsidiary's												
1	Innovative output	15.18	23.78	0	151								
2	Internal AC routines	0.96	0.74	0	3	0.210+							
3	External AC routines	1.41	1.04	0	3	0.336***	0.229***						
4	Exploitation mandate	0.33	0.47	0	1	-0.099	0.253***	-0.522***					
5	Exploration mandate	0.73	0.45	0	1	0.0815	-0.081	0.744**	-0.838***				
6	Age of the subsidiary	6.56	4.51	1	34	0.402***	0.522***	0.559***	-0.135	0.297***			
7	Collaboration with HQ	29.94	32.16	0	100	0.046	0.033	-0.082	0.331***	-0.288***	-0.134		
8	Number of acquisitions	0.16	0.48	0	4	0.384***	0.201*	0.262**	-0.050	0.086	0.267***	-0.027	
9	Size of subsidiary (log of headcount)	5.29	1.35	0	7.6	0.482***	0.423***	0.144	0.324***	-0.182*	0.492***	0.108	0.316***

Sample size 14 subsidiaries, 128 subsidiary-year observations

*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Table 2.4: Results of a panel negative binomial fixed effects regression for subsidiary's innovative output

Dependant variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Subsidiary's innovative output	Intercept	Only AC routines	Only Mandates	Interaction model	Full model
Internal AC routines		0.234* (-0.124)			-0.432 (0.391)
External AC routines		0.323*** (-0.100)			1.473*** (0.391)
Exploitation Mandate			-0.279 (0.329)		0.056 (0.763)
Exploration Mandate			0.215 (0.263)		0.053 (0.932)
Internal AC routines *					
Exploitation mandate H 1(a)				0.629*** (0.162)	1.034*** (0.309)
Internal AC routines *					
Exploration mandate H 1(b)				-0.305*** (0.150)	0.042 (0.343)
External AC routines *					
Exploitation mandate H 2(a)				-0.587** (0.277)	-1.202*** (0.326)
External AC routines *					
Exploration mandate H 2(b)				0.791*** (0.278)	-0.194 (0.312)
Age of the subsidiary	0.103 (0.074)	-0.005 (0.083)	0.076 (0.0790)	0.096 (0.117)	0.018 (0.108)
Collaboration with HQ	0.005** (0.002)	0.004* (0.002)	0.005* (0.002)	0.001 (0.003)	0.002 (0.003)
Number of acquisitions	-0.008 (0.076)	-0.017 (0.073)	-0.018 (0.078)	0.033 (0.062)	0.032 (0.054)
Size of subsidiary (log of headcount)					
Constant	0.469*** (0.123)	0.500*** (0.123)	0.473*** (0.122)	0.363*** (0.126)	0.375** (0.124)
Year dummies	-3.396*** (0.889)	-3.531*** (0.901)	-3.457*** (0.934)	-2.763*** (0.808)	-2.627* (1.249)
Subsidiary FE	Yes	Yes	Yes	Yes	Yes
Log likelihood	Yes	Yes	Yes	Yes	Yes
Wald Chi2	-305.999 120.38***	-299.651 136.91***	-305.116 119.07***	-293.707 231.56***	-281.967 307.10***
Degrees of freedom	14	16	16	18	22
Observations	128	128	128	128	128
Number of subsidiaries	14	14	14	14	14

Standard errors in parentheses; year dummies calculated not shown

*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

2.6 DISCUSSION AND IMPLICATIONS

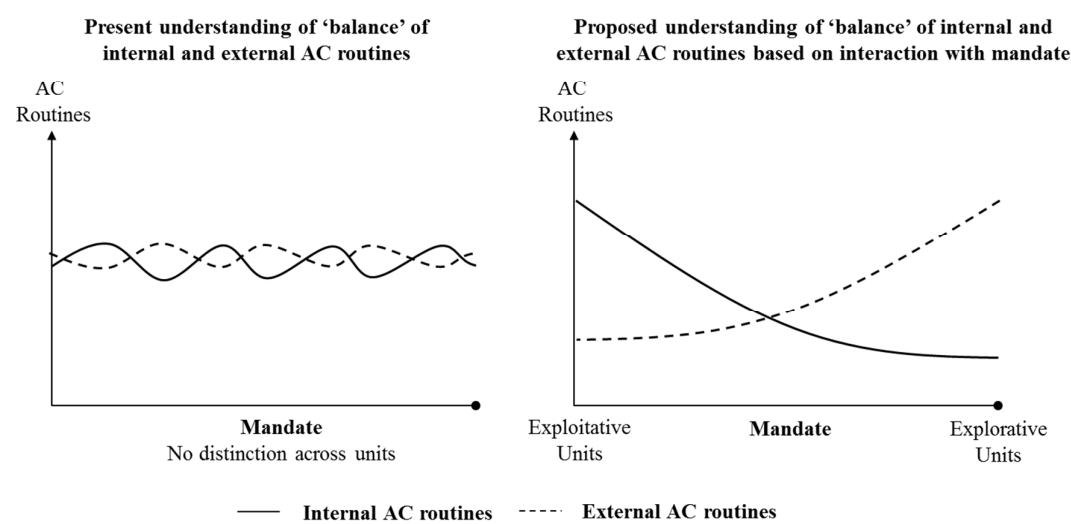
Directionally, there are two types of AC routines i.e. internal AC routines that enable the flow of internal knowledge to different units and external AC routines that enable the flow of external knowledge into the organisation (Lewin et al., 2011). Scholars suggests that organisations would benefit most from a ‘balanced’ adoption of internal and external AC routines (Cohen & Levinthal, 1990; Lewin et al., 2011). This study develops a deeper understanding of how the balance between internal and external AC routines is skewed, based on an interaction with the R&D mandate.

We argue that management teams often rely on a ‘dominant logic’ (Bettis & Prahalad, 1995) to organise R&D. This ‘dominant logic’ aligns the attention of managers to the firm’s innovation objectives. This allows the management team to assign R&D mandates to units without getting into the full complexity of execution. Therefore, the mandate focuses the unit’s attention on internal or external knowledge, while the AC routines provide the mechanism to access it. Even though some scholars have indicated that organisational antecedents matter in the realising the potential from AC (Jansen, Van Den Bosch, & Volberda, 2005; Volberda et al., 2010), hardly any scholarly work has explored the effect of alignment or misalignment of AC routines at the micro level with the organisation’s R&D mandate at the macro level. Our research aims to address this gap by proposing that the R&D mandate of an organisational unit is a key determinant of the effectiveness of AC routines in promoting or inhibiting innovative output.

Implications for research on absorptive capacity routines: We see our study as having three key implications for the research on AC routines. First, we provide evidence to show that the introduction of internal and external AC routines positively impact innovative output in R&D subsidiaries. Second, and perhaps more significantly, we show that AC

routines do not work in isolation, but that the R&D mandate of an organisational unit determines impact of AC routines. And finally, we show that instances of misalignment between AC routines and R&D mandates can lead to dysfunctional innovation outcomes. Together, these implications add to our understanding of how firms *balance* the adoption of internal and external AC routines at the level of the organisational unit, based on its innovation mandate.

Fig 2.2: Balance of internal and external AC routines in the context of mandates



Using Lewin et al. (2011) typology of internal and external AC routines, our study is the first of its kind to provide evidence that the introduction of AC routines positively impacts innovative output. While many studies have highlighted the role of internal and external sources of knowledge, our longitudinal study design allowed us to study the mechanism i.e. the same set of AC routines that enable access to internal and external sources of knowledge.

Next, we show that the R&D mandate of an organisational unit is a key variable in our understanding of which AC routine is adopted, and how AC routines impact innovation? Evidence from prior research shows that AC routines are more likely to be adopted when

managers perceive them to be useful in meeting their R&D objectives. For instance, Allen, Lee, and Tushman (1980) found that when organisations pursue incremental innovations in existing products and processes, they adopt and benefit from good internal knowledge sharing practices. While Cardinal (2001), in a study of pharmaceutical firms, found that projects that had an objective to pursue innovations on novel technological trajectories were more likely to tap external knowledge sources. This observation is also reflected in our interview data. For example, a senior vice president in R&D pointed out the essential role of internal AC routines in subsidiaries with the mandate to maintain existing products:

“We have some labs with a pure maintenance focus ... [standard X] makes sure that we keep a common development standard across this network [of R&D labs doing maintenance]”

On the other hand, some subsidiaries were built to connect with external clusters. In this case, external AC routines clearly enable this purpose. A development head recounted the underlying reasons for setting up a research centre in the Silicon Valley as:

“[A founder of the firm] moved to Palo Alto to setup a lab there ... our largest partners were American, North America was our biggest market ... we wanted to be part of the innovation from the Silicon Valley”

Finally, we show that the misalignment of internal AC routines and explorative R&D mandates can depress innovation outcomes. We propose that when internal AC routines are introduced in subsidiaries with an explorative mandate, managers do not always find them useful in meeting their primary objective to seek external knowledge. However, these internal AC routines are often imposed by corporate teams to ensure more effective diffusion of new knowledge throughout the organisation. As one senior executive at a unit with an explorative mandate points out:

“I encourage my developers to experiment. There are no rules here. We want to build the latest and greatest cutting edge technology... You will see this in the culture in everything we do. The way we work, our workspace, the tools ... everything.” He later adds *“Our strategy is to innovate on a stable core, which means that whatever innovations we bring must complement and not disrupt the core. It is very important that the customer’s landscape is not disrupted and that the end-user has a seamless experience... We have to follow the same development standards as everyone else.”*

These standardised processes are often perceived as ‘bureaucratic’ and may lead to *excessive standardisation of processes* in these subsidiaries. In a comparative case analysis Dougherty (1992) shows that internal AC routines can indeed impose strict standards that do not meet the requirements of new product development and form barriers to innovation. She goes on to point out that successful innovators often do not comply with non-value adding routines.

Misalignment can also happen when units with an exploitative R&D mandate adopt external AC routines. When the mandate of the organisational unit is to exploit existing knowledge, the introduction of external AC routines exposes the unit to new and often unrelated knowledge from outside the firm. This expands the knowledge pool available to the unit, albeit not productively, and leads to an *excessive diversification of the scope* of the unit. The adoption of external AC routines, especially by units with an exploitative mandate, is expensive. While it is uncommon for decision makers to invest in such routines in exploitative units, in our data we found that 13 out of 41 exploitative subsidiary-years had at least one active external AC routine. We believe that this misalignment is caused when

decision makers within the exploitative units (as opposed to the HQ's prerogative) adopt external AC routines. One explanation of why this could occur is offered by institutional theory, which argues that mimetic and normative mechanisms may lead to adoption of routines independent of the mandate of the subsidiary (DiMaggio & Powell, 1983; Meyer & Rowan, 1977; Scott, 1987). A mimetic mechanism operates when the subsidiary imitates routines from more successful subsidiaries (often labelled 'best-practice sharing'), whereas a normative mechanism operates when the subsidiary adopts routines that are viewed as appropriate for the type of environment by the local decision maker. In these cases, it is unlikely that the introduction of external AC routines will result in the unit gaining similar type of external knowledge as in the case of explorative units. Instead, the investment in these routines may develop the ecosystem for future exploration. In such instances, when the subsidiary invests in external AC routines, knowledge tends to flow outwards and local partners are the chief beneficiaries. As a Managing Director of an R&D centre with an exploitative mandate notes:

"We are here not just because of the cost and talent. We see great opportunities in this location for both the market and the partner ecosystem ... We want to develop our local ecosystem ... [by] training partners ... [by] training university students"

Limitations and future research: While this study provides a number of insights, it also has some limitations. First as our focus was to study the *same* AC routine, we purposefully selected a 'deeper' design and restricted our analysis to one large firm. Future studies may develop a 'wider' methodology by designing measures to compare similar routines across a larger sample of firms in the same industry. Second, we have assumed that all internal and external AC routines have the same magnitude. While this has greatly simplified our analysis,

a more nuanced analysis could explore the interaction of organisational mandates and specific routines. Finally, as many scholars have noted – the count of patents does not capture all innovative output and not all patents have the same potential of commercialisation. An examination of the impact and quality of inventions would further improve our understanding of this effect.

We believe that this study opens up a new area of research on the interaction of innovation strategy as R&D mandates and the mechanisms that build AC i.e. AC routines. Our results show that a misalignment of R&D mandate and directionality of the AC routines can reduce innovative activity. Further research is needed to understand the underlying causes of this misalignment. In particular, we need to know more about the micro level process by which agents in these locations search for new routines as well as the macro level processes that guide the diffusion of routines across firm boundaries.

In our analysis we have argued that absorptive capacity as a capability is built by the practice of absorptive capacity routines. This is in line with the literature on capabilities in general that argues organizational capabilities are built on routines or collection of routines (Nelson & Winter, 1982; Winter, 2003). This stream of literature from the capabilities tradition does not adequately deal with innovation that may come about from wide experimentation or serendipitous discoveries. However, the later can be understood through the lens of organizational slack. As our literature review indicates the relationship between slack and incidence of innovation is often treated as an inverted U i.e. too little or too much organizational slack is not conducive to innovation (Nohria & Gulati, 1996). Put differently, if ‘free time’ is considered to be a proxy for organizational slack then having no free time and having a lot of free time may not turn out to be conducive for innovation. However as many organizations such as 3M and Google point out giving employees some amount of free time

may improve inventive productivity. In essence AC, or AC built of AC routines is not necessarily the only predictor of inventive activities in an organization but there are clearly other variables that influence the incidence of innovation.

2.7 CONCLUSION

Current research on technological innovation in global firms with foreign R&D subsidiaries, is largely dominated by the knowledge-based view (Almeida & Phene, 2004; Lahiri, 2010; Monteiro, Arvidsson, & Birkinshaw, 2008; Phene & Almeida, 2008; Song, Asakawa, & Chu, 2011; Tallman & Phene, 2007). This stream of literature suggests that R&D productivity is influenced by the subsidiary's embeddedness in the internal knowledge context of the parent firm (i.e. HQ), and the external knowledge context of its location. While these studies have greatly added to our understanding of how knowledge flows impact innovation in subsidiaries at a macro level, they do not shed much light on the impact of intra-organisational attributes on innovation, largely because they assume that all subsidiaries in a firm have the same role to pursue innovation. However, as Almeida and Phene (2004: 860), have pointed out, subsidiary mandates vary, and to understand the R&D strategy of large global corporations, it is necessary to take account of "how different subsidiary strategies and roles impact innovation and evolution."

Our analysis suggests that R&D mandates are a central pillar in understating how various routines to access knowledge impact innovation. R&D mandates are usually consistent and tailored to minimize the subsidiary constraints and make the best of its capabilities. In some cases this means crafting an R&D mandate that builds on a subsidiary strengths for exploring new areas. In other instances, this means giving subsidiaries with a track record in established and well exploited technological areas, an R&D mandate that

makes the most of their cost effectiveness. Organisational units are more likely to be effective if top managers evaluate and align the strategies and roles of each subsidiary that reflect the location's history i.e. knowledge and skills with the adoption of suitable AC routines.

This essay provides new insight into how corporate innovation strategy at the macro level influences choices of adopting routines at the micro level. It also opens up new questions on a relatively micro-micro relation, which is, while we expect decision makers to choose a routine from an existing set of choices, when would they initiate search for a new routines? Put differently, what kind of structural constraints might trigger search for new routines?

3. INGENUITY AND THE CREATION OF NEW ROUTINES: EVIDENCE FROM LABORATORY EXPERIMENTS

3.1 INTRODUCTION

Ohno-San came by the Kyoto Plant about once a week for the next six months. He reminded us frequently and severely what we needed to do:

“Make do with the equipment you’ve got.”

“Don’t automate anything.”

“Don’t spend any money.”

“Limit your production output to the numbers in the sales plan.”

“Your costs will eat up all your profit if you don’t watch out, so don’t hire more people”

As soon as we complied with Ohno-San’s insistence on monitoring the pace of work cycles, he raised the stakes.

