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**MANAGING ALLIANCE PORTFOLIO INTERDEPENDENCIES FOR INNOVATION:
THE ROLE OF GOVERNANCE CHOICE IN NEW ALLIANCES***

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Abstract

Firms can govern their alliances through contractual agreements or equity joint ventures, the latter involving the shared ownership of a newly formed legal entity. This paper argues that the governance choice in a new alliance can be a lever for a firm to manage interdependencies in its alliance portfolio. We examine two related ideas. The first is that the choice of governance structure for a new alliance depends on the composition of a firm's alliance portfolio. The second is that this governance choice has implications for the nature of the firm's innovation outputs. Using data on U.S.-listed dedicated biotechnology firms, we find that firms are more likely to govern a new alliance through a contractual agreement when the accessed resources are similar to the resources available in their existing alliance portfolio. This choice also increases innovation in these similar resource domains. In contrast, firms are more likely to choose an equity joint venture when the accessed resources are complementary to their existing alliance portfolio, a choice that increases innovation in these complementary resource domains. Our findings extend the alliance portfolio perspective by linking portfolio interdependencies to the governance choices in new alliances and their implications for innovation.

1 Introduction

Firms often form alliances to access the resources held by others. The innovation-related benefits of such alliances broadly depend on three decisions, regarding what activities the alliance entails, who the partners are, and how the alliance is governed (Oxley, 2009; Li et al., 2008). While each alliance can provide unique benefits, firms that manage their alliances as a portfolio can achieve gains that exceed the sum of the benefits from individual alliances (Hoffmann, 2007; Lavie, 2007; Ozcan & Eisenhardt, 2009; Wassmer, Li, & Madhok, 2017). These additional gains derive from portfolio interdependencies—the interplay of the synergies and conflicts in an alliance portfolio (Hoehn-Weiss, Karim, & Lee, 2017; Wassmer & Dussauge, 2012). Recent research shows that newly formed alliances can reshape the conflicts and synergies in a firm’s alliance portfolio, and firms consider these anticipated changes when making decisions about the nature of the activities and partners in their new alliances (Asgari, Singh, & Mitchell, 2017; Kavusan & Frankort, 2019; Sen & Puranam, 2022).

However, how alliance portfolio considerations affect the third critical alliance decision—namely, the choice of governance structure in a new alliance, between a contractual agreement and an equity joint venture—remains an open question. It is an important one, however, because the governance structure in a new alliance can affect relationships with a firm’s existing partners, so it can reshape portfolio interdependencies (Asgari et al., 2018; Hoehn-Weiss et al., 2017; Kavusan & Frankort, 2019; Lavie, 2007). A related and equally important question is how governance choices in new alliances affect the nature of the firm’s subsequent innovation outputs. Understanding how portfolio interdependencies relate to the governance choices in new alliances, as well as the resulting implications for firms’ innovation, can generate novel insights into how firms can optimize the value that they derive from their alliance portfolios.

Consider two biopharmaceutical alliances formed in the late 1990s, a period when the

emergence of new technologies led many biotechnology firms to engage in alliances to build new capabilities. Interneuron Pharmaceuticals and Vertex Pharmaceuticals—both dedicated biotechnology firms—each formed an R&D alliance with third parties, focused on synthetics and containing a commercialization component. In both alliances, the respective partners had not collaborated before, in both they had technological capabilities in largely distinct domains, and in both they had formed a total of about twenty prior contractual agreements but no joint ventures. In short, the two alliances were observationally equivalent in terms of their functional focus (i.e., R&D and commercialization), their horizontal and vertical scope, and the familiarity, technological overlap, and prior governance experiences of the partners—some of the typical predictors of governance choice (e.g., Argyres & Liebeskind, 1999; Gulati, 1995; Oxley, 1997; Oxley & Sampson, 2004; Sampson, 2004b). Why, then, was Interneuron’s alliance a contractual agreement, while Vertex’s was an equity joint venture?

We theorize that governance choice depends on how the resources in a firm’s existing alliance portfolio relate to the resources in the focal alliance—specifically, whether they are similar or complementary (see Figure 1). Resource similarity—and the conflict potential it generates between the new and existing partners—is better managed through a contractual agreement, while complementarity—and the synergy potential it creates between the new and existing partners—is better exploited through a joint venture. This lens helps resolve the above puzzle: Interneuron’s portfolio already contained resources similar to those accessed through its new alliance but no complementary ones, consistent with its choice of a contractual agreement, whereas Vertex’s portfolio included multiple resource domains complementary to the synthetics resources accessed through its new alliance, consistent with its choice of a joint venture. Building on this logical framework explaining governance choice, our theory also suggests that a joint venture (relative to a contractual agreement) is associated with a lower level of innovation in

similar resource domains accessed through a new alliance, but a higher level of innovation in complementary resource domains accessed through a new alliance.

--- Insert Figure 1 about here ---

We test and find support for our theory in an empirical study of around 140 U.S.-listed dedicated biotechnology firms that formed about 600 R&D alliances between 1996 and 2000. This historical context is ideally suited for our study not only because it is a canonical industry setting in much recent research on innovation within interorganizational relations in general (e.g., Aggarwal, 2020; Asgari et al., 2026; Hohberger, Kruger, & Almeida, 2020; Howard et al., 2016; Verginer et al., 2025), and alliance portfolios in particular (Asgari et al., 2017, 2018, 2025; Kavusan & Frankort, 2019). It also offers an unusually clean setting for identifying resource complementarities. The mid-1990s saw an exogenous technological discontinuity with the emergence of two new technologies—combinatorial chemistry and high-throughput screening—both of which for some time offered clear and well-documented complementarities with some, but not all, resources in this industry (Asgari et al., 2017; Thomke & Kuemmerle, 2002).

Our study makes two broad contributions. First, it advances research on the antecedents of alliance governance. Alliance-governance decisions have often been viewed as driven primarily by the attributes of the focal alliance (e.g., Garcia-Canal, 1996; Oxley, 1997), with far fewer studies exploring potential antecedents beyond the focal alliance (e.g., Argyres & Liebeskind, 1999; Gulati, 1995). We build on this line of research by extending the alliance-portfolio logic to alliance-governance decisions, demonstrating how anticipated changes in portfolio conflicts and synergies influence not only activity and partner selection in newly formed alliances (Asgari et al., 2017; Kavusan & Frankort, 2019; Sen & Puranam, 2022), but also governance decisions. Second, we contribute to research on innovation through alliances (e.g., Friedmann, Lavie, & Rademaker, 2025; Kavusan, Noorderhaven, & Duysters, 2016; Sampson,

2007) by demonstrating that these governance choices affect the nature of firms' innovation outputs. In doing so, we offer novel insights into the interplay between firms' alliance portfolios, their governance decisions in new alliances, and subsequent innovation outputs.

2 Theory and Hypotheses

2.1 Alliance Governance Choice

From a governance perspective, alliances are hybrid organizational arrangements situated between markets and hierarchies (Williamson, 1991). In line with prior literature (e.g., Hagedoorn, Cloudt, & van Kranenburg, 2005; Oxley, 1997, 1999; Oxley & Sampson, 2004; Sampson, 2004a,b), we focus on the choice firms face between two broad classes of governance structures when forming a new alliance: a contractual agreement and an equity joint venture. A contractual agreement is a project-based arrangement that facilitates the unilateral or bilateral sharing of resources by partner firms towards achieving mutually beneficial objectives, without the formation of a separate legal entity (Oxley, 1997).¹ An equity joint venture also enables partner firms to share their resources, yet it differs from the contractual agreement by being a separate legal entity jointly owned by the partners (Kogut, 1988). While an equity joint venture also has a contractual basis (Hagedoorn & Hesen, 2007), it represents a more significant commitment because it always involves equity investments, and it has a joint management board, administrative controls, and more stringent disclosure requirements (Kogut, 1988).

Due to stronger incentive alignment and enhanced control and monitoring, scholars have emphasized that partner firms are better equipped to mitigate the risks of opportunism in equity joint ventures compared to contractual agreements (e.g., Oxley, 1997; Oxley & Wada, 2009). Moreover, contrary to a typical contractual agreement, the employees of a joint venture's parent

¹ In our theory and empirical analysis, we focus on two-partner alliances. While some alliances involve more than two partners, the vast majority consist of only two, which aligns with the predominant focus in alliance research.

firms tend to collocate. This facilitates personal interactions among partners, stimulating the transfer of fine-grained, tacit, and context-specific knowledge. Finally, enhanced controls over employee responsibilities and mobility in joint ventures mitigate concerns regarding the leakage of knowledge outside the resource domains covered by the alliance (Oxley & Wada, 2009).