Michikazu Tanaka (Production manager at Toyota affiliate Daihatsu)

Excerpts from (Tanaka, 2009: 33)

Consider the following case of ingenuity at Daihatsu. Under pressure from Taiichi Ohno, production chief at Toyota, to ramp up production, and cut costs, but explicitly instructed not to use new technology, Michikazu Tanaka and his team at Daihatsu came up with the idea of placing speakers along the line and playing different musical tones at the end of each part of the production, to pace the line. This solution was soon incorporated as a

standard practice in all of Toyota's lean production systems and later adopted throughout the world of lean based automobile manufacturing units. In this essay we will take a closer look at what triggers agents to perceive new opportunities and search for qualitatively better routines. For instance, what triggered Michikazu Tanaka and his team at Daihatsu to search for new opportunities?

A rich tradition of research in innovation shows that some firms are able to innovate more than others, for example, larger firms (Damanpour, 1992), new entrants (Foster, 1986), or firms with access to greater resources and capabilities (Methe et al., 1997) and knowledge (Zhang & Li, 2010). But do these firms necessarily come up with better innovations? Many scholars of behavioural theory argue that innovation is not just a function of the so called measurable economic variables, such as investments in R&D, but it is also a result of relatively less measurable variables like managerial cognition of opportunities that influences managerial decision making. They propose that managers are not entirely rational when searching for opportunities to innovate, but in fact rely on their interpretation of available information to make strategic decisions. For instance, when it comes to investment decisions for new R&D projects, it is common knowledge that executives who project confidence in a new plan are more likely to get approval than the ones who project the risks and constraints of the plan. The behavioural perspective of how decision makers perceive opportunities is a central pillar in our understanding of why some firms innovate more and perhaps *better* than others.

We know that over time decision making in organisations become *routinized* and form predictable patterns. The use of routines in decision-making processes help agents to economise on cognitive effort of searching and focus on productivity gains from labour effort. For instance, if a decision maker finds that current sales in a region are lower than its

rival, she might follow the organisational routine, often based on past experiences, of allocating more resources (labour effort) to promote short-term sales in that region over a long-term investment. Such a reallocation of resources may indeed come as a result of a routine that helps to answer “how to choose” questions.

In reality however, these choices are not static, but evolve by the variation, selection, and retention of underlying routines by decision makers as they respond to *new problems* (Nelson & Winter, 1982). Organisations often confront new problems when there is a ‘mismatch’ between available resources and desired outcome. These circumstances arise when organisations face reduced resource availability, for instance due to external supply shock, or a shift in desired outcome that may be among other things due to new regulations or changing competitive conditions, or financial constraints. Under these circumstances, decision makers are often forced to choose between lowering their aspiration, searching for new opportunities, or rethinking their existing routines.

In this essay we look at the third option. Specifically, we argue that when organisations are neither able to obtain more resources, nor willing to compromise on their aspiration, they will turn their attention to internal production and management processes. This focussing of attention on internal processes may result in attempts to pressure employees to economise on the use of existing resources or accelerate production processes. In some situations, employees may push hard to meet these targets without questioning existing methods and practices (i.e. apply more labour effort/ work harder), but in others their observation and analysis of production processes may lead them to ‘see’ better ways of arriving at the desired targets (i.e. apply cognitive effort to search/ work smarter). Such insights are often at the origins of new practices and our aim to understand what triggers some decision makers to search for better routines.

Aspiration and constraints may focus the attention of agents (at the micro level) to search for new and better routines to improve productivity. We argue that under normal conditions, an agent's familiarity with the routines of a task helps them to economise on the cognitive effort of search and focus attention on performance improvement through labour effort, when such labour effort is available i.e. apply more resources using known techniques. However, under sufficiently high aspiration and resource constraints, the routines can be rendered ineffective, thereby framing agents to search for better routines through cognitive effort. We design two experiments to test the relationship between high aspiration from competitive pressure and performance through the increase in labour effort (apply known solutions) and cognitive effort (search for new solutions) in repeated task and a novel task. Our results show that agents are more likely to discover new routines under high aspiration and resource constraints.

3.2 MICRO-FOUNDATIONS OF SEARCH FOR NEW ROUTINES

At the heart of the organisational ingenuity discussion (Lampel et al., 2014) lies the argument – How do agents frame problems under constraints?¹¹ For instance, when placed under constraints do they problematize the lack of resources, idiosyncratic environmental conditions, or would they problematize internal processes i.e. the way a particular objective can be achieved. The latter option, of framing the problem as not having the right internal processes or routines, then triggers cognitive effort in searching for a better routine.

¹¹ For details see the special issue on Organisational Ingenuity in Organisation Studies and the edited volume Handbook Of Organisational And Entrepreneurial Ingenuity.

Lampel, J., Honig, B., & Drori, I. 2014. Organisational Ingenuity: Concept, Processes and Strategies. *Organisation Studies*, 35(4): 465-482.

Honig, B., Lampel, J., & Drori, I. (Eds.). 2014. *Handbook Of Organisational And Entrepreneurial Ingenuity*: Edward Elgar.

In this essay we are interested in understanding if agents rely on labour effort i.e. apply known solutions with more resources or cognitive effort i.e. search for ingenious solutions to improve performance under high aspiration set by competitive pressure while performing (a) a repeated task and (b) a novel task. We argue that while there is a large body of evidence to show that cognitive effort suffers under pressure; there is still a possibility that high competitive pressure may trigger cognitive effort in questioning implicit and explicit routine assumptions that might otherwise limit performance.

A repeated task, much like any real-world production task, is characterized by *routines* that form production techniques (Nelson & Winter, 1982). As agents involved in the execution of a repeated task gain experience, they become more proficient with the underlying routines, leading to increasing productivity at a decreasing rate, as observed in various industries from semiconductor production (Gruber, 1994) to pizza production (Darr, Argote, & Epple, 1995). The use of routines acts like decision-rules that help agents to economise on the cognitive effort and focus their attention on labour effort. Put differently, once the routines involved in executing a repeated task are established, agents know ‘how to do’ the task and apply labour effort to meet the production targets. In such a scenario, increasing competitive pressure may first induce agents to apply more labour effort to improve performance, indicating a *preference* for labour effort, but sufficiently high competitive pressure may also trigger agents to question the underlying routines and increase cognitive effort to search for better routines. This indicates the existence of a possibility that under competitive pressure, agents may apply more cognitive effort to search for better routines to improve productivity at repeated tasks.

On the other hand when agents are presented with novel tasks (e.g. problem solving) they do not have the answers to ‘how to do’ questions. In such cases agents depend heavily

on their working memory, which is an indication of cognitive effort, to find solutions. However, evidence from both psychology and behavioural economics dealing with work effort and performance under pressure, suggests that performance at cognitive tasks is negatively associated with pressure, often leading to either poor performance i.e. ‘choking under pressure’ or an avoidance of tasks that involve ‘thinking’ (Beilock & Carr, 2001; Beilock, Kulp, Holt, & Carr, 2004; Bracha & Fershtman, 2013). Beilock and Carr (2005) offer a psychological explanation that argues increasing performance pressure consumes an agents working memory capacity that is required for superior performance in cognitive tasks such as solving mathematical problems. We propose that in certain novel tasks, superior performance may also be achieved by reframing of the problem. While under low competitive pressure the cognitive effort applied in search for solutions is bound by the implicit assumptions about how the problem is framed by the agent, a sufficiently high competitive pressure may trigger agents to question theses underlying assumptions. We aim to test if high aspiration, set by high competitive pressure, is likely to trigger a ‘framing effect’ that directs cognitive effort to question the explicit and implicit assumptions in the search for solutions. Our hypotheses are based on the argument that – While it may be difficult to think under pressure, can sufficiently high competitive pressure trigger agents to think differently!

We test these hypotheses using two experiments based on three common design principles. First, we use competitive pressure, as opposed to financial incentives, to induce increase in work effort. Research shows that agents improve performance in repeated tasks when they are presented with incentives (Hossain & List, 2012) as well as competitive pressures (Kuhnen & Tymula, 2012). While incentives appeals to the agents desire for a larger financial reward for performance, competitive pressures appeal to the agents’ self-esteem and the desire of not falling behind peers. Recent evidence, from laboratory

experiments (Tafkov, 2013) to field observations in various sectors from financial services (Gino & Staats, 2011) to charities (Ariely, Bracha, & Meier, 2009), shows that competitive pressures can be a stronger trigger for increased work effort to achieve higher performance. Researchers go on to argue that small financial rewards for performance may in fact have a detrimental effect on increased effort (Gneezy & Rey-Biel, 2014), as agents may perceive accepting financial reward to work harder dilutes their social image amongst peers (Ariely et al., 2009). As we use laboratory experiments, in which we could only offer small financial rewards to the participants, we decided not to use any financial incentives for performance but rely only on competitive pressure to increase work effort (Gneezy & Rustichini, 2000).

Second, we assume that when agents increase work effort, they can choose to increase both labour effort and cognitive effort, as there is no apparent trade-off (Kocher & Sutter, 2006). Furthermore, our tasks are designed in such a way so as to eliminate any possible conflict between the two efforts. The repeated task, just like real-world production activities, is punctuated by gaps where agents are not engaged in any production activity that requires labour effort. In such cases, the increase in cognitive effort would be applied in-between the production activities and observed in the changes implemented in the production activity (e.g. redesigning routines), where as any increase in pure labour effort would be observed in the execution of the production activity (e.g. working faster with the same routines). Similarly, the novel task, much like real-world tasks that have a clear mandate for inventions, requires the agents to find a new solution that indicates application of cognitive effort. Agents may also choose to solve the problem using purely labour effort (e.g. random trial and error) however, the chance of success with such an approach is quite low and unlikely to be pursued. We discuss the tasks in detail in the experiment section.

Third, we run our experiment in teams, for two reasons. First, this is to come closer to the real-world scenarios where most tasks, both repeated and novel, are executed in teams. Even lab experiments involving organisational routines in repeated tasks, are often designed around teams of agents working towards the same objective (Cohen & Bacdayan, 1994). Second, as we do not use any financial incentives to induce work effort, we are keen to reduce the noise from individual motivation issues. In a recent study Mas and Moretti (2009) present evidence to show that individual agents are likely to increase work effort to perform well when they work with co-workers.

In the following sections we present and then discuss the evidence from two laboratory experiments to show that in repeated tasks under low competitive pressure, agents are more likely to rely on known techniques and labour effort to improve performance. However, under high competitive pressure, agents increase cognitive effort and search for new techniques to improve performance. In novel tasks, where participants must rely on cognitive effort to perform, groups under high competitive pressure are more likely to apply cognitive effort to question implicit assumptions in their search for novel solutions. These results indicate that the presence of suitably high competitive pressure may *frame* agents to apply increased cognitive effort i.e. work smarter by questioning explicit and implicit routine assumptions that might otherwise limit performance. We conclude by discussing the implications of these results on our understanding of when agents choose to increase labour effort and cognitive effort as well as on the design of tasks used in laboratory experiments.

3.3 EXPERIMENT 1: USING A REPEATED TASK

Our first experiment uses a repeated task to test the relationship between competitive pressure and performance through increased work effort. In repeated tasks, agents rely on implicit and

explicit routines that store procedural knowledge that enable them to perform the task repeatedly, without rethinking about the procedural logic over and over again (Cohen & Bacdayan, 1994). Therefore, the use of established routines economises on the cognitive effort needed to execute the task, but focuses the agent's attention on productivity improvements through increased labour effort. However, a sufficiently high competitive pressure may trigger agents to question the underlying routines and search for better techniques, indicating an increase in cognitive effort. Our hypotheses for repeated tasks are:

H1: In repeated tasks

(a) Under low competitive pressure, agents are more likely to increase labour effort over cognitive effort to improve performance

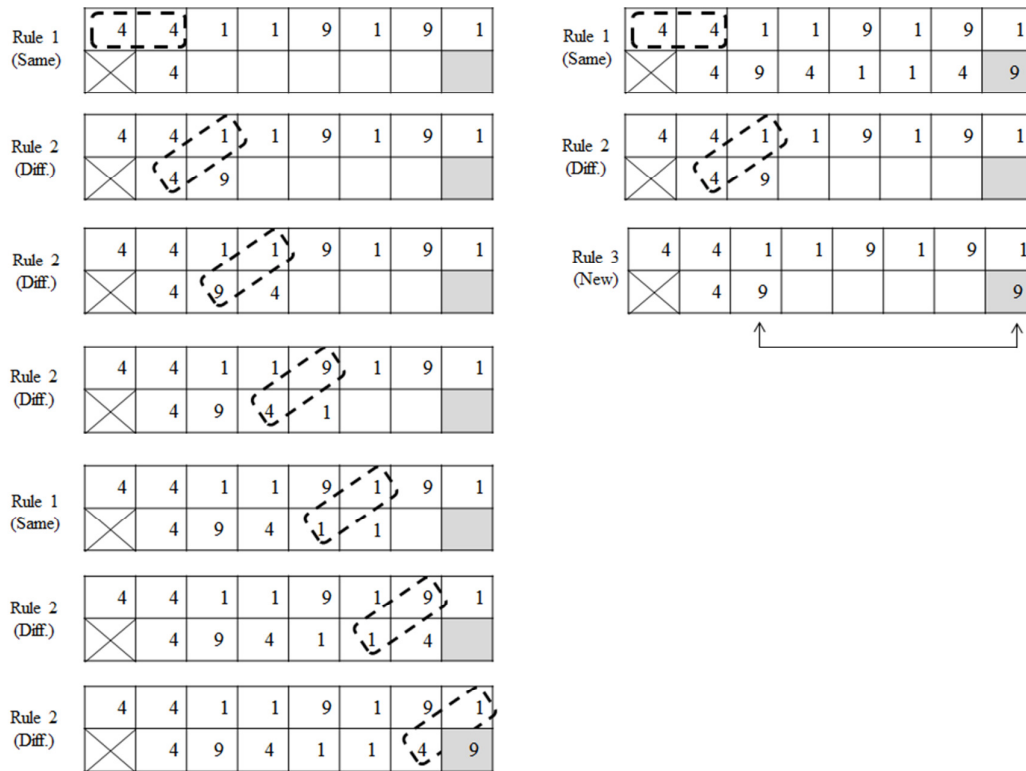
(b) High competitive pressure is likely to induce agents to increase cognitive effort to find new techniques for improving performance

3.3.1 REPEATED TASK

The repeated task used in experiment 1 is an adaptation of a Number Reduction Task (NRT) (Wagner, Gais, Haider, Verleger, & Born, 2004). The objective of the task is to generate solutions for a series of NRTs using certain decision rules that act like routine production techniques. In this task, groups of participants can choose to complete the task through labour effort, using the knowledge of the rules already given to them (i.e. working harder), or by more labour and cognitive effort by creating new knowledge and applying new rules (i.e. working smarter).

Fig 3.1 The two ways of solving a NRT

(i) Left side shows how to solve the NRT by sequentially executing the task using the two known rules (ii) Right side shows how to solve the NRT by using the two known rules and by creating a third new rule



The stated objective of each Number Reduction Task (NRT) is to find the 'last number' of a sequence from a given sequence. Each NRT comprises of the digits '1', '4', and '9'.

Participants can find the last number by sequentially processing the digits pairwise from left to right, according to two simple rules that are (i) the 'same rule', which states that the result of two identical digits is the same digit (for example, '4' and '4' results in '4', as shown in the first response in Fig 3.1). (ii) The 'different rule', which states that the result of two non-identical digits is the remaining third digit of this three-digit system (for example, '1' and '4'

results in '9' as shown in the second response Fig 3.1). After the first response, comparisons are made between the preceding result and the next digit. The seventh response indicates the last number of the new sequence. Instructions given to the participants stated that only the last number was to be determined and this can be done at any time.

What is not mentioned to the participants is that the NRT sequences were generated in such a way that the last three responses of the new sequence always mirrored the previous three responses. This implies that in every NRT, the second response coincides with the last response. In the example,, it is '9' as shown by the arrow in Fig 3.1. Teams that gain insight into this hidden rule abruptly cut short the sequential process by identifying the solution immediately after the second response. Right panel of Fig. 3.1 illustrates the two possible ways of solving the NRT (i) Using the two decision rules that are part of the initial briefing and (ii) Using the two decision rules and creating a third new rule; based on the insight that second and last number of the new sequence are always the same. Using the third hidden rule, participants can solve each NRT in three steps as opposed to the usual seven steps, thereby improving their productivity by at least two-folds.

3.3.2 PROCEDURE

The experiment was run with participants at three executive education workshops. We followed the recommendations of designing extra-laboratory experiments to collect data from classroom participants (Charness, Gneezy, & Kuhn, 2013; Loyd, Kern, & Thompson, 2005). The exercise was used as an introductory exercise in workshops on break-through thinking in 2012 and 2013. Over the three cohorts, 33 groups with six participants in each group i.e. 198 individuals participated in the exercise. We had four groups with less than six participants whose response has not been counted in this study. The average age of the participants was

35 years with an average work experience of 11 years and 24% of the participants were women. The participants were randomly pre-assigned to 33 groups as was the experiment condition. Participants were informed that data collected during the exercise would be used in research, it is anonymous at the individual level, and that their participation in the exercise is voluntary. Summary statistics from the exercise was shared and discussed with the participants during the course of the workshop.

When the participants assembled in the class they were given the same initial briefing. This included the briefing for informed consent, introduction to the NRT, a practice round with five NRTs to ensure that everyone was aware of how to apply the two rules to solve the NRT and logistical information. Each group was told that they would be given 70 NRT sequences and their team's performance would be measured by the number of sequences they correctly solve in 60 seconds. They had to agree on a target for their team and an overall approach to meet whatever target they set out to achieve. They were informed that the task would be repeated three times and at the end of each round they would be given feedback on their performance. They were also told that there would be a ten-minute break, in-between rounds, during which they would have to respond to a short survey and that they were free to use the rest of the time to rethink their strategy if needed. During the course of the exercise they were told not to communicate with the 'outside world' and stay in their assigned room. The teams were then assigned separate rooms with a moderator assigned to each room.

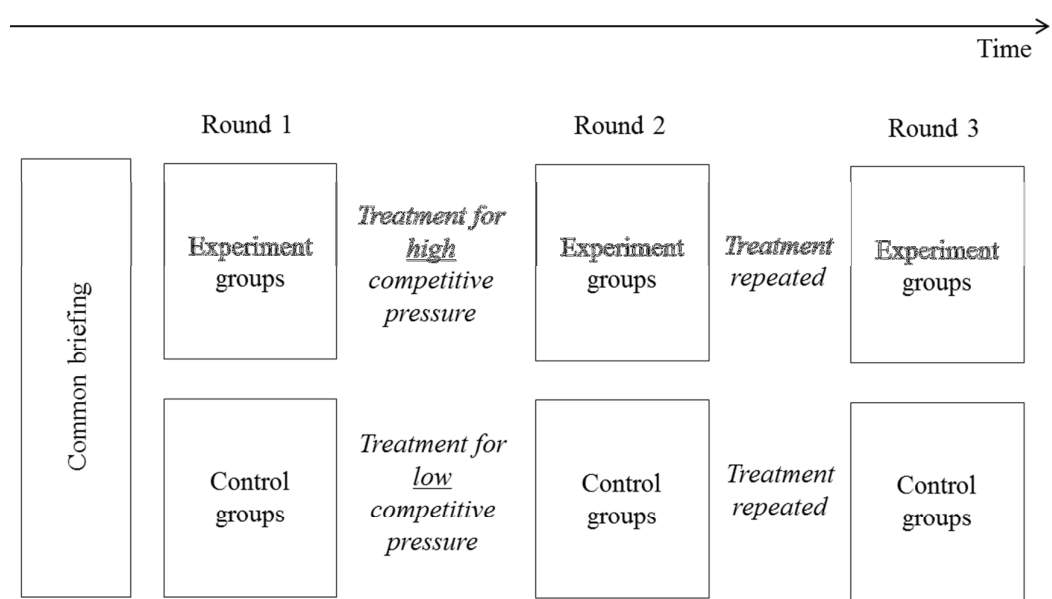
At the end of every round, the groups were asked to fill out a short survey to capture their response to the task on stress, perceived self-confidence, and perceived importance of the goal. Stress was measured using an adapted three item scale ($\alpha = 0.91$) used by Bowman and Wittenbaum (2012) to measure stress felt by participants, after they have participated in a group exercise to execute a task under time pressure. Perceived self-confidence at the given

task was measured by an adapted three item scale ($\alpha = 0.70$) used by Anderson (2004), while perceived importance of the goal was measured by a three item scale ($\alpha = 0.61$) that was adapted from Butler (1993). Participants rated each item on a seven point scale (1 = Not at all true to 7 = Very true).

3.3.3 COMPETITIVE PRESSURE TO SET HIGH ASPIRATION

In this task, time (i.e. 60 seconds in each round) and labour (i.e. six participants per team) serve as constraints in resources while competitive pressure is manipulated by providing performance feedback (Lant, 1992). Regardless of the group’s actual performance, at the conclusion of round 1 and 2, the control groups were informed that their performance was “very good compared to the other groups” whereas the experiment groups were informed that their performance was “very poor as most other groups had solved all 70 sequences”. Fig 3.2 summarises the overall design of the experiment.

Fig 3.2: Experimental design for repeated task



3.3.4 OBSERVATIONS

Observation 1 (a): Fig 3.3 shows that the performance of the control groups (i.e. groups with low competitive pressure) improved over the three rounds. Table 3.1 shows that only 28% of these groups gained insight into the hidden rule, indicating that a majority of the groups relied solely on labour effort to improve performance.

Observation 1 (b): From Fig 3.3 we find that the experiment groups (i.e. groups with high competitive pressure) performed better than the control groups and Table 3.1 shows that this is because 87% of the experiment groups found the insight into the hidden rule. This indicates that the experiment groups applied more cognitive effort to search for a better technique to meet the competitive pressure. The stock lines of the experiment group indicate that the variance in performance amongst the experiment groups was lower compared to the control groups.

Fig 3.3: Performance of control and experiment groups

Bars indicate the mean performance and the stock lines represent the maximum, 75th percentile, 25th percentile, and minimum values within a group. N = 18 for control groups and N = 15 for experiment groups

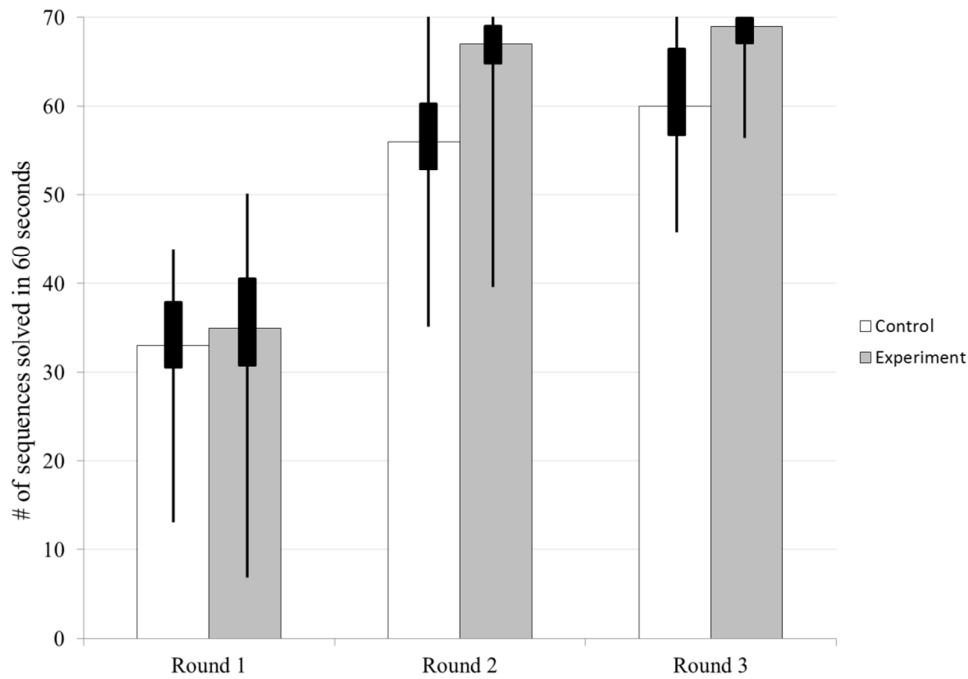


Table 3.1: Evidence of cognitive effort as observed in the discovery of the new, hidden rule in experiment and control groups

Condition	Total	No	Yes	Success rate
Experiment groups: High competitive pressure	15	2	13	87%
Control groups: Low competitive pressure	18	13	5	28%
Total Observations	33	15	18	

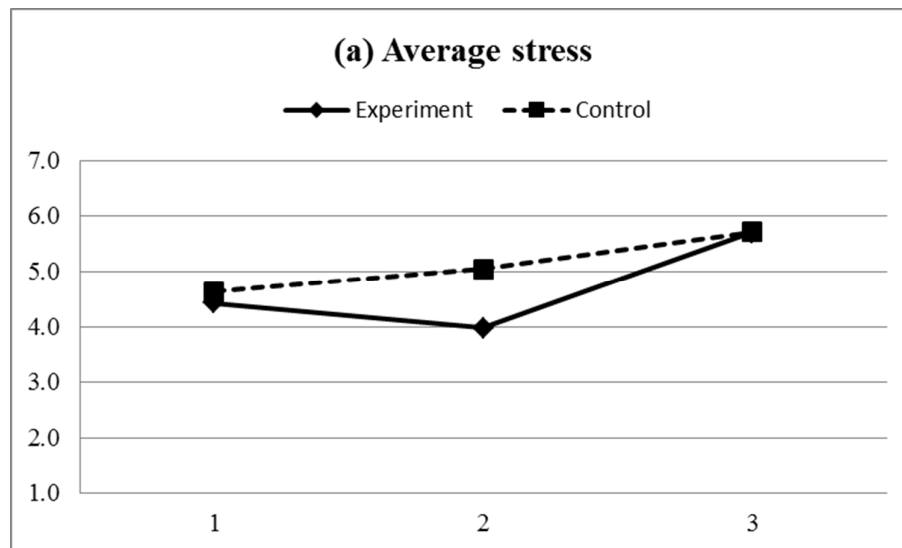
$$\chi^2 = 11.444^{***}$$

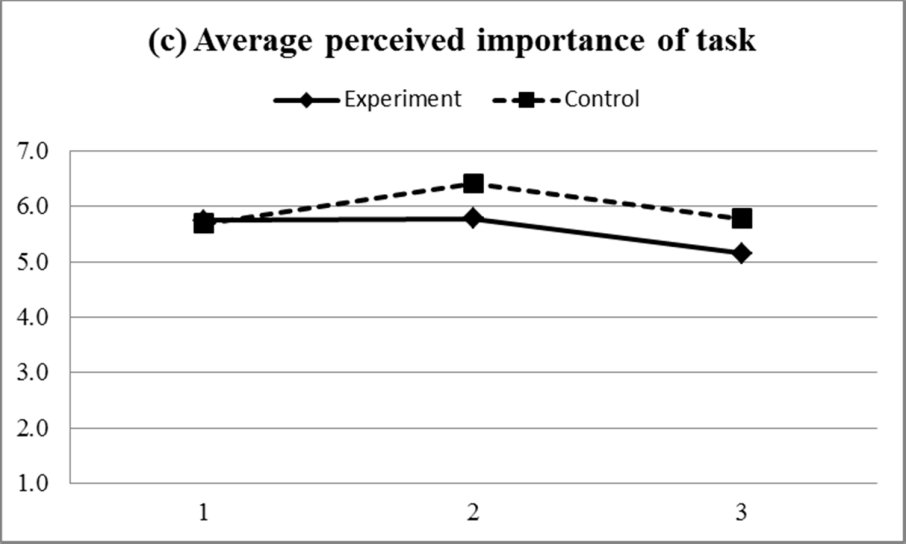
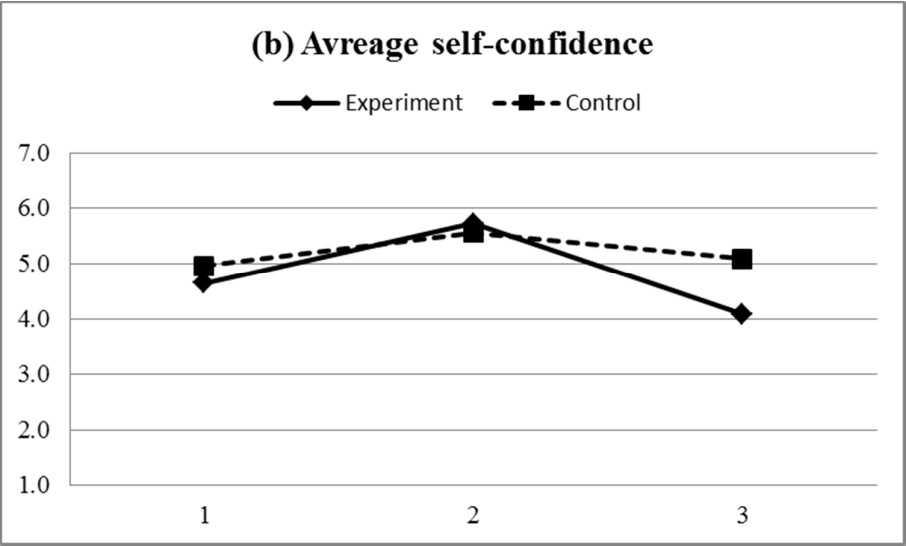
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Figs 3.4 (a) (b) and (c) show the average stress, self-confidence and perceived importance of the task, over the three rounds, for the two groups. We observe that after the second round, when most experiment groups had found the hidden rule, the average stress dropped and self-confidence increased. Surprisingly, however, the average stress shot up and self-confidence dropped in the final round. In a discussion with the participants after the results were shared, we learnt that in the final round the participants of the experiment groups were aiming for a perfect score (i.e. all correct NRTs) that caused a build-up of stress while undermining their confidence as they were not sure that they can avoid inadvertent errors under stress. The average perceived importance of the task was high and remained so throughout the three rounds for both the groups.

Fig 3.4: Representation of the data collected from a survey of the participants

(See appendix 8.4)





3.4 EXPERIMENT 2: USING A NOVEL TASK

Our second experiment uses a novel task where agents must rely on cognitive effort to perform. In this experiment, we investigate if suitably high competitive pressure can induce agents to question the implicit routine assumptions within which they search for solutions.

Our hypothesis for the novel task is:

H2: In novel tasks,

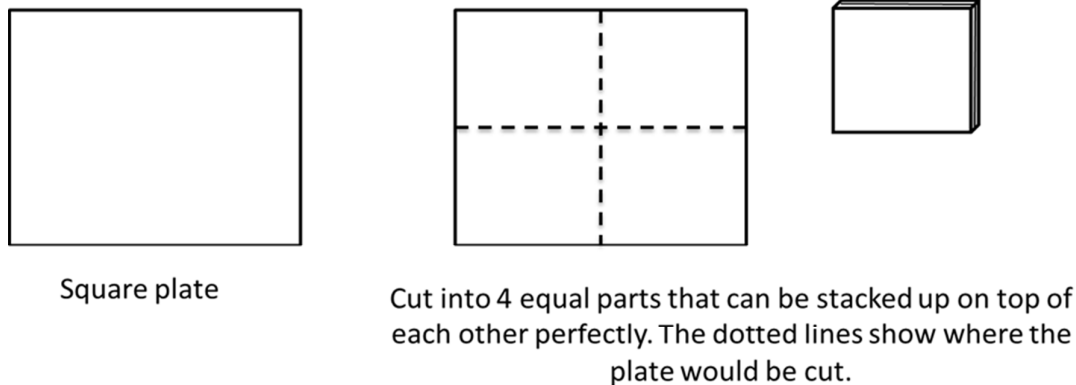
(i) Compared to low competitive pressure, high competitive pressure is more likely to induce agents to apply increased cognitive effort in questioning routine assumptions in search for solutions

3.4.1 NOVEL TASK

The novel task used in experiment 2 is a problem solving task. Fig 3.5 describes the instructions given to the participants. The stated performance objective of the task is to find as many unique solutions as possible in ten minutes.