The governance structure of an alliance is a critical decision because the governance choice shapes the extent to which partners can create and capture value through the alliance. For example, empirical evidence shows that alliance governance predicts firms' degree of learning through an alliance (Frankort, 2014; Gomes-Casseres, Hagedoorn, & Jaffe, 2006; Mowery, Oxley, & Silverman, 1996; Oxley & Wada, 2009), and their propensity to generate new technologies and products (Jiang & Li, 2009; Nicholls-Nixon & Woo, 2003; Sampson, 2007). Key in this literature is the notion that no one governance arrangement constitutes the optimal choice in all circumstances (Aggarwal, Siggelkow, & Singh, 2011; Masten, 1993; Williamson, 1991). Alternative arrangements have distinctive costs and benefits, so they may be relatively more or less suitable depending on a firm's objectives. Thus, established literature has invoked various theoretical perspectives to examine the circumstances under which firms choose to govern a new alliance either through a contractual agreement or through an equity joint venture.

Transaction-cost economics proposes that firms opt for more hierarchical governance structures in alliances where the risk of opportunistic behavior by transaction partners—e.g., the misappropriation of shared resources—is relatively higher (e.g., Oxley, 1997). Complementing these insights, the knowledge-based view predicts that firms opt for more hierarchical governance structures in alliances where the interorganizational exchange of tacit knowledge is a key objective (e.g., Sampson, 2004a). The real options perspective offers an alternative view, by suggesting that firms refrain from committing to more costly-to-reverse governance structures, such as an equity joint venture, when substantial uncertainty surrounds the scientific and

commercial prospects of the activities embedded in the alliance (e.g., Santoro & McGill, 2005).

Through theoretical perspectives such as these three, most studies of alliance governance choice have focused on how characteristics of a focal alliance determine the choice of governance structure for the alliance, in turn enabling a firm to create and capture value through that single alliance. However, a growing literature shows that firms manage their alliances as a portfolio. According to this separate, firm-level line of work on alliance portfolios, the decisions of a firm regarding a new alliance would also be influenced by how that new alliance may affect the interdependencies, i.e., the synergies and conflicts, in the firm's alliance portfolio (Asgari et al., 2017; Kavusan & Frankort, 2019). Thus, when making governance decisions regarding a new alliance, firms with alliance portfolios may consider not only the new alliance in isolation, as suggested by existing research. They plausibly also consider how the new alliance will reshape portfolio interdependencies and, this way, affect portfolio-level value creation and capture.

2.2 Alliance Portfolio Interdependencies

Alliance portfolio interdependencies result from “*the complex patterns of resource exchanges or flows between a focal firm and one alliance partner as well as the resource flows between a focal firm and other partners within its alliance portfolio*” (Hoehn-Weiss et al., 2017: 57). Portfolio-level synergies arise from a firm's ability to combine complementary resources accessed across the alliances in its portfolio (Gulati, Lavie, & Madhavan, 2011). By complementary resources, we mean distinct resources that together create more value than the sum of the value created by these resources in isolation (Dyer & Singh, 1998; Milgrom & Roberts, 1990).² A firm can realize synergies to the extent it can leverage its portfolio resources,

² Some prior research considers assets to be complementary when they must be deployed together to create value, implying mutual dependency among their holders (e.g., Teece, 1986). We define complementarity more broadly as the potential for value enhancement when resources are used in combination, without assuming that joint deployment is a necessary condition for value creation.

which Gulati et al. (2011) term a firm's receptivity. Receptivity reflects the degree to which portfolio partners share their resources with the focal firm, which depends on the conflicts in the portfolio. Conflicts between a focal firm and its alliance partners, which arise when partners perceive the firm's behaviors as opportunistic, may lead partners to limit or sever their resource exchanges with the focal firm, thus reducing the firm's receptivity (Hoehn-Weiss et al., 2017).

New alliances can alter both the synergies and the conflicts in a firm's alliance portfolio, affecting the overall value that the firm derives from its portfolio. Whether and to what extent this happens depends on the degree to which a firm's existing alliance portfolio focuses on resources that are *similar* or *complementary* to the resources accessed through the new alliance. On the one hand, a new alliance can generate conflicts between the firm and its existing partners in alliances that focus on resources *similar* to the ones in the new alliance (Asgari et al., 2018; Lavie, 2007; Singh & Mitchell, 1996). For example, USAir famously took its partner British Airways to court when BA announced a new alliance with USAir's rival American Airlines for access to the same market (Behr & Faiola, 1996). On the other hand, the more a firm's existing portfolio contains resources that are *complementary* to resources in the new alliance, the greater the opportunities for portfolio synergies (Asgari et al., 2017; Gulati et al., 2011; Wassmer & Dussauge, 2012) and the lower the potential for conflicts with existing partners. For example, a new alliance between Apple and Salesforce complemented an existing alliance between Apple and IBM by expanding the enterprise use cases for iOS. Analysts anticipated that IBM would react positively because it stood "*to benefit from the...partnership between Apple and Salesforce*" (Raviart, 2018).

Connecting these ideas from firm-level research on alliance portfolios to the alliance-level literature on governance choice, below we theorize how alliance portfolio interdependencies affect the choice between a contractual agreement and an equity joint venture in a firm's newly formed alliances. We also propose that this governance choice has implications for the nature of a

firm's subsequent innovation outputs. Together, our arguments supply two sets of hypotheses, regarding governance choice and innovation outputs.

2.3 Alliance Portfolio Interdependencies, Alliance Governance Choice, and Innovation

2.3.1 Resource similarity and conflict potential

Firms often form new alliances in broad resource domains that are similar to the resource domains in their existing alliance portfolio. While such redundancy can enhance a firm's bargaining power (Lavie, 2007; Wassmer & Dussauge, 2012) and generate substantial learning benefits (Frankort, Hagedoorn, & Letterie, 2012; Phelps, 2010), it may also generate conflicts between a firm and its existing partners in these similar resource domains. Thus, firms tend to exercise some caution when entering collaborations in domains similar to the ones covered in their existing alliance portfolio, and they may refrain from forming alliances in such domains altogether. For example, biotech firm Exelixis reported that “...*some of our collaborations are exclusive and preclude us from entering into additional collaborative arrangements with other parties in the area or field of exclusivity.*”³

When a firm enters a new alliance focusing on resource domains similar to the ones in its existing alliance portfolio, conflicts can emerge with its existing partners due to three concerns: (1) the firm may reallocate attention and resources away from existing partners; (2) the firm may use the newly gained access to similar resources as leverage against them; and (3) the existing partners' proprietary knowledge may leak through the focal firm to the new partner. These concerns may prompt existing partners to take defensive actions and reduce resource exchanges with the focal firm to protect their own interests (Asgari et al., 2026; Hoehn-Weiss et al., 2017).

De Rond's (2003) case study of an R&D alliance between Rummidge, a biotech firm,

³ https://www.sec.gov/Archives/edgar/data/939767/000093976700500009/ex_q300.htm

and Plethora, a pharmaceutical firm (both pseudonyms) provides fascinating examples of these three concerns, fueling a conflict between the two partners. After starting its collaboration with Plethora, Rummidgen formed alliances with various other pharmaceutical partners in closely related domains. First, this led Plethora's alliance champion to complain that "*We don't get the same exclusivity and attention as before*" (de Rond, 2003: 68). Second, its expanded alliance portfolio, and its newfound reputation in the industry, led Rummidgen to demand a 20 per cent increase in funding when the two firms extended their collaboration for one year. Third, Plethora accused Rummidgen of misappropriating intellectual property by making alliance-related technologies available to third parties. In light of Rummidgen's growing portfolio of related alliances, this fed broader concerns that the biotech firm was progressively using its alliance with Plethora only to grow its business with other partners. This dynamic elicited strong reactions, reportedly leading a senior Plethora scientist to claim that "*Rummidgen rip us off, they cheat us*" (de Rond, 2003: 72), sentiments not lost on Rummidgen. For example, its COO noted, "*there must be people within Plethora saying...they stole from us and we hate them*" (de Rond, 2003: 76), while its CEO, in hindsight, acknowledged that the firm's negotiation tactics "*probably ensured that we didn't continue [the alliance] beyond the third year*" (de Rond, 2003: 57).

The potential for conflict likely increases with the extent to which the firm's portfolio contains more alliances focused on resources similar to the resources in the new alliance, so the firm has an incentive to limit conflicts with existing partners holding similar resources. We argue that concerns by a firm's existing partners about potential conflicts of interest will be greater if the firm chooses to govern its new alliance through an equity joint venture rather than a contractual agreement. A focal firm's investment of substantial financial and organizational resources in an equity joint venture reflects a strong commitment to the new alliance. This strong commitment will amplify the perceptions by existing partners that the focal firm may refocus its

attention and resources away from them, towards the new alliance (Singh & Mitchell, 1996). Moreover, the firm's engagement with a costly-to-reverse alternative to its existing partners will also heighten partners' concerns that the focal firm may demand greater concessions to continue collaborating (Asgari et al., 2018).