Fig 3.5: Novel task description

You are part of an engineering team at a manufacturing firm. Your task today is to find different ways to cut a square metal plate into four equal parts such that the four pieces can be stacked up on top of each other perfectly. Slicing on the thin edge is not possible and no waste is allowed! For example, the dotted lines in the following diagram show one way to cut the metal plate into four equal parts.



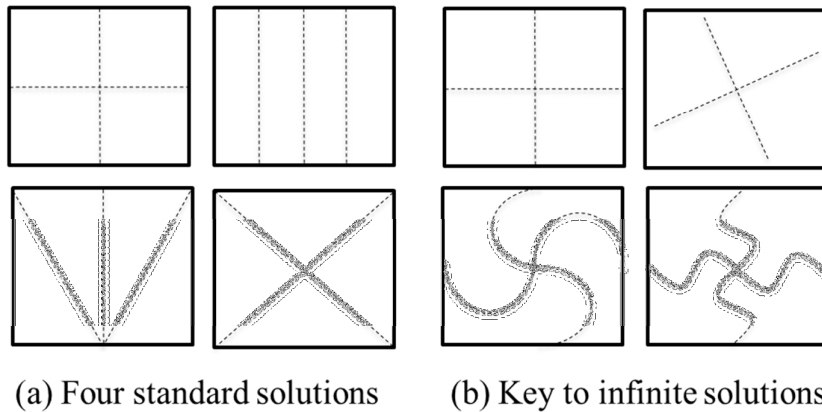
Your objective is to find as many unique solutions as possible in ten minutes.

Instruction given only to the control groups: Most teams typically find eight solutions (i.e. eight unique ways to cut the square metal piece) to this problem.

Instruction given only to the experiment groups: Most teams typically find hundreds of different solutions (i.e. 100+ unique ways to cut the square metal piece) to this problem.

The novel task has two solution states. Most groups are able to find the four standard solutions as shown in Fig 3.6 (a). Any variants of these solutions are not considered as unique solutions. However, Fig 3.6 (b) shows the possibility of generating infinitely many unique solutions once agents are able to see through the implicit assumptions and realise that the cuts do not have to start and end from key points (e.g. corners or midpoints) or that the cuts do not have to be in straight lines.

Fig 3.6: Solutions to the novel task



3.4.2 PROCEDURE

The experiment was run with participants at an MBA workshop on innovative thinking. As in experiment 1, we followed the recommendations of designing extra-laboratory experiments to collect data from classroom participants (Charness et al., 2013; Loyd et al., 2005). Twenty groups with six participants in each group i.e. 120 individuals participated in the exercise. Results of groups with less than six participants have not been counted in this study. The average age of the participants was 30 years; with an average work experience of six years and 28% of the participants were women. The participants were randomly pre-assigned to the groups as was the treatment condition. Participants were informed that data collected during the exercise would be used in research, it is anonymous at the individual level, and that their participation in the exercise is voluntary. Results from the exercise was shared and discussed with the participants during the course of the workshop.

Each team was assigned to a room. When the team was assembled and seated, a moderator gave out one sheet with the task description and one sheet for the participants to note down the solutions. The moderator was instructed not to give any further guidance on

the subject, to keep time (i.e. ten minutes), and to ensure participants do not leave the room or communicate with the ‘outside world’ during the exercise.

3.4.3 COMPETITIVE PRESSURE

In this exercise time constraint (i.e. 10 mins) and group size (i.e. 6 individuals) serve as constraints. Competitive pressure was manipulated by informing the groups about ‘typical’ performance of other groups. The instructions to the control groups included a highlighted line stating that “most teams typically find eight solutions (i.e. eight unique ways to cut the square metal piece) to this problem”, whereas the instructions to the experiment groups included a line stating that “most teams typically find hundreds of different solutions (i.e. 100+ unique ways to cut the square metal piece) to this problem”.

3.4.4 OBSERVATIONS

Results from experiment 2 are shown in Table 3.2. The experiment groups were more likely to improve performance by questioning routine assumptions. While 44% of the experiment groups (compared to 27% of the control groups) found insight into the better way of generating solutions, this effect was not found to be significant.

Table 3.2: Impact of competitive pressure on performance though increased cognitive effort in questioning routine assumptions in a novel task.

Condition	Total	No	Yes	Success rate
Experiment groups: High competitive pressure	9	5	4	44%
Control groups: Low competitive pressure	11	8	3	27%
Total Observations	20	13	7	

$$\chi^2 = 0.6416$$

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

3.5 IMPLICATIONS AND CONCLUDING COMMENTS

Our study has two key implications. First, we show that performance under competitive pressure (high aspiration) can improve due to increased labour effort or increased cognitive effort. In the case of repeated tasks, agents show a *preference* to improve performance through labour effort (working harder) under low competitive pressure while under high competitive pressure, the increased cognitive effort (working smarter) is directed towards searching for new techniques to improve performance. Similarly in novel tasks, under competitive pressure the increased cognitive effort to improve performance is likely to challenge implicit assumptions used in framing the search for solutions. This indicates that high competitive pressure may *frame* agents to apply increased cognitive effort i.e. working smarter by questioning explicit and implicit routine assumptions that might otherwise limit performance.

Second, many experimental designs that require participants to execute certain tasks repeatedly may be inadvertently introducing learning effects. On the one hand such a learning effect may inflate both absolute performance and predictability of outcomes, it may also introduce bias against change to another procedure especially under conditions of risk and uncertainty.

We would like to highlight that our observations are limited to competitive pressure as a mechanism to set high aspiration and are not generalizable to any or all pressures. Competitive pressure clearly works by appealing to an agents' desire of doing better than the benchmark set by their peers. Work effort induced by such a mechanism is motivated by the aspiration that 'it is possible to meet the target as others have done it'. On the other hand, pressure mechanisms like time pressure may not adequately inspire the same aspiration. To that extent we do not advocate a 'creativity under the gun' approach in organisations (Amabile, Hadley, & Kramer, 2002). Clearly more research to understand the psychological implications of pressure to perform is needed. The main argument of the paper is to show the possibility of finding ingenious insights into novel techniques that improve performance in both repeated and novel tasks may be triggered by competitive pressure.

Key contributions: In this essay, we design two experiments to test the relationship between high competitive pressure and performance through the increase in labour effort (working harder) and cognitive effort (working smarter) in (a) repeated task and (b) novel task. In repeated tasks, we find that under low competitive pressure agents are more likely to rely on labour effort to improve performance, indicating a *preference* towards labour effort. However, under high competitive pressure, agents increase cognitive effort and search for new techniques to improve performance. In novel tasks, where participants must rely on cognitive effort to perform, we find that groups under high competitive pressure are more likely to apply cognitive effort to question implicit assumptions in their search for novel solutions. These results indicate that high competitive pressure may *frame* agents to apply increased cognitive effort i.e. work smarter by questioning explicit and implicit routine assumptions that might otherwise limit performance.

From a behavioural theory perspective, our aim was to go deeper i.e. to the micro level and understand how agents respond to mismatch in performance and aspiration. Behavioural theorists suggest that when there is a mismatch between aspiration and performance organizational decision makers will respond to bridge the gap. However, it is not clear how they choose to bridge the gap. For instance do they commit more resources to solve the problem or do decision makers rethink the problem. This essay aims to make a contribution to this discussion by showing that decision makers have a preference to commit resources without rethinking the underlying assumptions of the problem. Furthermore, we show that there comes a point in the decision making logic where decision makers realize that increasing resources (i.e. labour effort) would not be sufficient to meet the performance aspiration – that may lead agents to apply increased cognitive effort to rethink the problem.

In the final essay, we aim to extrapolate this micro level decision to adopt new routines and observe how the decision to adopt new routines diffuses in a population of firms that are engaged in competition with each other to varying degrees? Put differently, we would expect that the variance in perception of competitive pressure, across a population of firms, to be a determinant of the adoption decision. We propose to test this idea in the next essay.

4. CHOOSING WHICH BATTLES TO FIGHT: AN ATTENTION-BASED ARGUMENT FOR THE DIFFUSION OF A ROUTINE AS A COMPETITIVE ACTION

“If we can keep our competitors focused on us while we stay focused on the customer, ultimately we'll turn out all right”

- Jeff Bezos

Quote from “One Click: Jeff Bezos and the Rise of Amazon.com” by
Richard L. Brandt

In this essay our interest is to understand how routines diffuse in an industry. Specifically, we study when do firms decide to adopt a routine as a response to rivals’ actions of adopting the same routine. Diffusion of competitive actions like adoption of new routines is often viewed to be driven by a combination of two forces that are explained by (i) rivalry-based theories that propose firms are motivated to respond to competitive threats and (ii) information-based theories that propose firms are motivated to respond once they have access to information about the routine. Based on this view, it would seem that firms with greater threat perception and greater scope to gather information would be the early movers.

We argue that this analysis does not account for the mechanisms by which a firm would distribute its limited attention towards information from different competitors. This has particular significance for firms engaged in competition across multiple markets and business domains (multipoint competition) as these firms are likely to allocate more attention to information from major competitors than minor ones. Moreover, when a firm is engaged in competition with many players (as opposed to few) its limited attention is also distributed

across many players. In essence, engaging in multipoint competition with many plays can potentially reduce the attention allocated to the moves of any one player.

Drawing on the literature on attention-based view of strategy formulation and Chen & Miller's AMC model of competitive dynamics (Chen & Miller, 2012), we propose an attention-based diffusion model for the spread of a routine throughout an industry. Using an agent-based simulation, we then estimate the characteristics of early and late adopters of a new routine in such a system. We propose that (i) early adopters of a new routine are more likely to be firms with a small reference group and high rivalry, while (ii) firms with large reference groups and low rivalry are least likely to be early adopters. We then illustrate this attention-based diffusion mechanism with data from the adoption of a new software delivery technology called Software-as-a-Service (SaaS) by packaged-software firms from 2002 - 2012.

4.1 INTRODUCTION

What drives the adoption of routines (as capabilities) in an industry where firms are engaged in multipoint competition? Over the past couple of decades the main predictions of multipoint competition theory have been tested across various markets such as airlines (Gimeno, 1999; Gimeno & Woo, 1996), financial services (Fuentelsaz & Gómez, 2006; Haveman & Nonnemaker, 2000), hotels (Fernandez & Marin, 1998), hospitals (Stephan, Murmann, Boeker, & Goodstein, 2003), and computer software (Young, Smith, Grimm, & Simon, 2000). Scholars have long argued that in a multipoint competitive system widespread adoption of the same routines (i.e. imitation) is driven by a combination of two explanatory factors: (i) rivalry-based theories that see firms as motivated to respond to competitive threats (Baum & Korn, 1996; Livengood & Reger, 2010) and (ii) information-based theories that see firms as basing their response on information that points to the benefits of adopting a routine (Lieberman & Asaba, 2006; McCardle, 1985; Swanson & Ramiller, 2004). In essence these views suggest that while multipoint competitive rivalry is constant, firms pay special attention to moves by major rivals that disproportionally affect key market segments, and the decision to adopt new routine is triggered as firms scan their competitive environment for information about the benefits of the new routine.

At first sight, this would suggest that firms are more likely to be early movers if their perception of threats posed by rivals, and the scope of their scanning activities, is greater than other firms in the same industry. The attention-based perspective of strategy formulation would suggest that this analysis ignores the influence of limited attention resources on how firms interpret threats and process information. At a deeper level, this means that the current view of multipoint competition does not take into account the mechanisms by which firms distribute their limited attention when confronting different types of competitors (Ocasio, 1997; Ocasio & Joseph, 2005). This is precisely the situation that normally occurs when firms

are engaged in competition across multiple markets. In these situations firms are likely to allocate more attention to adoption decisions (as well as non-adoption decisions) of a routine by a major competitor than a minor competitor. Also from an attention-based perspective, when a firm is engaged in competition with many players as opposed to few, its threat interpretation and information processing are likely to be less effective since it must distribute its attention resources across many players. Allocating attention resources is even more challenging when we consider the fact that the number of firms in a particular industry may increase, and that firms can also expand their product line, posing a threat in an increasing number of market segments. Adoption decisions in this dynamic context are likely to stretch the firm's attention resources even further, reducing its ability to interpret threats and gather reliable information.

Take for instance the case of adoption of 'voice recognition' capabilities by manufacturers of consumer devices. Even though the basic technology has been around for some time¹², it received mainstream attention only when Apple acquired Siri in 2010 and launched it as a standard feature in its iPhones in 2011. Competitors' response to the introduction of Siri in consumer devices varied significantly. Google, which competes against Apple in this market with its Android operating system, and Nexus range of devices, responded almost immediately by launching voice search applications for Android devices. In 2011, Google's executive chairman and former CEO, Eric Schmidt, conceded that Apple's Siri voice controlled personal assistant could pose a 'competitive threat' to Google's core

¹² "Audrey" the first voice recognition software was developed in 1952 by Bell Laboratories. This was capable of recognising digits spoken by a single voice. In 1962, IBM demonstrated the "Shoebbox" that could recognise a few English words. Progress in this field picked up with major funding from the US Department of Defence and in 1976 a research team at Carnegie Mellon developed a system called "Happy" that could recognise more than 1000 words, considered to be the vocabulary of an average three year old. Automated speech recognition became commercially available in the 1990s with the launch of "Dragon Dictate", priced at an incredible US\$9000. However by 1997, "Dragon NaturallySpeaking" priced at US\$695 can be considered to be the first modern voice recognition technology that could understand continuous speech at about 100 words per minute after the user had to spend about 45 minutes to train the software. See Juang, B., & Rabiner, L. R. 2005. Automatic speech recognition—a brief history of the technology development. *Georgia Institute of Technology. Atlanta Rutgers University and the University of California. Santa Barbara*, 1. For more details.

search business and therefore they had to respond with urgency. On the other hand, consider the adoption decision by Amazon that competes across a wide variety of markets like online retail, on-demand entertainment, and infrastructure services, and Microsoft that competes across different markets like office productivity software, video games, and enterprise applications. Amazon made its competitive move much later in 2013, when it announced the acquisition of Ivona Software, a small technology firm specializing in bespoke text-to-speech functionality for its Kindle range of devices. Similarly, Microsoft that also competes with Apple and Google in the mobile operating systems market with Windows mobile adopted a similar technology called 'Cortana' in 2014. Could the fact that Amazon and Microsoft also compete across a wide range of different markets have played a role in the decision to adopt the technology later? As in the case of Google, Apple, Amazon, and Microsoft in any industry rivals confront each other across multiple market segments, with greater presence in some segments as opposed to others.

In this essay, our aim is to use the attention-based perspective in order to explore how firms that are engaged in multipoint competition respond to the adoption (or non-adoption) decisions of rivals. Our starting point is the observation that firms in multipoint competition not only have to deal with rivals whose product lines overlap theirs, but also that some of these firms overlap more than others. In other words, that there is a variance in the level of portfolio overlap and the number of overlapping firms. To examine this in depth, we consider the adoption of a new set of routines that constitute a new technology as a competitive action. Thus, the adoption, of a new technological feature or new production techniques, is seen as an identifiable 'competitive action'. Furthermore, this competitive action is an externally directed, specific, and observable competitive move initiated by a firm to enhance its relative competitive position, (Smith, Ferrier, & Ndofor, 2001). Such competitive actions can include

“new product introductions or advertising campaigns, entry into new markets, changes in pricing policy, and relocation or redesign of facilities” (Chen & Miller, 2012: 138).

This essay is structured as follows. We first develop a diffusion model of the spread of a technology that is based on firms’ perception of competitive threats. We draw on the attention-based theory of strategic decision making (Ocasio, 1997; Ocasio & Joseph, 2005), and Attention Motivation Capability (AMC) model in competitive dynamics (Chen & Miller, 2012), to build a diffusion model of the spread of a technology in an industry. Using this model, we run simulations to study when different types of firms choose to respond to a competitive threat, with particular focus on the characteristics of the early movers. We then illustrate this attention-based diffusion mechanism with data from the adoption of a new software delivery technology called Software-as-a-Service (SaaS) by packaged-software firms from 2002 - 2012.