Finally, the scale of inter-firm knowledge sharing within the alliance is greater in an equity joint venture compared to a contractual agreement (e.g., Frankort, 2014; Gomes-Casseres et al., 2006; Mowery et al., 1996), intensifying the concerns of existing partners that their knowledge will leak through the focal firm to its new partner. Although a joint venture restricts knowledge flows between the partners in domains outside of the scope of collaboration, it can intensify knowledge flows within the scope of collaboration (Oxley & Wada, 2009). Moreover, a joint venture does not safeguard against spillovers from third parties, such as existing portfolio partners, *into* the joint venture. Thus, when the resource domains accessible to the firm within its existing alliance portfolio are similar to the domains accessed through the new joint venture, the resource scope within the joint venture overlaps with that of the firm's pre-existing portfolio alliances. Under these conditions, a greater extent of knowledge sharing in a joint venture, facilitated by collocation and close personal interactions, may increase the risk that knowledge sourced from other portfolio partners indirectly leaks to the new partner via the focal firm.⁴

These concerns may lead existing partners to withdraw resource commitments from their alliances with the focal firm, choosing instead to reallocate resources to more worthwhile applications with fewer knowledge-leakage risks. In the extreme, existing partners may even take retaliatory actions against the firm, like severing resource exchanges (Hoehn-Weiss et al., 2017) or terminating their alliances with the firm (Asgari et al., 2018). Because the potential negative

⁴ We are agnostic as to whether such leakage occurs out of malicious intent (Friedmann et al., 2025) or simply due to knowledge contagion through employees' personal networks (Singh, 2005).

implications of conflicts grow with the degree to which resources accessible through the firm's portfolio are similar to the ones in the new alliance, so does the firm's incentive to avoid conflicts among new and existing partners. Consequently, the focal firm's preference for a joint venture rather than a contractual agreement should decrease the greater the extent to which resources accessible through the firm's portfolio are similar to the resources in the new alliance.

Hypothesis 1a: *A firm is less likely to govern a new alliance through an equity joint venture rather than a contractual agreement the greater the extent to which the firm's existing alliance portfolio provides access to resources that are similar to the resources accessed through the new alliance.*

How does governance choice affect innovation outcomes in resource domains that are similar between the new alliance and the firm's existing alliance portfolio? When a firm governs a new alliance through an equity joint venture rather than a contractual agreement, existing partners in similar resource domains may impose stricter controls over resource exchanges with the firm and limit knowledge sharing in those domains (Hoehn-Weiss et al., 2017). In turn, the firm's receptivity to portfolio resources in domains similar to the ones accessed through the new alliance diminishes, reducing the firm's ability to benefit from its alliance portfolio for innovation in those domains (Gulati et al., 2011).

While the new alliance may itself provide valuable resource access, the adverse effects of restricted resource access from existing partners can weigh against these benefits. Newly formed alliances often involve greater uncertainty regarding knowledge exchange, as partners may remain cautious about each other's behavioral integrity and strategic intentions (Doz, 1996; Li et al., 2008). These challenges amplify when the new partner also perceives a risk that its knowledge could indirectly leak to the focal firm's existing partners holding similar resources, who may use the leaked knowledge competitively against the new partner. As a result, although

joint ventures facilitate knowledge exchange within the resource scope of the alliance (Oxley & Wada, 2009), the new partner may be reluctant to share knowledge in resource domains similar to a firm's existing partners. Consequently, if the firm governs a new alliance through an equity joint venture, it may not only struggle to leverage resources from its existing partners in resource domains that are similar to the ones in the firm's new alliance, but it can also face barriers in accessing knowledge from its new partner in these domains. This two-sided restriction of resource access weakens the firm's ability to generate innovations in resource domains that are similar between its new and existing alliances.

***Hypothesis 1b:** A firm's subsequent innovation output in similar resource domains—i.e., domains accessed through a new alliance that are similar to the ones already available through its existing alliance portfolio—is lower if a new alliance is an equity joint venture rather than a contractual agreement.*

2.3.2 Resource complementarity and synergy potential

In addition to affecting portfolio conflicts, a newly formed alliance can also alter portfolio synergies. Specifically, a new alliance will enhance portfolio-level synergy potential to the extent that the portfolio includes resources complementary to the resources in the new alliance. Synergies arise when the firm combines resources accessed through the new alliance with complementary portfolio resources accessed through existing alliances (Asgari et al., 2017), which can enable the firm to develop new products and processes (e.g., Rothaermel, 2001a,b; Rothaermel & Boeker, 2008). Realizing these synergies requires that the firm can access the complementary resources with synergistic potential without hindrance, and that it can acquire the tacit knowledge required to deploy those resources effectively. We argue that an equity joint venture will be more effective than a contractual agreement to achieve these two goals.

Both equity joint ventures and contractual agreements have distinct merits and drawbacks.

Contractual agreements offer flexibility by being more easily reversible, and they allow firms to quickly access external resources. Yet they may also fall short in securing sustained access to desired resources and tacit knowledge due to their more arm's-length nature and the associated challenge of aligning partners' incentives (Almeida, Grant, & Phene, 2002). By contrast, equity joint ventures are more substantial and harder-to-reverse commitments, yet they may be more effective at facilitating resource access and fostering the exchange of the tacit knowledge required to utilize a partner's resources for innovation (Oxley & Wada, 2009; Sampson, 2004b).

Joint ventures reduce transaction costs and behavioral uncertainty by converting individually held resources into jointly owned assets (Oxley, 1997). Unlike contractual agreements—in which resources are effectively 'borrowed' and remain under one partner's control—joint ventures render committed resources common property. This facilitates partners' use of each other's resources, while also lowering the risks associated with sharing proprietary tacit knowledge (Oxley & Wada, 2009). Moreover, tacit technological knowledge transfers more easily through co-application (Kavusan et al., 2016). By enabling partnering firms to apply each other's knowledge, joint ventures thus facilitate the transfer of tacit knowledge in a way that might be harder to achieve in contractual agreements (Kogut, 1988). Accordingly, when an alliance is governed as a joint venture, a firm will be better positioned to access and exploit a partner's resources to realize synergies with other resources accessible through its portfolio.

A new alliance, when governed as a joint venture, is also less likely to ignite conflicts with a firm's existing partners when these partners operate in resource domains complementary rather than similar to the ones in the new alliance. Because the new alliance does not constitute a substitute for resources provided by existing partners, they are less likely to perceive it as a threat. Therefore, these partners will be less concerned that the new alliance will divert the firm's attention and resources away from them, or that the firm will use the new alliance to force more

favorable exchange terms (Lavie, 2007). Moreover, while some knowledge leakage concerns remain inevitable (Asgari et al., 2018), they likely are less severe for partners in complementary, and hence distinct, resource domains. In fact, the new complementary alliance likely enhances, rather than reduces, the firm's engagement with existing partners because complementary resources require increased utilization of existing portfolio resources to unlock their full potential. Relatedly, when the new alliance is a joint venture—a more visible and higher-commitment choice than a contractual agreement—existing partners may perceive this as a credible signal that the firm is strongly committed to investing in resource domains that complement their own. This can encourage existing partners to deepen their own commitment to the focal firm.⁵

Overall, the more a firm's alliance portfolio provides access to resources that complement the resources accessible through the new alliance, the stronger its incentive to govern the new alliance through an equity joint venture rather than a contractual agreement. This choice will enable the firm to build knowledge in the complementary resource domains accessible through the new alliance, while also posing few notable retaliation risks from existing partners. Thus, a joint venture will maintain the firm's receptivity, so that the firm is subsequently better able to realize the potential synergies across the complementary resources in its alliance portfolio.

Hypothesis 2a: *A firm is more likely to govern a new alliance through an equity joint venture rather than a contractual agreement the greater the extent to which the firm's existing alliance portfolio provides access to resources that complement the resources accessed through the new alliance.*

How does governance choice affect a firm's innovation outputs in resource domains accessed through the new alliance that complement the resources accessed through its existing

⁵ We thank an anonymous reviewer for suggesting this interpretation.

alliance portfolio? When a firm governs a new alliance through an equity joint venture rather than a contractual agreement, the firm is better able to access its partner's tacit knowledge, and so better positioned to learn and innovate in the partner's complementary resource domains (Sampson, 2007). This is so especially because the larger-scale but more focused exchange of knowledge in a joint venture (Oxley & Wada, 2009) means that existing partners in complementary—rather than similar—resource domains are less threatened by the new partner's potential indirect access to their resources. To the contrary, realizing the full potential of complementary resources accessed in the new alliance may require a focal firm to increase its use of existing portfolio resources. This positive-sum dynamic reduces existing partners' concerns about knowledge leakage and limits the potential for conflicts. Thus, when a firm governs a new alliance through a joint venture, it is more likely to be able to innovate in the resource domains accessed through the new alliance complementing the ones in its existing alliance portfolio.

Hypothesis 2b: *A firm's subsequent innovation output in complementary resource domains—i.e., domains accessed through a new alliance that complement the ones already available through its existing alliance portfolio—is higher if a new alliance is an equity joint venture rather than a contractual agreement.*

3 Methods

3.1 Setting

We test our theory in an empirical study of R&D alliances formed by U.S.-listed dedicated biotechnology firms (DBFs) from 1996 to 2000. This historical setting is particularly suited for testing our hypotheses, for three reasons. First, DBFs are the central innovative forces in the biopharmaceutical industry, who care deeply about the value creation and appropriation potential of their alliance portfolios (Asgari et al., 2017, 2018; Kavusan & Frankort, 2019).

Second, a key technological discontinuity occurred in this industry in the mid-1990s,

allowing us to measure resource complementarities with great precision. In 1995, a sudden increase in the relevance of two emerging technologies generated a marked discontinuity: (1) *combinatorial chemistry*, which enabled large chemical libraries, and (2) *high-throughput screening*, which automated assay testing (Persidis, 1997, 1998; Thomke & Kuemmerle, 2002). These two technologies held the promise of speeding up and transforming the identification and testing of lead molecules and concomitant drugs and application areas (Nightingale, 2000). The two technologies had clear complementarities with some other resources in use in the industry, allowing us to follow prior research (Asgari et al., 2017) in operationalizing resource complementarities in the period immediately following the discontinuity.

Third, trusted, detailed, and relevant data are available for this setting through the Recombinant Capital (ReCap) database. ReCap is a leading source of alliance data in the biotechnology industry (e.g., Reuer & Devarakonda, 2016; Ryu, McCann, & Reuer, 2018; Schilling, 2009). It contains granular data on the resources involved in each alliance, which has allowed recent studies of alliance portfolios to operationalize resource similarities as well as differences or complementarities (e.g., Asgari et al., 2017, 2018; Kavusan & Frankort, 2019).

3.2 Data and Estimation Samples

Our sampling frame comprises 280 public DBFs drawn from the *2001 BioWorld Stock Report for Public Biotechnology Companies* (Gulati & Higgins, 2003; Higgins & Gulati, 2006). We used ReCap to identify all 1,060 R&D alliances formed by these firms from 1996 to 2000. We deliberately ended the sampling window in 2000 because the period immediately thereafter became far less analytically clean (see also Asgari et al., 2025). For example, the Human Genome Map represented a major breakthrough in February of 2001 and, more generally, subsequent technological waves (e.g., genomics, proteomics, bioinformatics, RNA therapeutics, and later AI/ML) overlapped and were more diffuse, substantially complicating the empirical definition of

resource complementarities. Thus, compared to periods up to 1995 or from 2001 onwards, the 1996-2000 window offers a uniquely sharp setting for operationalizing resource complementarities with high measurement validity.

Next, we collected data on all alliances formed by the firms in the four years prior to each R&D alliance. To test our hypotheses, we focus on firms with existing alliances portfolios, meaning firms that formed at least one alliance within a four-year window prior to a focal R&D alliance. For example, the alliance portfolio of a firm forming a new R&D alliance in 1996 includes all alliances the firm formed during 1992-1995, consistent with the canonical assumption of a 5-year alliance duration in biotechnology (e.g., Aggarwal, 2020; Howard et al., 2016; Kavusan & Frankort, 2019; Robinson & Stuart, 2007; Van de Vrande, 2013).⁶

We identified 822 focal R&D alliances formed by the DBFs with existing alliance portfolios, which we used to specify our estimation sample at the firm-alliance level. For alliances in which both partners were DBFs from our sample, we created a second observation, so that each DBF appeared once as the focal firm and once as the partner.⁷ This generated an estimation sample of 924 firm-alliance observations. We have complete data for a sample of 683 firm-alliance observations involving 609 R&D alliances of 138 focal DBFs with 326 partners.⁸

⁶ Asgari et al. (2025) report an average alliance duration of 4.74 years for a sample of biopharma alliances formed during 1986-2000. We also consulted the Cooperative Agreements and Technology Indicators (CATI) dataset, a separate database on R&D alliances (e.g., Frankort & Hagedoorn, 2019), which has data on disclosed time horizons for about 7% of its sampled biopharma alliances during our study window (1992-2000). The average time horizon for these alliances was 4.88 years.

⁷ We conducted various robustness tests to examine the potential effects of the repeat occurrence of focal firms and alliances. For example, we generated logit estimates with standard errors clustered by focal firm, as well as random firm effects logit estimates. As for the repeat occurrence of some alliances in our data, we also added an indicator variable for whether an alliance occurred twice, and generated logit estimates with standard errors clustered by alliance. Our results and interpretations were robust to these alternative modeling approaches.

⁸ Our examination of the firm-alliance level of analysis, which models a focal firm's considerations and outcomes relative to a specific alliance, is consistent with the broader alliance literature (e.g., Devarakonda, Reuer, & Tadikonda, 2022; Hohberger et al., 2020; Runge, Schwens, & Schulz, 2022; Ryu et al., 2018; Sampson, 2004b, 2007). Of course, a governance choice depends on the focal firm as well as its partner. Thus, to adequately account for the partner perspective, we align with recent alliance governance studies (e.g., Devarakonda et al., 2022; Reuer &

On average, each DBF had 11.81 alliances in its portfolio at the time of a focal R&D alliance's formation. Jointly, the DBFs maintained 1,405 portfolio alliances with 714 partners.⁹ We use this sample for the first part of our analysis, which tests Hypotheses 1a and 2a. These hypotheses focus on how similarities and complementarities between portfolio resources and the resources in the new alliance affect the governance choice in that focal alliance.

To test Hypotheses 1b and 2b, which focus on how the nature of firms' innovation outputs varies with governance choice, we collected patent data for the focal DBFs and their partners. We relied on the NBER patent data (Hall, Jaffe, & Trajtenberg, 2001), whose latest version covers USPTO patents from 1976 until 2006 and incorporates the 2008 version of the International Patent Classification (IPC) (e.g., Duysters, Lavie, Sabidussi, & Stettner, 2020; Kavusan et al., 2016). We consider patent applications rather than granted patents, as the year of a patent's application is closer to the time of invention (e.g., Duysters et al., 2020; Friedmann et al., 2025). While all focal DBFs appear in the NBER database, only 235 out of 326 partners in the focal alliances and 442 out of 714 portfolio partners had available patent data. Thus, we test Hypotheses 1b and 2b on a subsample of cases with available patent data for the focal alliance partner and for at least one portfolio partner. This was the case for 466 firm-alliance observations, involving 399 alliances of 120 focal DBFs.¹⁰ Collectively, these focal DBFs applied for a total of 13,546 patents and their partners applied for 276,011 patents during 1976–2006.

A valid test of Hypotheses 2a and 2b requires us to specify which resources complement

Devarakonda, 2016; Ryu et al., 2018) by including control variables for transaction characteristics—which both partners will consider—and firm and partner characteristics.

⁹ As defined earlier, we consider as portfolio alliances those alliances formed within the four years prior to the formation of a focal R&D alliance. A given portfolio alliance may feature in the portfolios of multiple focal alliances if it falls in the four-year window of more than one focal alliance. Moreover, a focal alliance automatically becomes a portfolio alliance of a subsequent focal alliance by the same firm if it falls within the latter's four-year window. Overall, the sample contains data on 1,516 unique alliances (portfolio and focal) involving 750 partners.