4.2 THEORETICAL FRAMING

Levinthal (2011) has argued that the perception of an opportunity or threat from a competitor’s action is a behavioural act that is prone to perceptual variation. Through this behavioural lens “the properties of a firm such as propensity to act, responsiveness, execution speed, and action (or response) visibility are brought into focus” (Chen & Miller, 2012: 144). For a firm that is engaged in multiple markets and businesses, the perception of threats is represented through an attention-based mechanism (Ocasio, 1997) that builds ‘awareness’ of some threats more than others at the corporate level. Such heterogeneity in awareness of a competitive threat is built as a combination of two factors.

First, if a competitor’s move to introduce new technology impacts a large part of the focal firm’s market portfolio, it is likely to receive more attention than a competitive move

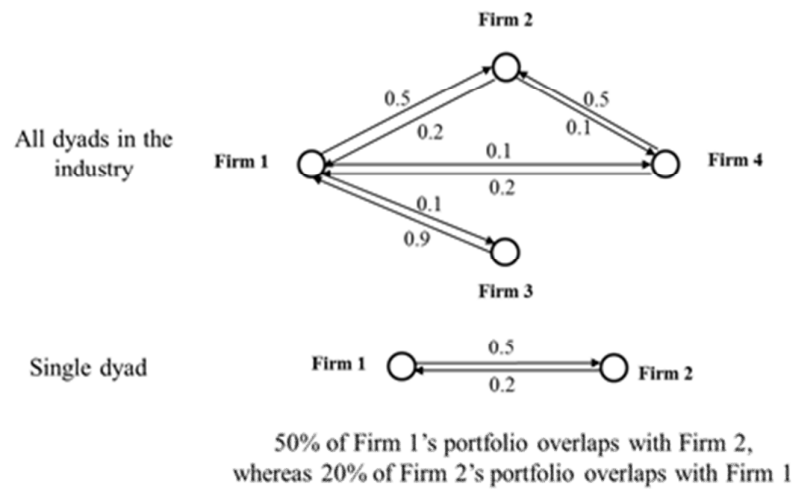
that impacts a small part of the portfolio. Baum and Korn (1996) called this the ‘market domain overlap’. Threats to a larger market domain overlap are perceived as an encroachment on the firm’s ‘turf’, or overall industry position (Livengood & Reger, 2010). Therefore not only do such threats get more attention from the firm, but the response is also prioritized, and hence more likely to elicit a response. Taking the enterprise software industry as an example, when Oracle acquired Hyperion in 2007 with the intention of boosting its Business Intelligence (BI) technology; Oracle’s main competitors SAP and IBM responded by acquiring Business Objects and Cognos respectively in less than a year.

Second, as the profitability of a new technology is rarely known, firms can arrive at a more accurate calculation of the cost/benefit analysis of adopting this new technology by observing the behaviour of other firms in their industry (Lieberman & Asaba, 2006; McCardle, 1985; Swanson & Ramiller, 2004). By the same token, a firm is likely to pay more attention to a competitive move adopted by many firms in the industry, as opposed to a few (Fiegenbaum & Thomas, 1995; Greve, 1998). For instance, Giachetti and Lampel (2010) observe that mobile phone manufacturers not only respond to the competitive moves of strong rivals (e.g. market leader) but also react to the market average i.e. the collective product decisions of industry rivals. The reference group that attract attention comprise of firms with which the focal firm has a market domain overlap. Groups of both high and low competitive rivalry firms are subsets of the reference group. In addition, the size of the reference group is important. The larger the reference group, the more data becomes available that the firm can profitably analyse.

To sum up, a firm’s awareness of threat is built through a combination of (a) the size of the market domain overlap i.e. strength of rivalry and (b) the number of competitors imposing the threat i.e. the size of the reference group. When interpreting how such threats are interpreted, it is important to note that firm A, observing threat from firm B, can arrive at

a different threat perception than firm B, observing firm A. In other words, as depicted in Fig 4.1 the competitive relationship between two firms, based on the above conceptualization of awareness, is asymmetrical (Chen, 1996).

Fig 4.1: Representation of asymmetric competitive relationship in multipoint competition



Given asymmetric perception, how does a firm respond to a threat? Chen and Miller (2012) argue that the response to a threat is a combination of motivation and capability. They point out that the firm's motivation to respond is dependent on various factors including market domain overlap (Baum & Korn, 1996), the nature of the competitive action, i.e. its irreversibility (Chen, Venkataraman, Sloan Black, & MacMillan, 2002), and micro-factors such as top management team characteristics (Hambrick, Cho, & Chen, 1996). On the other hand, the capability to respond is dependent on a variety of micro- and macro-factors that impact the availability of suitable organisational resources and capabilities. Micro-factors include externally derived resources such as network positions (Kilduff & Tsai, 2003), whereas macro-factors include the firm's internal resources and capabilities (Barney, 1991). Since responding is costly and risky, a firm's willingness to respond is constrained, and will

only take place if motivation and capability exceed a certain threshold. The propensity to respond to a competitive threat is therefore a dichotomous variable i.e. respond or do not respond at any given time (Chen & Miller, 2012). By aggregating the dichotomous response of all firms in a given time period, we can observe the rate of adoption of the new technology in the industry. Furthermore, we can observe the diffusion patterns and the characteristics of early adopters.

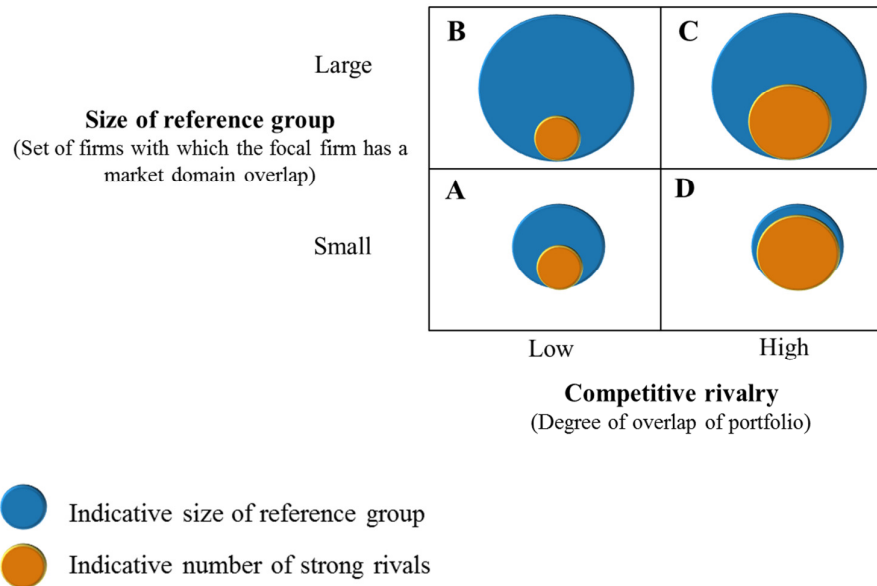
Diffusion of new technologies has long attracted considerable interest from organisational scholars. The basic premise of diffusion studies is that certain firm characteristics increase, or decrease, the likelihood of adoption of features from the environment in which it operates (Rogers, 1983; Strang & Macy, 2001). With the exception of the diffusion of normative practices (Fiss & Zajac, 2004), researchers tend to argue that firms adopt new features due to a combination of economics of competitive advantage, or social reasons, specifically the search for greater legitimacy in their operating environment (Abrahamson & Fairchild, 1999; Katz & Shapiro, 1987). For instance, Kennedy and Fiss (2009) show that in US hospitals the motivation to implement Total Quality Management (TQM) practices were a mix of seeking better quality competitiveness, and the crucial importance of increasing legitimacy for changes in the medical community.

Empirical evidence shows that that diffusion of new features at the population level follows a contagion model (Garud, Tuertscher, & Van de Ven, 2013). Such models are represented by sigmoid functions and form “S” shaped diffusion curves that have three central features. First, the initial adoption of the feature is relatively limited and flat. Second, this is followed by rapid adoption by the majority of population, often termed as the ‘tipping point’. Third and finally, the diffusion curve flattens as it reaches saturation in the market. In this paper our interest is to study the early stages of the diffusion pattern along the

dimensions of (a) the size of the market domain overlap i.e. strength of rivalry, and (b) the number of competitors imposing the threat i.e. the reference group impact adoption.

Rivalry-based theories would suggest that firms with higher market domain overlap and thus higher levels of rivalry, would be early adopters. Similarly, information-based theories would suggest that firms with a larger number of rivals i.e. a larger reference group, would be early adopters as they are more likely to get access to the information early. Based on the combination of the information- and rivalry-based theories, we would expect that firms with high rivalry and larger reference groups would be the early adopters of a new technology, whereas firms with low rivalry and small reference group will be late movers. We also have intermediate situations where firms have high rivalry and large reference group, and large reference group and low rivalry. In general, we would expect firms with large reference group to have access to information from more sources than a firm with small reference group, and given the greater amount of information these firms have access to, they are able to act more quickly when they perceive a competitive threat. For this reason, as shown in Fig 4.2, we would expect category C to be early adopters and category A to be late adopters.

Fig 4.2: Categorisation of firms engaged in multipoint competition within an industry based on (i) The strength of competitive rivalry, and (ii) The size of the reference group



Attention-based theory makes different predictions about how the four types of firms, outlined above, will react. A large reference group indicates that the limited attention resources of the firm would also be ‘spread’ throughout the reference group. This means that a firm with a large reference group would pay less attention to a competitive threat from another firm than a firm with a small reference group, given that both have the same market domain overlap with the competitor. Furthermore, the benefits of the adoption of the new technology are uncertain when we bear in mind that the absence of the adoption in the reference group is not the same as the absence of information. The fact that some firms in the reference group do not adopt a particular technology may indicate that the technology is difficult to implement, or is not that attractive to consumers. Based on this reasoning, we would expect firms in category D to be early movers, and category B to be late movers.

4.3 AN AGENT-BASED SIMULATION MODEL OF ATTENTION-BASED MULTIPOINT COMPETITION

We use an agent-based simulation model with interactions between multiple firms engaged in multipoint competition, to understand how the adoption of a technology would diffuse in an industry. To construct the model, we make two simplifying assumptions about the adoption of the technology. First, we assume that all firms adopt the same technology, and the technology does not change over time. Second, we assume that firms will only pay attention to the moves of other firms when they have a market domain overlap with these firms. In our simulation we keep the market domain overlap constant over time.

We model the decision to adopt a new technology as a dichotomous variable A , that is 1 if the technology is adopted by firm i in time t , and zero otherwise. The decision to adopt is a function of the strength of rivalry due to adoption by competition (Competitive threat) S , the proportion of adoptions in the reference set (information uncertainty) N and an arbitrary variable that denotes the firm's capabilities C . The function is represented as follows:

$$A_{it} = f(S_{it-1}, N_{it-1}) = \begin{cases} 1 & \text{if } f(S, N) > C_i \\ 0 & \text{otherwise} \end{cases} \dots\dots\dots (1)$$

We setup the simulation with a population of 100 firms that are engaged in competition across multiple markets and businesses. The overlap of the portfolio between two firms is randomly drawn from a uniform distribution between 0 and 1. Any overlap of less than 0.1 was converted to 0. The overlap is assumed to be constant over the time period. We then

categorise each firm in the industry as High/Low based on the mean across the two dimensions i.e. average of the domain overlap with other firms and number of overlapping firms. Fig 4.3 shows the categories and the number of firms in each category. We then simulated the diffusion of a single competitive action, introduced at a single firm at $t = 1$, 100 times for each firm as the initial adopter, thereby leading to a total of 10,000 iterations of diffusion.

Fig: 4.3 Categorisation of the firms in the simulation

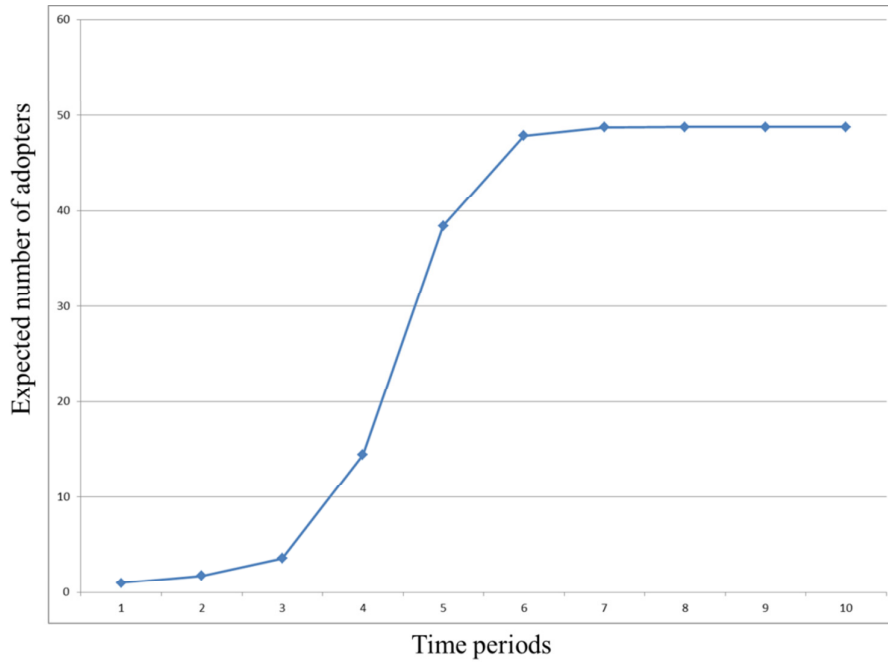
based on (a) the size of the reference group, and (b) the strength of rivalry

Size of reference group	Large	B (24)	C (26)
	Small	A (23)	D (27)
		Low	High
		Competitive rivalry	

Categories of firms by degree of market domain overlap (Competitive rivalry) and number of overlapping firms (Size of reference group). Numbers in parentheses indicate the division of 100 firms in the simulation along these types

Fig 4.4 shows the average diffusion pattern of the technology over ten time periods. As expected, the pattern is sigmoid in nature with three clear stages (Rogers, 1983). The first stage comprises of innovators and early adopters (Stages 1 – 3), followed by the majority (Stages 4 – 6) and finally the laggards (Stages 7 onwards). In our subsequent discussion of the outcomes, we will split the ten time periods according to these three stages.

Fig 4.4: Overall diffusion pattern



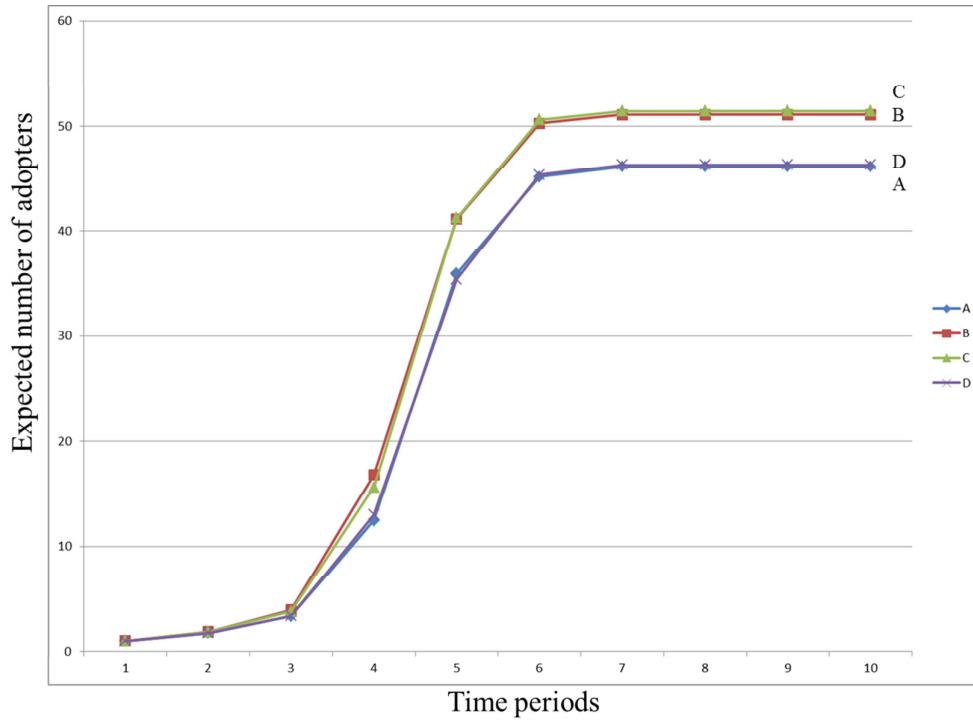
In this attention-based mechanism of diffusion of the technology, we would expect the starting point i.e. the ‘innovator’ to influence how far the technology diffuses in the industry. Specifically, if the innovator is involved in competition with many players in the industry, then on an average we would expect more players to adopt the technology than if the starting point was competition with only with a few players. This leads us to the first proposition:

Proposition 1: Expected number of adopters of a new technology is more when the initiating firm has a larger reference group (Categories C and B)

This is represented in the simulation results shown in Fig 4.5. When we take a closer look at the diffusion pattern, separated by the starting point, we find that on average the technology

is expected to diffuse further when the innovator is in categories C and B i.e. for firms with a large reference group.