¹⁰ We show descriptive statistics for both samples for comparison (Tables 1 and 2). We also replicate a test of Hypotheses 1a and 2a in the subsample used to test Hypothesis 1b and 2b (Table 3, Models 4–6).

one another, in the sense of being both distinct and superadditive. As explained above, our sampling period purposely follows a technological discontinuity in the mid-1990s—the emergence of high-throughput screening and combinatorial chemistry—which allows us to code resource complementarities with precision. Asgari et al. (2017) categorized the technological resources shared in biotechnology alliances after the discontinuity by whether they were complementary to the two emerging technologies. Based on extensive consultations of industry experts as well as industry and scientific material, they labeled 13 technology categories as ‘reinforced resources.’ These resources were in common use among biopharmaceutical firms before the discontinuity. Yet their marginal utility increased due to high-throughput screening and combinatorial chemistry, reflecting complementarities between the two emerging and these 13 reinforced technological resources post-1995.¹¹

Testing Hypothesis 2b furthermore requires identifying innovations related to these complementary resources. Because no direct concordance exists between ReCap’s technologies and patent classifications, we relied on three generative AI applications and we consulted with five industry experts to compile a list of IPC patent classes corresponding to these complementary technologies. This approach enabled us to distinguish between patent applications pertaining to the two emerging and 13 reinforced technologies. Appendix A provides a detailed description of our methodology and the resulting IPC class list.

3.3 Variables for Estimating Governance Choice

3.3.1 Dependent and independent variables

In the first part of our analysis testing Hypotheses 1a and 2a, the dependent variable

¹¹ ReCap divides technological resources into 53 different categories. Among these Asgari et al. (2017) identified 15 resources as exhibiting complementarities. These are combinatorial chemistry, high-throughput screening, device, drug delivery (liposomes), drug delivery (oral), in-licensed products, microarrays, microspheres, monoclonals (conjugates), natural product, peptides, rational drug design (computational), rational drug design (small molecules), service laboratory, and small molecules (synthetics).

gauges the choice of governance structure for the focal alliance. *Joint venture* is a binary variable set to ‘1’ if the focal alliance is an equity joint venture, meaning a separate legal entity co-owned by the partners. The variable is set to ‘0’ instead if the alliance is a contractual agreement.

The independent variables measure the degree of similarity and complementarity of the resources in the firm’s existing alliance portfolio relative to the resources in the focal alliance. We base all measures on ReCap’s classification of alliances as pertaining to one or multiple of 53 possible technology categories. These categories identify the primary technological resources exchanged through an alliance (Asgari et al., 2017, 2018; Kavusan & Frankort, 2019).

The measure for *Portfolio similarity* counts the number of resource categories in a firm’s existing alliance portfolio that also appear in the focal alliance. We use this variable to test Hypothesis 1a. To measure complementarity between resources in the firm’s existing alliance portfolio and the resources in the focal alliance, we rely on the complementarities identified by Asgari et al. (2017).¹² Specifically, *Portfolio complementarity* counts the number of resource categories in a firm’s existing alliance portfolio that have complementarities with the ones in the focal alliance. This measure is greater than zero either if the focal alliance includes at least one emerging resource while the firm’s portfolio contains at least one reinforced resource, or if the focal alliance includes at least one reinforced resource while the firm’s portfolio contains at least one emerging resource. We use this variable to test Hypothesis 2a.

3.3.2 Control variables

Our models of governance choice adjust for several factors that might confound the associations of interest. Specifically, we account for characteristics of the partner firms and the focal alliance, and for broader temporal trends homogeneously affecting the sampled firms.

¹² In Appendix C2 we report a somewhat less precise test of Hypothesis 2a based on measures of distinctiveness rather than complementarity. Despite measurement differences, the empirical results are qualitatively consistent.

At the focal-firm level, we control for experience forming different kinds of alliances and the nature and scale of internal technological capabilities. To capture general alliance experience, we include two variables. *Contract experience* is a firm's number of alliances governed by contractual agreement prior to the focal alliance. *JV experience* is a firm's number of alliances governed by equity joint venture prior to the focal alliance. These two control variables are critically important, for at least three reasons. First, they absorb the effects of experiential learning and inertial forces, which may lead firms to repeat prior governance choices due to perceived competence, convenience, or necessity (Anand & Khanna, 2000; Argyres & Liebeskind, 1999). Second, unobserved firm-specific factors would be manifest in firms' prior governance choices, so such unobserved heterogeneity should not confound our analyses (Heckman & Borjas, 1980; Lincoln, 1984). Third, an experienced firm can devalue the reputations of opportunistic partners and might suffer reputation damage should the firm itself behave opportunistically (Robinson & Stuart, 2007). Thus, a track record of alliances may influence governance decisions. Because governance choice depends also on the track record of the alliance partner, we also control for the *Partner's contract experience* and the *Partner's JV experience* within the biopharmaceutical industry.

To capture technological capabilities, we control for the patent stock of the focal firm through two variables. *Emerging-technology patents* captures the number of successful applications by the firm for patents in high-throughput screening and combinatorial chemistry during the decade preceding the focal year. *Other patents* captures the number of successful applications by the firm for any other patents during the decade preceding the focal year. These variables account for the possible effects of internal technological capabilities on a firm's bargaining power and the nature of the resources it seeks to access through its alliances. We capture emerging-technology patents separately because biopharma had a pervasive focus on

these two resource categories following the technological discontinuity in 1995 (Persidis, 1997, 1998; Thomke & Kuemmerle, 2002). Firms skilled in these two resource categories might have had more leverage in their external collaborations.

We control for four characteristics associated with the focal alliance. We proxy for possible trust and routines associated with partner-specific experience through a control for *Repeated ties*. It captures the number of prior alliances between the partners in the focal alliance, in the five-year window up to the formation of that alliance (Gulati, 1995). *Vertical scope* is set to '1' if apart from an R&D component the focal alliance also contains a commercialization component, and '0' otherwise (Ryu et al., 2018). *Horizontal scope* captures the number of technological resource categories in the alliance and takes values of 1, 2, and 3 or more (Oxley, 1997). Broad-scope alliances encompass multiple activity domains, so they are harder to monitor and more likely to require investments in specialized assets. This may give rise to greater appropriation and hold-up concerns. To proxy for task uncertainty in the alliance (Santoro & McGill, 2005), we include a vector of fixed effects for the stages of drug development to which the alliance pertained. We distinguish *Lead molecule*, *Formulation*, *Pre-clinical*, and *Phase I/II/III trials* (*Discovery* is the omitted category).

Finally, we include fixed effects for years. These absorb broader trends that might correlate with resource and governance choices, such as fluctuations in the financing environment (Lerner, Shane, & Tsai, 2003), the increasing preference for contractual agreements (Frankort & Hagedoorn, 2019), and the evolving technological landscape (Asgari et al., 2017).

3.4 Variables for Estimating Innovation Outputs

3.4.1 Dependent and independent variables

In the second part of our analysis testing Hypotheses 1b and 2b, the dependent variables capture two types of innovation outputs. Consistent with numerous recent studies of alliances

(e.g., Balachandran & Hernandez, 2018; Duysters et al., 2020; Hernandez, Lee, & Shaver, 2025; Howard et al., 2016; Runge et al., 2022), we measure innovation outputs during a 5-year interval following the announcement of the alliance. This period corresponds to the commonly assumed alliance duration in the biotech industry (e.g., Aggarwal, 2020; Howard et al., 2016; Kavusan & Frankort, 2019; Robinson & Stuart, 2007; Van de Vrande, 2013).

Innovation in similar domains assesses the focal firm's innovation outputs following the formation of a new alliance in technology domains in which both the new partner and the portfolio partners were active prior to the new alliance's formation. We capture this by the focal firm's number of patent applications within those four-digit IPC classes in which both the new partner and the portfolio partners applied for patents during the decade preceding the formation of the focal alliance. This variable serves as the dependent variable for testing Hypothesis 1b.

Innovation in complementary domains captures the focal firm's innovation outputs in the new partner's technology domains that complement the technology domains of the firm's portfolio partners. To measure this, we identify the IPC patent classes in which the new partner patented during the decade before the new alliance and determine whether these classes complement the IPC patent classes in which the portfolio partners patented during the same period. We determined complementarity of patent classes based on the procedure detailed in Appendix A. If the portfolio partners' patents include reinforced technology classes, we count the focal firm's patent applications in the emerging technology classes in which the new partner has patented. Conversely, if the portfolio partners' patents include emerging technology classes, we count the focal firm's patent applications in the reinforced technology classes in which the new partner has patented. We use this variable as the dependent variable for testing Hypothesis 2b. We provide a numerical example of the computation of both dependent variables in Appendix B.

The independent variable in the innovation models is the *Joint venture* indicator. It is

equivalent to the dependent variable in the models of governance choice.

3.4.2 Control variables

In the innovation models, we include the same set of control variables also included in the models estimating governance choice. Additionally, we control for the *Partner's emerging-technology patents* and the *Partner's other patents*, counting, respectively, the partner's accumulated patent applications in the emerging technology classes and any other technology classes during the decade preceding the focal year. These measures reflect that innovation-based synergies in an alliance may be a function of both the focal firm's and its partners' patenting experience (Gomes-Casseres et al., 2006). We also include a measure of *Technological overlap* between the focal firm and the partner in the new alliance, which is a known predictor of innovation in alliances (e.g., Frankort, 2016; Sampson, 2007). We measure technological overlap using Jaffe's (1986) cosine index of the distributions of the firm's and partner's patent applications across technology classes during the decade preceding the focal alliance (e.g., Duysters et al., 2020; Friedmann et al., 2025). The index is defined as $(F_i F_j') / [(F_i F_i') (F_j F_j')]^{1/2}$, where the vector $F_i = (f_i^1 \dots f_i^k)$ indicates the distribution of patent applications across patent classes for focal firm i and partner j in classes 1 through k , and F_i' is the transpose of F_i . Values range between 0 and 1, with higher values indicating greater technological overlap.

As these additional control variables depend on patent data for the partner, they are only available for observations with partner patent data. However, because the partner's patenting experience and the partnering firms' technological overlap can also influence alliance governance choice (Oxley & Sampson, 2004; Ryu et al., 2018), we also estimated governance choice using the extended set of controls for the subsample of observations with available partner patent data.

3.5 Estimation

3.5.1 Governance choice

In the governance choice models, the dependent variable is a binary indicator. We use a logit specification that models the log of the odds that the focal alliance is an equity joint venture (versus a contractual agreement) as a linear function of the explanatory variables. As in many industries, contractual agreements in biopharma have long been more common than equity joint ventures (Frankort & Hagedoorn, 2019; Roijakkers & Hagedoorn, 2006). In a maximum likelihood framework, such lower incidence of equity joint ventures might produce upwardly biased point estimates. Thus, as in other recent alliance studies (e.g., Hawk, Reuer, & Garofolo, 2024; Ryu et al., 2018; Ryu, Reuer, & Brush, 2020), we use a conservative penalized likelihood method to estimate the logistic model (Firth, 1993; Woo, Berns, & Solanelles, 2022).

3.5.2 Innovation outputs

In the innovation models, the dependent variables are counts of the focal firm's patent applications during a 5-year window after alliance formation. We estimate these models in three variations. First, we use a Poisson pseudo-maximum likelihood (PPML) estimator on the full sample (Correia, Guimarães, & Zylkin, 2020; Santos Silva & Tenreyro, 2006), in line with recent alliance research (e.g., Friedmann & Pedersen, 2023; Friedmann et al., 2025). PPML estimates are robust to overdispersion and zero-inflation and so provide reliable estimates even for outcomes not following a Poisson distribution (Blackburn, 2015). The same alliance may be sampled twice (when both partner firms are DBFs), so we cluster standard errors by alliance.

Second, we estimate these same models on a smaller, matched sample so that the estimation relies only on observations of joint ventures for which at least one contractual agreement exists with sufficiently overlapping covariate values. Using coarsened exact matching (Iacus, King, & Porro, 2012), we match contractual agreements to joint ventures based on a set of covariates whose standardized mean differences between the subsamples exceeded $|0.25|$ (Stuart, 2010). These covariates are *Contract experience*, *JV experience*, *Other patents*, *Vertical scope*,

and *Phase I/II/III trials*. After pruning 246 unmatched observations (~53%) from our dataset, we estimate the PPML regressions in the matched sample, while controlling for those covariates not used during matching. We include match-strata fixed effects, which capture the influence of each combination of observed matching covariates on firms' innovation outputs. To account for strata-size differences, we apply proportionate weights assigned during matching.¹³

Third, we return to the full sample and exploit the fact that firms in our sample often form multiple new alliances. This allows us to account for stable firm-level heterogeneity in the determinants of governance choice, a potential source of endogeneity in the innovation models. We adopt the Mundlak (1978) approach, which adds controls for the firm-level means of all time-varying predictors of innovation. This method is functionally similar to a fixed-effects estimator (Arkhangelsky & Imbens, 2024), it is compatible with maximum likelihood estimation (Wooldridge, 2010), and it has been used in other studies to address the endogeneity of governance arising from unobserved heterogeneity (e.g., Ceccagnoli & Jiang, 2013; Kosová, Lafontaine, & Perrigot, 2013; Kosová & Sertsios, 2018; Wilson, 2015).

3.5.3 Joint estimates of governance choice and innovation outputs

In the final part of our analysis, we jointly estimate the governance-choice and innovation equations using a generalized structural equation model (GSEM), with standard errors clustered by alliance. The model employs a logit specification to predict governance choice and a Poisson specification with the Mundlak (1978) approach to predict innovation outputs. By testing the four hypotheses within a single model, the GSEM allows us to examine the role of alliance governance as a mediating mechanism indirectly linking portfolio interdependencies to a firm's innovation outputs. We explore these indirect effects motivated by the chain of events in our

¹³ Matching increases covariate overlap but it also reduces imbalance. For example, in our matching procedure, CEM's measure of global imbalance, multivariate L distance, reduced from .63 to .53.

theory: Firms choose a governance structure, and then they innovate (or not) in similar or complementary domains as a function of that choice. To establish the *presence* of indirect effects, we jointly test whether (a) portfolio similarity/complementarity predicts governance choice and (b) governance choice predicts innovation in similar/complementary domains while controlling for the two independent variables (MacKinnon et al., 2002; Yzerbyt et al., 2018). To establish the *magnitudes* of the mediated effects, we used Monte Carlo resampling with 10,000 repetitions to estimate median indirect effects and 95% confidence intervals (Yzerbyt et al., 2018).

4 Results

Table 1 shows summary statistics both for the full sample to test Hypotheses 1a and 2a and for the subsample with available partner patent data to test Hypotheses 1b and 2b.¹⁴ The two samples appear mostly consistent. Table 2 shows correlation matrices both for the full sample (below the diagonal) and for the subsample (above the diagonal). Correlations between the measures of portfolio similarity and complementarity are low, meaning these constructs are not only conceptually but also empirically distinct.

--- Insert Tables 1 and 2 about here ---

4.1 Results for Governance Choice

Table 3 shows penalized logistic regression estimates of alliance governance. Models 1–3 are estimated on the full sample and Models 4–6 are estimated on the subsample for which partner patent data were available and include additional controls relying on the partners' patents.

Model 1 introduces *Portfolio similarity* to test Hypothesis 1a in the full sample. The negative coefficient on the measure is statistically significant ($\beta = -.65$; $p = .049$) and supports Hypothesis 1a. As portfolio similarity increases by one resource category, the odds that the focal

¹⁴ Some variables of theoretical interest, especially those for innovation outputs, exhibit considerable skewness. Yet, reassuringly, all hypotheses remained supported in a robustness test where we winsorized all variables of interest at the 99th percentile.

alliance is an equity joint venture rather than a contractual agreement decrease by 48% (a multiplicative factor of $\exp[-0.65] = 0.52$). Before we turn to tests of the remaining hypotheses, we first retest Hypothesis 1a in the patent-data subsample. Model 4 shows that the portfolio similarity measure retains its negative effect, consistent with Hypothesis 1a ($\beta = -1.05$; $p = .011$).

Model 2 introduces *Portfolio complementarity* to test Hypothesis 2a. The positive coefficient of the measure is significant ($\beta = .58$; $p = .006$) and so it supports Hypothesis 2a. As portfolio complementarity increases by one resource category, the odds that the focal alliance is an equity joint venture rather than a contractual agreement increase by 79% (a multiplicative factor of $\exp[0.58] = 1.79$). The positive coefficient in Model 5 also appears consistent with Hypothesis 2a ($\beta = .61$; $p = .016$). Models 3 and 6 examine Hypotheses 1a and 2a jointly. The main inferences remain consistent with the ones we drew from the partial models.¹⁵

--- Insert Table 3 about here ---

We performed additional analyses to probe how portfolio interdependencies affect alliance governance choice. For example, we tested alternative operationalizations of our measures of portfolio similarity and complementarity. We also disaggregated the complementarity measure to distinguish between cases where a firm's portfolio supplies reinforced resources that complement emerging resources in the focal alliance, and instances where the reverse is the case. Additionally, we restricted the analysis to firms that, through their existing alliance portfolios, already had access to the emerging or reinforced resource categories involved in the focal alliance. This rules out the possibility that the effects of portfolio complementarity are driven by a firm's mere unfamiliarity with these resources. Finally, we examined a more granular governance spectrum by including minority equity investments as an

¹⁵ In Models 4–6, all controls for the experience of the focal firm and its partner forming contracts or joint ventures fail to reach statistical significance, suggesting that residual time-varying heterogeneity at the firm or partner levels may be limited (Heckman & Borjas, 1980; Lincoln, 1984).

intermediate mode between nonequity contractual agreements and equity joint ventures. Overall, the evidence furnished by these additional analyses offers broad support for our theory. Appendix C provides detailed descriptions of all these additional analyses and their results.