Fig 4.5: Overall diffusion pattern separated by starting condition



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Next we turn our attention to early adopters (time periods 1 – 3). When we consider how a firm’s limited attention resources are distributed as it engages in multipoint competition, we find that having a larger reference set may reduce the attention allocated to any one player. This combined with weak rivalry in the reference set, may reduce the threat perception of the firm especially in the early stages of the diffusion pattern. In contrast, when the firm has a small reference group, its attention is focused on the competitive moves of relatively few firms. *Ceteris paribus*, a firm with a small reference group would perceive greater threat from the adoption decision of competitors. Therefore, we have the next two propositions on the characteristics of early adopters:

Proposition 2 (a): Early adopters of a new technology are more likely to be firms with a small reference group and high rivalry (Category D)

Proposition 2 (b): Early adopters of a new technology are least likely to be firms with large reference groups and low rivalry (Category B)

Propositions 2(a) and (b) are represented in the simulation results shown in Fig 4.6 (a) and (b). Figure 4.6 (a) shows the proportion of adopters by categories in each time period. We find that in time period 2, almost 40% of the adopters were in category D whereas only 11% were in category B. Fig 4.6 (b) shows the percentage of adopters by category for the first three time periods. In the starting time period each category has 1% share as the simulation is designed in such a way that every firm acts as the seed once. However, as we would expect in an attention-based mechanism, the most significant increase is seen in category D while the most significant drop is seen in category B.

Fig 4.6 Adoption pattern by categories

(a): Proportion of adopters by category in each time period

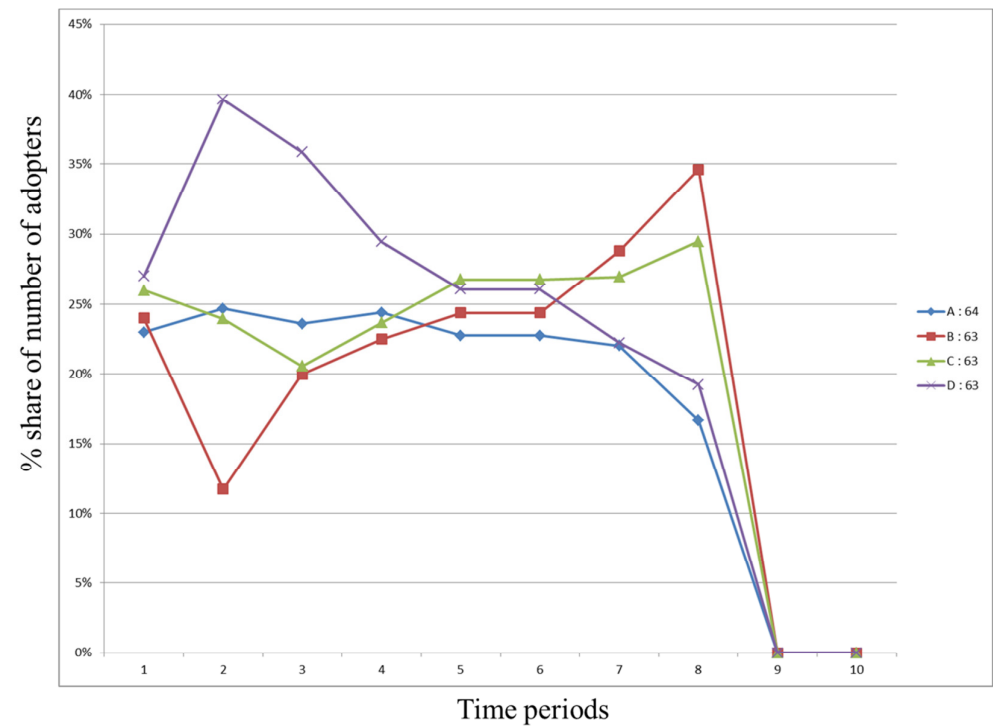
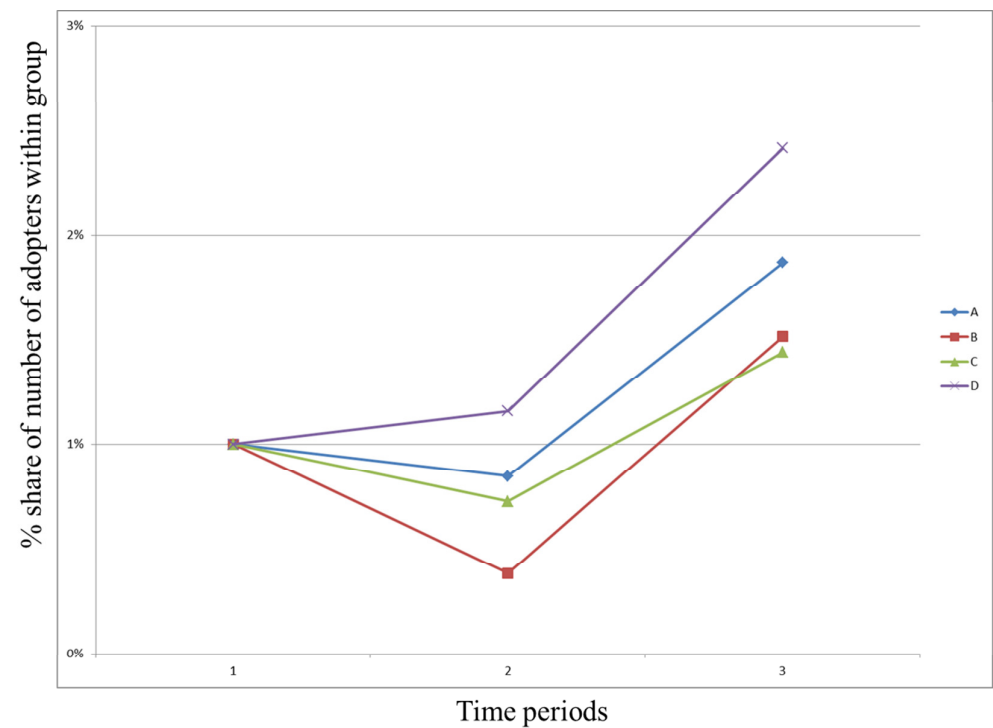


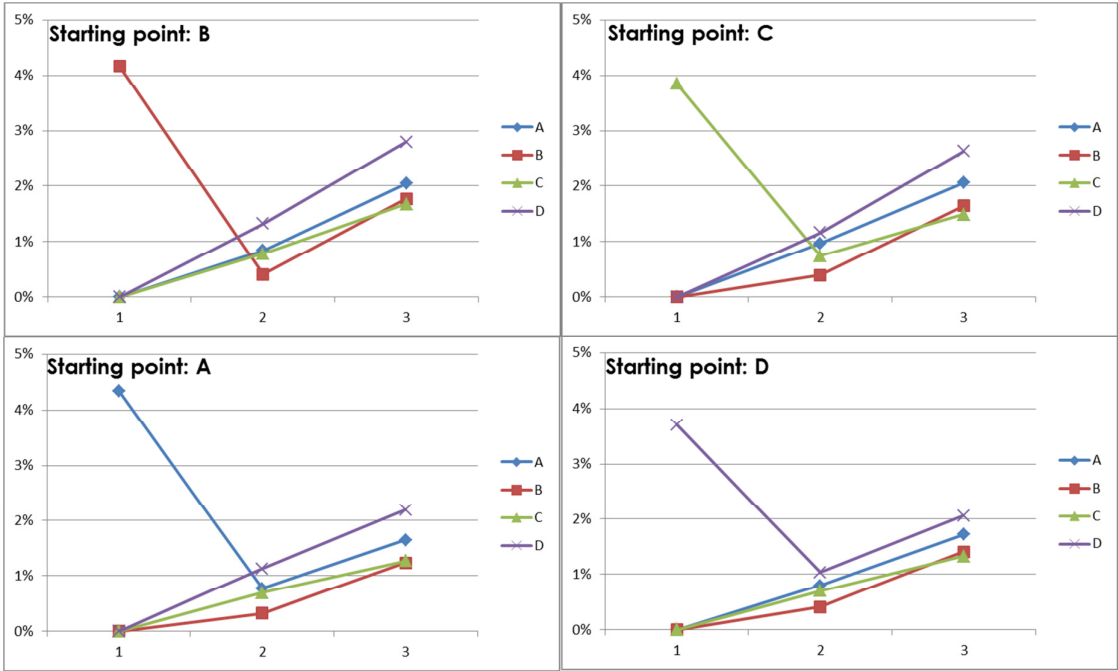
Fig 4.6 (b): Percentage of adopters by category in each time period



When we combine the arguments from proposition 1 and 2 (a) we would expect that the adoption of the technology by the early adopters would be highest when the initiating firm has a large reference group. Therefore, we have a final proposition:

Proposition 3: Firms with a small reference group and high rivalry (category D) would adopt the technology faster when the starting point is a firm with a large reference group (category B and C)

Fig 4.7: Early stage adoption separated by starting category



4.4 ILLUSTRATIVE CASE: DIFFUSION OF SAAS IN THE PACKAGED-SOFTWARE INDUSTRY

To illustrate how diffusion of technology amongst firms engaged in multipoint competition in an industry is driven by an attention-based mechanism, we examine the adoption of Software as a Service (SaaS): a new delivery model in the packaged-software industry. In this section, we will first briefly outline what is SaaS, how it is adopted, and why this is a suitable example to illustrate the diffusion of a technology. We will then discuss the data and descriptive results.

SaaS is essentially a new licencing and delivery model in which software is typically licenced to the customer on a subscription basis and provided in a hosted model i.e. the software code resides on the servers of the vendor and is accessed by the customer over the internet. To access the software customers typically install a very small piece of code on their devices that allows secure connection to the hosted service over a standard web browser. The basic technology of centralised hosting of business applications dates back to the 1960s, but the rapid growth of the internet and internet-based services during the 1990s brought about a new class of centralised computing technology firms called Application Service Providers (ASP). ASPs host and manage specialised business applications, with the goal of reducing costs through central administration. SaaS essentially extends the ASP model. The key difference is that while most initial ASPs focused on managing and hosting third-party or other software vendors' software, SaaS typically involves the vendor developing their own capabilities of delivering and managing their own software in this model.

For software firms to deliver its software in a SaaS model, it must be able to adopt the following changes to its production techniques. First, and foremost, the firm needs to make software architectural modifications. Most SaaS delivery models are based on a 'multi-

tenant' architecture. Simply put, this architecture requires a single version of the software, with a single configuration (i.e. hardware, network, operating system), to be used for all customers or tenants. This puts tremendous limitations on the choices available to customers to customise the software to their unique needs. So why would customers want SaaS? That is where the other major change comes in i.e. the way the software is licenced to customer. In essence, because the design of SaaS implies that customers are sharing the software and the configurations (i.e. the hardware, network and operating system), the total cost of ownership of SaaS solutions is typically divided amongst all the customers. Furthermore, as customers have the option of 'renting' the software and infrastructure, they pay for the service by a subscription, therefore turning their IT expenses from capital to operational expenses. Therefore, to deliver SaaS, the vendor has to adopt a new licencing model that benefits the customer greatly because of its flexibility. The adoption of SaaS as a new delivery model (or an option) therefore provides a competitive advantage to players in the packages-software industry.

To summarize, the adoption of SaaS requires a firm to adopt at least two new sets of capabilities. The first is around the architecture that calls for a move towards a multi-tenant architecture, and the second around the licencing model that calls for a move towards subscription-based pricing. The development of these capabilities indicates that the firm adopts new routines often copied from competitors. Our interest is in understanding which firms adopted SaaS capabilities and when.

4.4.1 DATA

SaaS has seen a rise starting from the early 2002. In the packaged-software industry, Salesforce.com (founded in 1999) is often seen as the pioneer in SaaS. The term SaaS is

thought to have first appeared in an article called "Strategic Backgrounder: Software As A Service," internally published in February 2001 by the Software & Information Industry Association's (SIIA) eBusiness Division. We start our study period from 2002 considering that the only major SaaS provider in the packaged-software industry at that time was Salesforce.com. We track the new product offering of the top 50 packaged-software firms (as of 2012) from 2002 to 2012.

To analyse multipoint competition in this industry, we first look at how the size of the reference group and the strength of rivalry are estimated. We define software firms using the Thomson Reuters Business Classification system, under which Packaged Software firms (57201020) are treated separately from IT Services & Consulting firms (57201010). Therefore, a firm like Accenture that is purely into IT services would not be counted as a packaged software firm. In contrast, a firm like IBM is counted under packaged software as IBM does have software products, while a firm like SAP that is primarily into software products is also counted under packaged software. Based on this classification, we identified the top 50 firms by revenue as of 2012. We then collected data on all the major software product releases announced by these firms in the time period 2002 to 2012. Specifically, we looked for the first SaaS solution announced by a firm in this period.

4.4.2 DESCRIPTION OF DIFFUSION OF SAAS

Whenever a firm announces the launch of a product in the SaaS delivery and pricing model, the firm is coded to have adopted the capability required to deliver software in a SaaS model. Fig 4.8 shows the number of firms that had at least one product that was delivered to customers in a SaaS model.

Fig: 4.8 Diffusion of SaaS in the packaged-software industry

(a): Diffusion of SaaS amongst top 50 packaged-software firms (2002 – 2012)

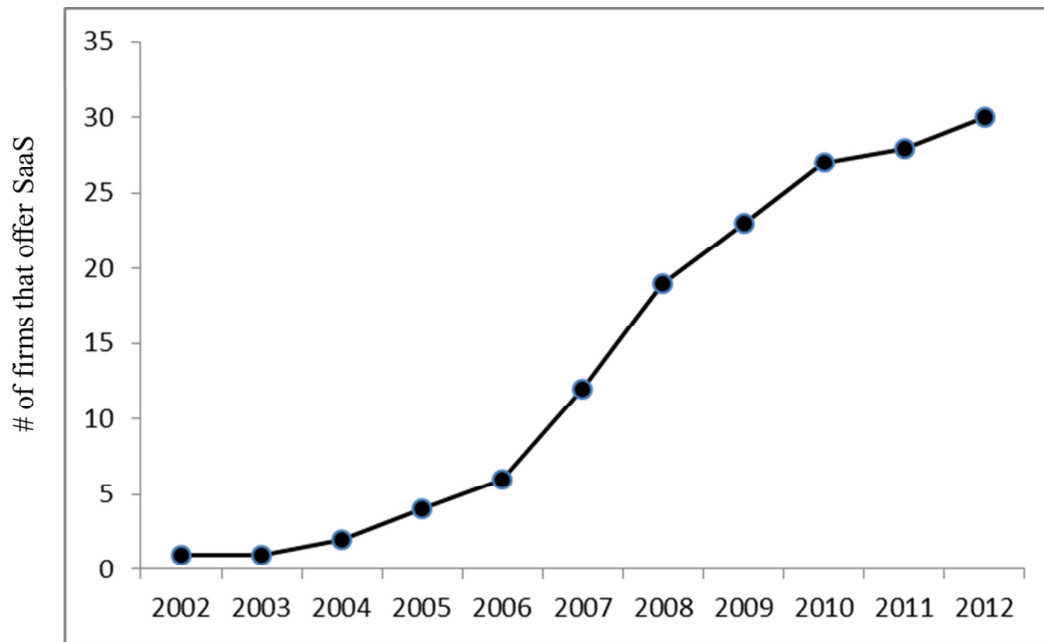
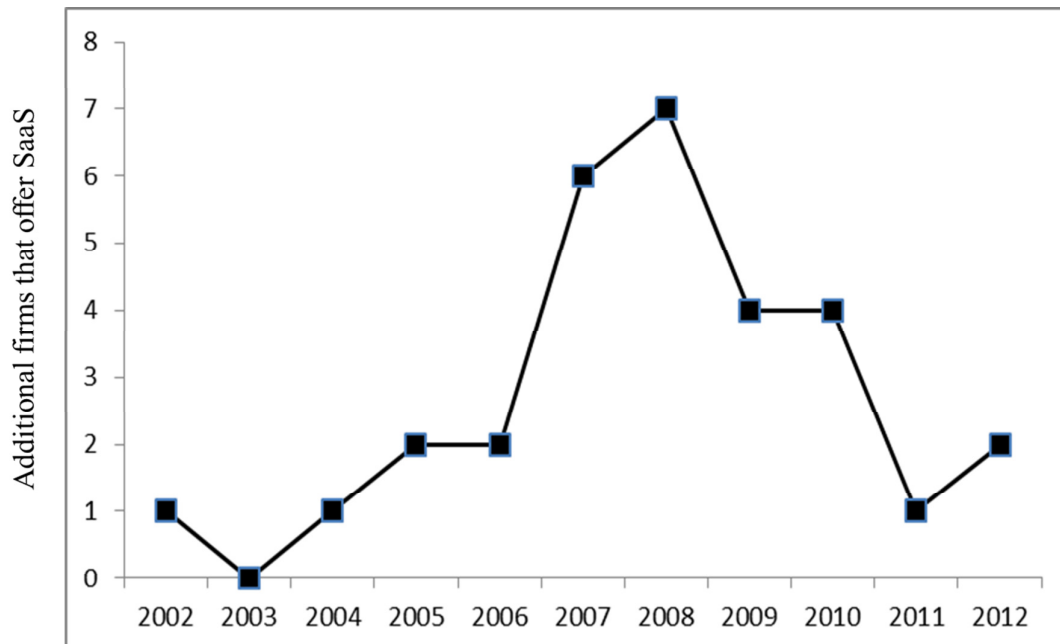


Fig: 4.8 (b): Number of new firms offering at least one product in a SaaS model, amongst the top 50 packaged-software firms (2002 – 2012)



From Fig 4.8 we make two observations. First, as expected, the diffusion of SaaS and a new software delivery model follows a sigmoid pattern. It has three distinct groups defined by the phases of adoption i.e. early adopters, followed by the majority that adopt the new routine in the growth phase, and finally the laggards. Second, even amongst the top 50 packaged-software firms, there are a few firms that do not offer any of their software in the SaaS model. Given that the technology is now ubiquitous (i.e. information is widely available), it can be inferred that these firms do not perceive a strong competitive threat and hence have not decided to adopt the technology.

4.4.3 DESCRIPTION OF DIFFUSION OF SAAS BASED ON CATEGORIES

How does the adoption differ by the categories, based on the size of the reference group and the strength of rivalry? To address this question, we first classify the firms into categories based on: (i) The strength of competitive rivalry; and (ii) The size of the reference group. The categorisation was done independently by two experts with deep knowledge of the packaged-software industry. There was a high degree of correlation (0.89) between the two expert's choices of categorisation. Note that the categorization was done based on the present portfolio of the firms (i.e. as of 2012). To that extent it is assumed the category of the firm would not have changed in the study period. The final categorisation is depicted in Fig 4.9.

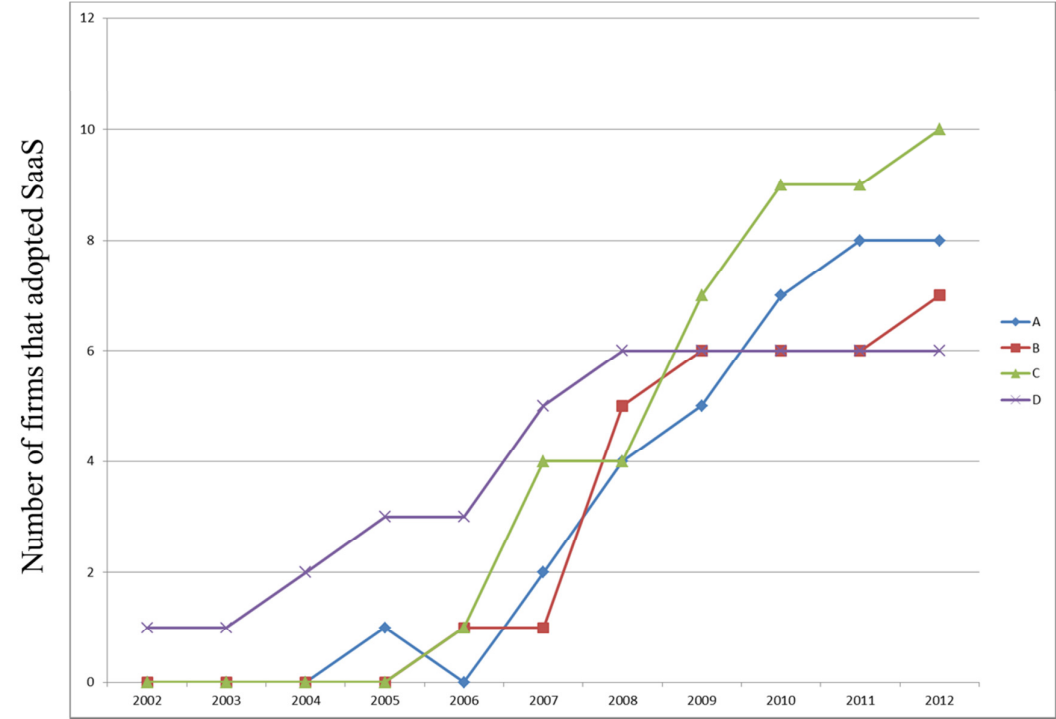
When we plot the diffusion pattern of the firms by category, we find that firms in category D were the earliest to adopt the new routines to deliver SaaS as shown in Fig 4.10. This is in line with the propositions of diffusion based on an attention-based mechanism when firms are engaged in multipoint competition.

Fig: 4.9 Categorisation of top 50 packaged software firms

based on (i) The strength of competitive rivalry and (ii) The size of the reference group

Size of reference group	Large	B 11	C 12
	Small	A 21	D 6
		Low	High
		Competitive rivalry	

Fig 4.10: Adoption of SaaS amongst top 50 packaged-software firms by categories



4.5 DISCUSSION

In this essay, we present an argument that competitive dynamics in multipoint competition is influenced by how the firm's attention is directed towards some threats more than other. We propose that the firm's limited attention resources are directed by two key variables. First, the market domain overlap with each firm (strength of rivalry), and second the number of overlapping firms (size of reference group). Using this argument we built an agent-based simulation model to estimate the diffusion of the decision to adopt a capability as a competitive action.

The simulation diffusion pattern that emerges gives us insights into three areas. First, we find that the capability is likely to be adopted by more firms in the industry when the initiating firm has a larger reference group. Second, we find that the early adopters are most likely to be firms that have a small reference group and high rivalry, while the early adopters of the capability are least likely to be firms with large reference groups and low rivalry. Third, firms with small reference group and high rivalry, adopt fastest when the starting point is a firm with a large reference group.

To understand this behaviour we must take into account how firms evaluate the risk of adopting and not adopting new capabilities. On the one hand, information-based theories suggest that firms adopt new capabilities when decision makers have access to information about the benefits of the capability. In essence, firms manage the risk of adopting new capabilities by gathering information from their reference group. While on the other hand, there is a risk of not adopting new technologies as competitive rivals may gain competitive advantage by adopting the capability sooner. When a firm has a large reference group it indicates the possibility of gathering more information to manage the risk of adopting. But at the same time, since the firm's limited attention resources are spread across a larger reference group, it delays adoption thereby increasing the risk of not adopting.

This analysis also suggests that firms pay attention to both adoption and non-adoption decisions in the reference group. That is to say, the absence of adoption does not mean absence of information, but is a signal in its own right. This means that the focal firm's calculation on whether to adopt the capability factors in the non-adoption decisions in the reference group.

Our analysis clearly has some limitations. Our main objective is to derive some insights into how a capability would diffuse in an industry where firms are engaged in multipoint competition when driven by an attention-based mechanism. To build such a model we have made some simplifying assumptions. First, we assume that the capability remains constant over time and across firms. Second, we assume that motivation to adopt the capability is only driven by competitive rivalry and availability of information but is not influenced by intrinsic factors like firm-specific resources. Third, we assume that each firm adopts the capability and benefits from it equally. While these assumptions do not necessarily compromise our objective of generating patterns based on an attention-based mechanism, they clearly limit our ability to make any industry-specific predictions.

Notwithstanding these limitations, our analysis produces patterns of diffusion that have been observed by other researchers. In particular, our model correctly predicts that the characteristics of early adopters in this industry, as firms that have a small reference group and high rivalry. Our model is also consistent with the adoption of Software as a Service (SaaS) in the packaged-software industry. Finally, our study points to the important role that attention-based mechanism plays in the diffusion of capabilities in an industry. This is a line of inquiry that we think holds great promise for further work on the interaction between managerial cognition, competitive dynamics, and the diffusion of innovations.

4.6 IMPLICATIONS AND CONCLUDING COMMENTS

Our study has two key implications. First, we show that the present analysis of competitive dynamics in multipoint competition does not adequately account for the limited attention of decision makers when choosing to adopt one competitive action over another. Second, we show that once we take into consideration that attention of the decision maker is a limited resource, we find that the predicted characteristics of the early adopter changes.

The main contribution of the essay is to argue that multipoint competition can be enriched by incorporating an attention based argument in the analysis of the diffusion of competitive actions. We show that the present theorization of information and competitive rivalry based theories of competitive dynamics in multipoint competition can benefit in its predictions by incorporating the attention based perspective. To conclude, we would like to reiterate the need to account for how the limited attention of firms is distributed when they engage in multipoint competition. Our central argument is that while it would seem to be based on rivalry-based and information-based theories, firms with high rivalry and large reference group would be the early adopters of new capabilities in an industry; an attention-based view would suggest that early adopters are most likely to be firms that have a small reference group and high rivalry, while the early adopters of the capability are least likely to be firms with large reference groups and low rivalry.

5. LIMITATIONS AND FUTURE RESEARCH

Each essay sheds new insight on our understanding of how organisational mandates, competitive pressure under constraints, and multipoint competition work as structural constraints. These structural constraints focus the attention of decision makers and enable them to filter through alternatives and make micro level choices to adopt or not to adopt routines. While this analysis opens up new areas of research, it is not without limitations. In this section we highlight some of these limitations and suggest how future research can possibly overcome these issues.

In the first essay there are three key limitations. First, our design is purposefully *deeper*, as we aim to study the adoption and influence of the same routine on technological innovation. Future studies can potentially adopt a *wider* design, though it would be difficult as routines by nature are context specific. Future studies in this direction may want to relax the ‘black box’ approach in the capabilities tradition to incorporate a measure of variations in such a wider design. Second, we do not differentiate between the strength of routines. For instance, all the internal and external AC routines are assumed to have the same strength. While this has simplified our analysis to a great extent, future studies may want to develop a more nuanced approach by developing a scale. Finally, we consider all innovative outcomes to be the same. This approach captures the quantity of innovation but future studies may want to incorporate a measure of the quality of innovation as another dependent variable.

The central limitation in the second essay is that our design studies one specific condition i.e. high aspiration under resource constraints, and the influence of this condition on the incidence of new routine generation. Further studies may want to expand the argument to other conditions. Another potential area of study would be to analyse the process of new

routine generation as well as the outcome. For instance, what is the influence of certain individual performing a role e.g. leadership or the influence of restricted communication within the group on its decision to search.

The final essay lays the foundation for an attention-based argument for the diffusion of routines as a competitive action when firms are engaged in multipoint competition. To build this theoretical model we have made some restrictive assumptions that may be relaxed in future iterations. These assumptions are about the adoption of the routine. First, we assume that all firms adopt the same routines, and the routine does not change over time. Second we assume that firms will only pay attention to the moves of other firms when they have a market domain overlap with these firms. Furthermore, the current empirical setting is used as an illustration of the attention-based diffusion and does not test the robustness of the model. Further research is needed in this direction to test the validity of this model with empirical data. The model can be developed further by building in finer evolutionary phenomena such as mutualism, multiple competing routines, or disruptive innovation in routines.

6. CONCLUDING REMARKS

To a large extent strategy research traces the differences in the ability to innovate across firms to a priori heterogeneity in resources and capabilities. This approach assumes that decision makers may have limited information about all innovation opportunities but are bound by a rational calculus when it comes to allocating resources and capabilities to various projects in the firm - without fully exploring the question: What guides the boundaries within which decision makers execute the rational choice process?

In this dissertation we explored this question from an attention-based perspective, arguing that the act of choosing an option from the choice set is essentially a behavioural act and it is subject to the decision makers' cognitive limitations. How a decision maker chooses what to do, is influenced by structural constraints that firms use to focus and distribute the *attention* of its decision makers. Performance outcome is therefore not just a matter of availability of resources and capabilities, but it is also influenced by the decision makers' commitment of resources and capabilities to various tasks, based on how their attention is focused on some opportunities more than others.

By investigating the influence of structural constraints as attention-focusing mechanisms on the adoption of organisational routines, our intent is to contribute to the literature connecting the macro and micro perspectives on strategy and strategic decision-making. In the first essay, we explore a macro-micro relationship and find that organisational mandates that focus decision makers attention to pursue explorative or exploitative innovation mandates, not only influence the adoption of AC routines, it also influences the effectiveness of the routines in furthering technological innovation. We believe that this study not only provides new insight into the interaction of macro level organisational mandates with micro level choices to adopt AC routines, it also opens up a new area of research on the

influence of innovation strategy as represented by R&D mandates on the mechanisms that build AC.

The second essay explores a micro-micro relationship in which we set micro level aspiration under constraints to trigger search behaviour. We find that teams are more likely to come up with qualitatively superior routines when they work under high aspiration, set by high competitive pressures, and constraints in resources. In repeated tasks, we find that under low competitive pressure (i.e. low aspiration) agents are more likely to rely on labour effort to improve performance, indicating a *preference* towards labour effort. However, under high competitive pressure (i.e. high aspiration) agents increase cognitive effort and search for new techniques to improve performance. In novel tasks, where participants must rely on cognitive effort to perform, we find that groups under high competitive pressure (i.e. high aspiration) are more likely to apply cognitive effort to question implicit assumptions in their search for novel solutions. These results indicate that high competitive pressure (i.e. high aspiration) may *frame* agents to apply increased cognitive effort i.e. work smarter by questioning explicit and implicit routine assumptions that might otherwise limit performance. Insights from this essay suggest a relatively new area of research on the micro-foundations of strategic management i.e. how aspiration influence the way agents frame problems and subsequently choose to commit resources?

In the third essay we explore a micro-macro relationship. We build an attention-based diffusion model for the spread of a routine throughout an industry where firms are engaged in multipoint competition. Using an agent-based simulation, we estimate the characteristics of early and late adopters of a new routine in such a system and propose that (i) early adopters of a new technology are more likely to be firms with a small reference group and high rivalry, while (ii) firms with large reference groups and low rivalry are least likely to be early

adopters. We illustrate this mechanism with data from the diffusion of SaaS in the packaged-software industry. Results indicate that firms not only pay attention to the adoption decisions of competitors, they also pay attention to the ‘non-adoption’ decision of competitors.