We also examined the external validity of our findings and their applicability to more recent alliances. To this end, we replicated our analysis of governance choice on alliances formed by firms active in the broader chemical and pharmaceutical industry during the period 2000–2019. Because we lack detailed insights into the specific technologies involved in the alliances within this broader sample (and their potential similarities and complementarities), we computed crude proxies for resource similarities and complementarities based on firms' SIC codes. The corresponding results provide evidence consistent with our main findings, suggesting that our findings generalize well beyond the specific context of the biopharma industry in the late 1990s. Appendix D provides all relevant details and results for this replication study.

4.2 Results for Innovation Outputs

Table 4 shows PPML estimates of innovation outputs. In Model 1, a significant negative coefficient of the *Joint venture* variable on innovation in similar domains supports Hypothesis 1b ($\beta = -.83$; $p = .025$). Average marginal effects indicate that, when the new alliance is an equity joint venture rather than a contractual agreement, the focal firm applies for 35.23 fewer patents within technology classes shared between the new partner and the portfolio partners. This marks a 57% reduction in such patent applications relative to the sample mean.

--- Insert Table 4 about here ---

Model 2 reveals a significant positive coefficient of *Joint venture* on innovation in complementary domains, in line with Hypothesis 2b ($\beta = 1.06$; $p = .010$). Accordingly, when the new alliance is an equity joint venture rather than a contractual agreement, a focal firm applies for 35.20 additional patents within those technology classes in which the new partner's patents

complement the portfolio partners' patents. This result corresponds to a 175% increase in complementary innovations relative to the sample mean.

Models 3 and 4 retest Hypotheses 1b and 2b in the matched sample. The estimates again support both Hypothesis 1b ($\beta = -1.63$; $p < .001$) and Hypothesis 2b ($\beta = .89$; $p = .019$). Models 5 and 6 revert to the full sample to test the hypotheses using the Mundlak (1978) approach to account for unobserved heterogeneity at the level of the focal firm. Here too, the estimates support Hypothesis 1b ($\beta = -.88$; $p = .004$) and Hypothesis 2b ($\beta = 1.04$; $p = .002$). Given the possible endogeneity of governance choice, these Mundlak estimates are particularly persuasive because they reflect a within-firm comparison: A firm's innovation outputs in similar domains would be lower, and that in complementary domains higher, if the firm chose a joint venture rather than if that same firm chose a contractual agreement.¹⁶

4.3 Joint Results for Governance Choice and Innovation Outputs

We tested all four hypotheses jointly using a GSEM. Figure 2 shows the corresponding path coefficients. They confirm the support for our hypotheses, as the four hypothesized paths are in the predicted direction and statistically significant. The joint significance of these four paths also provides plausible evidence that portfolio resource interdependencies have an indirect effect on firms' innovation outputs, mediated by the governance choice in the focal alliance (MacKinnon et al., 2002; Yzerbyt et al., 2018).

--- Insert Figure 2 about here ---

To understand these indirect effects, Table 5 shows median incidence rate ratios (IRRs) and confidence intervals associated with the indirect effects of portfolio similarity and

¹⁶ In an unreported supplementary analysis, we found comparable results using a conditional fixed-effects Poisson estimator. We opted for Mundlak's approach, which is functionally equivalent to the fixed-effects estimator but more flexible, so that it can also be implemented in more complex non-linear models (e.g., GSEM) without incurring the limitations of the incidental parameter problem.

complementarity on innovation in similar and complementary domains, mediated by the choice of governance structure in the focal alliance. The first row pertains to the combined Hypotheses 1a and 1b. It suggests that, at the median, by increasing the probability that firms opt for a contractual agreement over a joint venture, a one-unit increase in portfolio similarity increases innovation in similar domains by 171% (i.e., $[2.71-1.00]*100\%$). The second row pertains to the combined Hypotheses 2a and 2b. It suggests that, by increasing the probability that firms opt for a joint venture over a contractual agreement, a one-unit increase in portfolio complementarity increases innovation in complementary domains by 79% (i.e., $[1.79-1.00]*100\%$).

--- Insert Table 5 about here ---

Moreover, the last two rows in Table 5 further show that the other two indirect paths—i.e., from portfolio similarity to innovation in complementary domains, and from portfolio complementarity to innovation in similar domains—both have negative effects. Specifically, by increasing the probability that firms opt for a contractual agreement over a joint venture, a one-unit increase in portfolio similarity decreases innovation in complementary domains by 69% (i.e., $[0.31-1.00]*100\%$). And by increasing the probability that firms opt for a joint venture over a contractual agreement, a one-unit increase in portfolio complementarity decreases innovation in similar domains by 38% (i.e., $[0.62-1.00]*100\%$). These findings suggest that firms with both similar and complementary resources in their existing portfolio face a fundamental trade-off. They must decide whether to improve innovation in similar domains by opting for a contractual agreement, or to improve innovation in complementary domains by opting for a joint venture.

Finally, reverting to Figure 2, the GSEM also shows the direct effects of portfolio resource interdependencies on innovation outputs, once holding alliance governance constant. Portfolio similarity has a positive direct effect on innovation in similar domains, and a marginally significant, negative effect on innovation in complementary domains. The finding that portfolio

similarity predicts innovation benefits in similar domains is consistent with the idea that overlap among a firm's alliances offers learning and bargaining-power advantages (e.g., Frankort et al., 2012; Lavie, 2007; Phelps, 2010; Wassmer & Dussauge, 2012), despite the potential conflicts that this overlap may generate with and among the firm's partners. We find no evidence that portfolio complementarity directly predicts innovation outputs, suggesting that the effects of portfolio complementarity both on innovation in similar and on innovation in complementary domains are fully mediated by the choice of governance structure in the focal alliance.

4.4 Summary of Findings

The findings support our argument that firms consider alliance portfolio interdependencies when deciding how to govern a new alliance, and that governance choice influences the nature of the innovation outputs generated during the alliance. Across various analyses, we find evidence regarding alliance governance consistent with two ideas: (1) Firms anticipating that a new alliance may increase portfolio conflicts lean towards a contractual agreement as the governance choice for that alliance; and (2) firms anticipating that a new alliance may increase portfolio synergies lean towards an equity joint venture as the governance choice for that alliance. Consistent with these results, we also find that contractual agreements are more likely than joint ventures to facilitate innovations in resource domains shared between the firm's new and existing alliance partners. Instead, joint ventures are more likely than contractual agreements to facilitate innovations within resource domains in the new alliance that complement the domains to which the firm has access through its existing alliance portfolio.

5 Discussion

Recent work on alliance portfolios shows that firms consider anticipated changes in portfolio interdependencies when making decisions about alliance activities and partners—the 'what?' and 'who?'—in their new alliances (Asgari et al., 2017; Kavusan & Frankort, 2019; Sen

& Puranam, 2022). Building on this evidence, our objective has been to examine whether and how firms manage alliance portfolio interdependencies through the ‘how?’ decision—the choice between a contractual agreement and an equity joint venture as the governance structure in new alliances. To address this question, we conducted a comprehensive analysis of a large sample of biotechnology alliances formed between 1996 and 2000. Our findings support two related ideas. First, the choice of governance structure for a new alliance depends on the composition of a firm’s existing alliance portfolio. Second, this governance choice has implications for the nature of the firm’s subsequent innovation outputs. These findings broadly converge with our core argument—that governance choice in a new alliance is a strategic lever for firms to manage anticipated synergies and conflicts in their alliance portfolio.

Our first contribution is to the study of alliance governance. Many alliance-governance studies have examined the effects of focal transaction characteristics, such as alliance scope, on governance choices (e.g., Garcia-Canal, 1996; Oxley, 1997; Oxley & Sampson, 2004; Santoro & McGill, 2005). Other related studies have emphasized the need to look beyond the focal transaction, as governance decisions may also depend on the prior alliances that partners have formed. For example, Gulati (1995) showed that governance choice in a focal alliance may depend on a partner-specific history of prior alliances, while Argyres and Liebeskind (1999) argued that due to governance inseparability, governance choice in a focal transaction may resemble partners’ past governance choices (e.g., Casciaro, 2003; Oxley, 1999; Robinson & Stuart, 2007). Building on this broader perspective, we introduce a portfolio approach that shifts attention to how the characteristics of a new alliance may affect the interdependencies within a firm’s broader alliance portfolio. By integrating firm-level research on alliance portfolios with alliance-level studies of governance, we introduce portfolio concerns as a key contingency

shaping alliance-governance decisions.¹⁷

Our portfolio perspective on governance choice also enriches research on alliance portfolios. Recent research on alliance portfolios has documented how firms use decisions about activities and partners in new alliances as levers to manage interdependencies in their alliance portfolios (Asgari et al., 2017; Kavusan & Frankort, 2019; Sen & Puranam, 2022). We complement this research by extending the application of the alliance-portfolio logic to alliance-governance decisions. Thus, our study adds the decision regarding governance structures in new alliances as a third lever—besides decisions regarding activities and partners—to manage portfolio interdependencies, which enhances the understanding of how firms handle their alliance portfolio interdependencies through new alliances.