Together the three essays, each employing a distinct methodological approach, contribute to our understanding of how organisational mandates, competitive pressure under constraints, and multipoint competition act as structural constraints. These constraints focus the attention of decision makers and help them to filter through alternatives and make micro level choices to adopt (or not adopt) routines that influence performance at the macro level.

From a practitioners point of view this dissertation provides insights into how decision making in organizations is influenced by structural constraints often brought about by corporate policies. While policies focus the attention of decision makers on priorities of the firm and therefore makes the process of decision making faster, the key question from an innovation management perspective remains – do these mechanisms also restrict decision makers from pursuing opportunities that lie outside the purview of the structural constraints? The evidence presented in this dissertation show this to be true i.e. decision makers tend to search for innovations within these structural constraints. On the one hand this can be restrictive but on the other hand discerning managers can learn from these insights and choose to alter the structural constraints to promote innovation. After all ‘creative’ is an anagram of ‘reactive’ – reactive to the constraints.

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8. APPENDIX:

8.1. THEORIES AND CORRESPONDING VARIABLE TO UNDERSTAND THE EFFECT OF SLACK

Primary theoretical lens	Study	Measure of slack	Measure of outcome variable	Outcome
Organisation theory	(Singh, 1986b)	Absorbed slack (selling, general, and administrative expenses and working capital) and unabsorbed slack (cash and securities)	Performance measured as a composite measure of financial performance and top executive subjective response to questionnaire	A high level of absorbed and unabsorbed slack is related to good performance
Organisation theory	(Hambrick & D'Aveni, 1988)	Unabsorbed slack (equity-to-debt ratio and working capital as a percentage of sales)	Performance measured as financial bankruptcy	Bankrupt companies have substantially less slack than surviving companies
Organisation theory	(Bromiley, 1991)	Available slack (current ratio), recoverable slack (selling, general, and administrative expenses divided by sales), and potential slack (debt-to-equity ratio)	Performance measures as return on total assets (ROA), return on equity (ROE) and return on sales (ROS)	Slack, particularly available and potential slack, increases performance

Organisation theory	(Miller & Leiblein, 1996)	Recoverable slack (accounts receivable/sales, inventory/sales, and selling, general, administrative expenses/sales)	Performance as measured by Return on Assets	Firm performance is strengthened by the presence of slack
Organisation theory	(Reuer & Leiblein, 2000)	Recoverable slack (accounts receivable/sales, inventory/sales, and selling, general, administrative expenses/sales)	Downside risk is a probability weighted function of below-target performance outcomes. Performance measured by Return on Assets and Return on Equity	Slack is negatively related to firms 'downside risk
Agency theory	(Davis & Stout, 1992)	Cash flow	Performance measured by Return on Equity. To the extent that takeovers are meant to discipline underperforming firms, those that are earning higher returns should be subject to less risk of takeover	Greater cash flow increases the risk of being taken over
Inverted U relationship	(Nohria & Gulati, 1996)	A single composite measure of slack based on two questionnaire items	Performance measured by subjective responses from top executives.	There is an inverse U-shaped relationship between slack and innovation: both too little and too much slack may be detrimental to innovation

Prior performance	(Greenley & Oktemgil, 1998)	Generated slack (6 measures) Cash flow / investment, Debt to equity, FBIT/interest cover, Market to book value, Current assets/current liabilities, Sales per employee And Invested slack (4 measures) Administration costs/sales, Dividend pay-out, Sales/total assets, Working capital/.sales	Performance (5 measures) Sales revenue, ROI, RONA, ROS, ROE	A positive relationship between slack and performance exists only for high-performance firms; it does not exist for low-performance ones
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8.2. SUMMARY OF THE REVIEW OF STUDIES ON BRICOLAGE

Study	Focus	Sample	Measure of bricolage	Key finding
(Garud & Karnøe, 2003)	Bricolage as a process	Case study on the emergence of wind turbines in Denmark and in United States	As a processes that could harness the inputs of distributed actors who are embedded in accumulating artefacts, tools, practices, rules and knowledge.	A process of bricolage has been more successful that a process aimed to generate 'breakthrough' innovation
(Baker & Nelson, 2005)	Bricolage as a process Entrepreneurial bricolage	29 resource-constrained firms	Refusal to enact the limitations imposed by dominant definitions of resource environments	Demonstrates the socially constructed nature of resource environments and the role of bricolage in this construction
(Di Domenico, Haugh, & Tracey, 2010)	Bricolage as a process Social bricolage	8 social enterprises	Make do with resources at hand	Key element of successful social bricolage are make do, refusal to be constrained by limitations and improvisation
(Desa, 2012)	Bricolage as a process Social bricolage	202 technology social ventures from 45 countries	Reconfiguring existing resources to meet institutional demands	Social entrepreneurs who adopt a process of bricolage are better at succeeding in the face of institutional constraints

(Boxenbaum & Rouleau, 2011)	Bricolage as a process Theory building	Theoretical frame for epistemic scripts of knowledge production	Assembly of different knowledge elements that are readily available to the researcher to create new knowledge	
(Banerjee & Campbell, 2009)	Bricoleur characteristics	197 firms in Life Science Diagnostic	Inventor bricolage measured as the construction of technological capabilities through recombining the knowledge of inventors on hand to address opportunities.	Inventors with less assimilative capacity and more creative capacity in teams where there is relevant experience will promote inventor bricolage

8.3. INTERVIEW PROTOCOL

History of the R&D subsidiary

- When was the subsidiary founded? Why was it founded?
- What were the goals at the time of founding? How does it fit into the R&D strategy of the firm?
- Who made the decision? Who else was involved? If you were involved, what was your role?

Mandate: Content of work

- What were the initial projects given to this subsidiary? What are the key projects currently managed in this subsidiary?
- What would you say are the common features of the projects delivered from this subsidiary? How has this changed over its history?
- How do you see the role of the subsidiary in the global R&D network?

Mandate process

- What is the focus of this subsidiary? How has it evolved?
- How are projects assigned to this subsidiary? Who makes the decision?
- What are the strengths in this location? What are the threats? How do you see the project portfolio evolving in the future?
- How are projects evaluated?

AC routines

- What have been/ are the most important knowledge related practices in the subsidiary? (Focus on 2-3 years intervals since the foundation of the subsidiary)
- Do teams from this subsidiary communicate with other subsidiaries? How?
- Do teams from this subsidiary communicate with externals in this location? How?
- Ask about the roll-out of the 5 internal AC routines and 3 external AC routines and its impact

8.4 SURVEY INSTRUMENT FOR EXPERIMENT TASK 1

		Not at all (1)	2	3	4	5	6	Completely (7)
1	How clear are you about what your team's objective are?							
2	How far are you in agreement with these objectives?							
3	To what extent do you think other team members agree with these objectives?							
4	To what extent do you think your team's objectives can actually be achieved?							
5	The team is always moving forward towards the development of new answers?							
6	The team is open and responsive to change?							
7	People in this team are always looking for fresh new ways of looking at the problem?							
8	People in this team cooperate in order to help develop and apply new ideas?							
9	Do your colleagues provide useful ideas and practical help to enable you to do the job to the best of your abilities?							
10	Do your colleagues monitor each other so as to maintain a higher standard of work?							
11	Are the team members prepared to question the basis of what the team is doing?							
12	Does the team critically appraise potential weaknesses in what it is doing in order to achieve the best possible outcome?							

13	How anxious did you feel during the group discussion?							
14	How stressed to did you feel during the group discussion?							
15	Did you feel pressed for time during the group discussion?							
16	Did you feel that other group members would disapprove if your performance was poor?							

8.5 R CODE FOR SIMULATION

R Script for the diffusion of a routine as a competitive action in an industry where firms are engaged in multipoint competition

Author: Aneesh Banerjee

September 2014, results presented at SMS 2014

Start

creating a network table

options (width = 120) # setting the width for better reading

n <- 100 # n is the number of agents in the network

set.seed (234)

random <- runif (n^2, 0, 1.0) # generating the random network strengths

s.n <- matrix (random, nrow = n, ncol = n)

for (i in 1:n) {

 s.n [i,i] <- 0

}

overlap under 15% percentage is counted as 0

for (j in 1:n) {

 for (i in 1:n) {

 if (s.n [j,i] < 0.15) s.n [j,i] = 0

 else s.n [j,i] <- s.n [j,i]

 }

}

making the zero overlaps symmetric

for (j in 1:n) {

 for (i in 1:n) {

 if (s.n [j,i] < 0.1) s.n [i,j] = 0

 else s.n [j,i] <- s.n [j,i]

 }

}

Create categories

Number of connections

s.n2 <- s.n

for (j in 1:n) {

 for (i in 1:n) {

 if (s.n2 [i,j] > 0) s.n2 [i,j] = 1

 else s.n2 [i,j] <- 0

 }

}

row vector with all 1

r.v1 <- matrix (sample (c(1,1), size = n, replace = TRUE), nrow = 1, ncol = n)

vector of number of connections

number.conn <- r.v1 %*% s.n2

```

mean.conn <- rowMeans(number.conn, na.rm = FALSE, dims = 1)

# labels 5 and 3 for number of connections
for (i in 1:n) {
  if (number.conn [1,i] > mean.conn) number.conn [1,i] <- 5
  else number.conn [1,i] <- 3
}

# vector of number of connections
s.n3 <- s.n
s.n3 [s.n3 == 0] <- NA
mean.overlap <- matrix (colMeans (s.n3, na.rm = TRUE, dims = 1), nrow = 1, ncol = n)

# labels 10 and 6 of mean overlap
popmean.overlap <- rowMeans(mean.overlap, na.rm = FALSE, dims = 1)
for (i in 1:n) {
  if (mean.overlap [1,i] > popmean.overlap) mean.overlap [1,i] <- 10
  else mean.overlap [1,i] <- 6
}

# Final ABCD categorization
catagory <- number.conn + mean.overlap
i.catagory <- catagory
table (catagory)

for (i in 1:n) {
  if ( catagory [1,i] == 15) catagory [1,i] = c("C")
  else catagory [1,i] <- catagory [1,i]
}

for (i in 1:n) {
  if ( catagory [1,i] == 11) catagory [1,i] = c("B")
  else catagory [1,i] <- catagory [1,i]
}

for (i in 1:n) {
  if ( catagory [1,i] == 13) catagory [1,i] = c("D")
  else catagory [1,i] <- catagory [1,i]
}

for (i in 1:n) {
  if ( catagory [1,i] == 9) catagory [1,i] = c("A")
  else catagory [1,i] <- catagory [1,i]
}

# names for firms
colnames (catagory) <- paste ('Firm', 1:n)
a <- table (catagory)
a

```

```

# Starting conditions
# t.max in the maximum time period
# s.c is the randomized initial condition
# da and db is the number of agents that have the characteristic

time.final2 <- matrix (sample (c(0,0), size = n, replace = TRUE), nrow = 1, ncol = n)
final2 <- matrix (sample (c(0,0), size = 25, replace = TRUE), nrow = 1, ncol = 25)

for (v in 1:100) {

  # random row vectors ra, measure of resistance
  n <- 100
  set.seed (v)
  rdm <- 13
  random <- runif (n, 0 , rdm) # changed r
  ra <- matrix ( random, nrow = 1, ncol = n)

  final1 <- matrix (sample (c(0,0), size = 25, replace = TRUE), nrow = 1, ncol = 25)
  time.final1 <- matrix (sample (c(0,0), size = n, replace = TRUE), nrow = 1, ncol = n)

  for (u in 1:100) {

    t.max <- 25
    t <- 1

    # diffusion of action

    da <- 1
    diffa <- 1
    s.c.at1 <- 0

    #----- Starting conditions for action i.e. seed

    s.c.a <- matrix (sample (c(0,0), size = n, replace = TRUE), nrow = 1, ncol = n)
    initiala <- c(u)
    s.c.a [1,initiala] <- 1

    matrix (i.catagory)
    t(matrix (i.catagory))
    i.catagory2 <- s.c.a * i.catagory
    i.condition.a <- sum (i.catagory2)

    if ( i.condition.a == 15) i.condition.a <- c("C")
    if ( i.condition.a == 11) i.condition.a <- c("B")
    if ( i.condition.a == 13) i.condition.a <- c("D")
    if ( i.condition.a == 9) i.condition.a <- c("A")
  }
}

```



```

# -----

# matrix multiplication loops

time.meter <- s.c.a # adding a time meter
while (t < t.max) {

  # first loop

  pa <- s.c.a %*% s.n

  pa2 <- pa

  for (i in 1:n) {
    pa2 [1,i] <- pa2 [1,i]/number.conn [1,i]
  }

  cert <- s.c.a %*% s.n2
  for (i in 1:n) {
    pa2 [1,i] <- pa2 [1,i] * cert [1,i]
  }

  qa <- pa2-ra

  for (i in 1:n) {
    if (qa [1,i] > 0) qa [1,i] = 1
    else qa[1,i] = 0
  }

  s.c.a <- s.c.a + qa
  for (i in 1:n) {
    if (s.c.a [1,i] >= 1) s.c.a [1,i] = 1
    else s.c.a [1,i] = 0
  }

  s.c.at1 <- s.c.a

  time.meter <-time.meter + s.c.a
  sumqa <- sum(qa)
  da <- sum (s.c.a)
  #da
  diffa <- c(diffa,da)
  #diffa

  # Optional random decay coefficient a1r (Option not used)

  #   if (da < 50){

```

```

# a1r <- matrix (sample (c(0,0,0,0,0,0,0,0,0,1), size = n, replace = TRUE), nrow = 1,
ncol = n)
# s.c.a <- s.c.a - a1r
# for (i in 1:n) {
#   if (s.c.a [1,i] < 0) s.c.a [1,i] = 0
#   else s.c.a[1,i] = s.c.a[1,i]
# }
# }
# else s.c.a. <- s.c.a

t<- t + 1

}
time.final1 <- rbind (time.final1, time.meter)
final1 <- rbind(final1 , diffa)

}
# final1

final2 <- rbind(final2, final1)
time.final2 <- rbind (time.final2, time.final1)

}

#final2
final2 <- final2[!(apply(final2, 1, function(y) any(y == 0))),] # removes all 0 value rows from
final 2
diff.final <- colMeans(final2, na.rm = FALSE, dims = 1) # taking sum of the coloumns
plot (diff.final)#, ylim=c(0,100))
lines (diff.final)
title(main = rdm, sub = mean.conn , popmean.overlap)

write.csv(final2, " Diff_PatternvXX.csv")
write.csv(time.final2, "D iff_TimingvXX.csv")
write.csv(catagory, " Diff_catagoryvXX.csv")
write.csv(ra, "ResistanceXX.csv")
write.csv(number.conn, "ConnectionsXX.csv")
write.csv(mean.overlap, "MeanoverlapXX.csv")

```

8.6 CLASSIFICATION BY THE STRENGTH OF COMPETITIVE RIVALRY AND SIZE OF THE REFERENCE GROUP

Firm	Category by (i) The strength of competitive rivalry and (ii) The size of the reference group. A = (low, small) B = (low, large) C = (high, large), D = (high, small)
Ericsson	A
Hitachi	B
Siemens	B
NEC	A
Intel	A
Synopsys	A
Apple	A
McKesson	A
ADP	A
NetApp	A
Hexagon	B
Cadence Design Systems	B
TrendMicro	A
Teradata	A
DATEV	A
OpenText	A
Avaya	C
Mentor Graphics	C
Salesforce.com	D
Autodesk	A
Citrix	D
PTC	D
IBM	B
Oracle	C
Microsoft	C
SAP	C
Intuit	D
Cisco	D
Sage	C
Nuance Communication	A
Symantec	D
HP	B
CA	B
VMware	A
Fujitsu	B

Wolters Kluwer	A
Compuware	B
EMC (Excluding VMV)	A
Adobe	B
SunGard	C
Software AG	C
TIBCO	C
SAS	C
BMC	A
Cerner	C
ANSYS	A
Infor	C
Red Hat	A
Dassault Systèmes	B
Attachmate Group	A