Our second contribution is to research on the consequences of alliances for firm's innovation outputs. We show that in a newly formed alliance, the choice of a contractual agreement rather than an equity joint venture increases the firm's subsequent propensity to innovate in resource domains shared between the new and existing alliance partners. We also show that the choice of an equity joint venture rather than a contractual agreement increases the firm's propensity to innovate in the new partner's resource domains that complement the resource domains of existing alliance partners. These findings regarding the innovation consequences of governance choice in a new alliance are closely consistent with our evidence regarding the portfolio antecedents of that choice. Consistent with our argument that firms choose contracts to minimize portfolio conflicts, these contracts increase innovation outputs in resource domains shared between the new and existing partners. By contrast, governing a new alliance as a joint

¹⁷ All our estimates control for key transaction characteristics, as well as for the prior alliances between the alliance partners and the governance structures chosen by the partners in their prior alliances. Thus, our alliance portfolio approach both conceptually and empirically extends important prior work, including studies also looking beyond the focal transaction for relevant predictors of governance choice (e.g., Argyres & Liebeskind, 1999; Gulati, 1995).

venture can undermine innovation in shared domains, as partners may adopt protective measures that restrict knowledge exchange in these domains for fear of knowledge leakage. This highlights a previously unexplored downside of joint-venture governance in a portfolio context: While joint ventures can facilitate knowledge exchange in a given alliance, they may hinder knowledge flows when other partners in the firm's portfolio are active in similar resource domains. Yet, consistent with our argument that firms choose joint ventures to maximize synergy potential, joint ventures allow the firm to build knowledge in a new partner's resource domains that complement the resources accessible through existing alliances.

What sets our analysis of the innovation consequences of alliances apart from existing work is, first, the sharp distinction we make between innovation in similar and complementary domains. This distinction closely aligns and is fully consistent with our portfolio theory of governance choice. Second, to measure innovation in complementary domains, we used a comprehensive combination of three generative AI applications and deep knowledge from five domain experts to identify patent classes belonging to emerging and reinforced technologies (Appendix A), which are complementary in our setting. We believe that this approach provides numerous opportunities for testing more nuanced predictions regarding the innovation consequences of organizational choices.

Our examination of the consequences of alliances for the nature of innovation outputs also adds qualitatively distinct insights to prior studies of the knowledge-building implications of alliance governance. Findings in the literature suggest that in equity joint ventures, firms build more on the knowledge of their partners (Gomes-Casseres et al., 2006; Jiang & Li, 2009; Mowery et al., 1996), the knowledge bases of the partners show stronger convergence (Frankort, 2014), and firms are more likely to build knowledge within the scope of the alliance (Oxley & Wada, 2009). Moreover, firm-level studies suggest that counts of post-alliance patents in joint

ventures relative to less hierarchical alternatives may depend on the nature of transaction hazards (Sampson, 2004b, 2007) and on environmental dynamism (Nicholls-Nixon & Woo, 2003).

Complementing these insights, we show that the innovation implications of alliance governance also depend on the *nature* of the innovation outputs. Contracts work relatively better if a new alliance covers similar resource domains as the alliances in a firm's existing portfolio, while joint ventures work relatively better if the new alliance instead covers resource domains that complement the ones in the existing portfolio.

As one possible caveat, firms rarely disclose alliance termination dates and such information is typically unavailable in archival sources such as the ReCap database (Schilling, 2009). Thus, we assumed a five-year lifespan for each alliance, consistent with numerous studies of alliances in biopharmaceuticals (e.g., Aggarwal, 2020; Howard et al., 2016; Kavusan & Frankort, 2019; Robinson & Stuart, 2007; Van de Vrande, 2013). Yet, we have no reason to believe that this assumption is restrictive, first, because five years is a common alliance duration in this setting. Second, the possible early termination of some alliances is unlikely to affect our theoretical predictions. For example, recent research suggests that knowledge flows between partners can continue even after their alliance expires, due to persistent relational ties between the firms (Friedmann & Kavusan, 2026). If a former portfolio partner perceives such ties as a threat, it may still retaliate against the focal firm's governance choice in a new alliance, by pruning these persisting ties (Hernandez, Sanders, & Tuschke, 2015).

Moreover, we have employed multiple empirical strategies to reduce the concern that unobserved factors jointly influencing governance choice and innovation outputs confounded our estimates of the innovation-related consequences of alliance governance. For example, we included numerous relevant covariates, matched on observables, controlled for within-firm means of time-varying covariates, and jointly modeled governance choice and innovation outputs. Still,

none of these approaches exploits exogenous variation in governance choice. Thus, while our suite of results is strongly suggestive and robust, we cannot assert with full confidence that the innovation effects of alliance governance are causal.

Some areas for further research are worth noting. We examined the context of biopharmaceuticals following a major technological discontinuity in the mid-1990s (Asgari et al., 2017). In this context, high-throughput screening and combinatorial chemistry were emerging technologies about which many incumbent DBFs were keen to learn through alliances with new partners. Our focus on one set of players in one time period has the benefit of offering the necessary comparability in normal business activities and industry context. We chose the context to allow us to offer a direct test of the role of portfolio complementarities in governance choice, and our knowledge of complementarities in this setting also helped us to distinguish sharply between innovation outputs according to their similarity and complementarity. As our large-scale replication study underlines (Appendix D), however, our theory also applies beyond our chosen industry and time period. Our framework may be examined in other settings. We encourage future research to re-examine our (and related) theoretical insights with data on technological discontinuities within different empirical contexts and historical or contemporary settings that may also affect firm behaviors along the dimensions we theorize.

Also, we distinguished contractual agreements and equity joint ventures, which are governance structures that differ simultaneously in the economic and organizational commitments by the allied parties. According to our theory, such characteristics together play a role in mitigating conflicts or reinforcing complementarities stemming from the addition of a new alliance to a portfolio. However, as both kinds of commitments are greater in joint ventures than in contractual agreements, we are unable to isolate which of the two drives our findings. In a supplementary analysis reported in Appendix C3, we found that greater economic commitments

in the form of minority equity stakes are not sufficient to explain our results, as portfolio considerations determine the choice between nonequity contracts and equity joint ventures, but they do not determine the choice between contracts with and without shared equity. Thus, it could be valuable to examine a more granular governance taxonomy in which some adjacent cooperative forms differ in organizational but not in economic commitments, e.g., contractual agreements with and without a steering committee (Reuer & Devarakonda, 2016).

Our findings also carry implications for managers designing new alliances. When the goal is to deepen expertise and innovate in resource domains that overlap with the firm's existing alliance portfolio, managers may opt for contractual governance over a joint venture. In these settings, joint ventures could be counterproductive, as they amplify inter-partner frictions, increase managerial burden, and may ultimately constrain rather than expand access to sought-after resources. By contrast, when managers pursue alliances in complementary resource domains, joint ventures are more likely to pay off in terms of innovation in complementary resource domains, while looser contractual arrangements risk leaving such value on the table.

Bridging the alliance-portfolio perspective and alliance-governance research, our study argues and shows that the governance choice in a new alliance depends on the anticipated synergies and conflicts created through the addition of this alliance to a firm's existing alliance portfolio. It also offers novel insights into the interplay between alliance portfolios, firms' governance decisions in new alliances, and the nature of their subsequent innovation outputs. We hope our study encourages further research exploring a portfolio perspective both to understand the decisions that firms make regarding the formation, governance, and scope of new alliances, and to understand the implications of these decisions for relevant performance outcomes.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the authors used ChatGPT 4.0 (OpenAI, 2024); “Biotechnology Research Assistant,” (Aisautov, 2024), and “Patent Explorer” (Root, 2024) to match IPC patent categories to ReCap technology categories. Details are provided in Appendix A. After using these tools, the authors reviewed the content as needed. They take full responsibility for the content of the published article.

Aisautov, A. 2024. Biotechnology Research Assistant [Custom version of GPT 4.0].

(<https://chatgpt.com/g/g-9mQGUWr7g-biotechnology-research-assistant>)

OpenAI. 2024. ChatGPT 4.0 (<https://chatgpt.com/?model=gpt-4o>)

Root, C. 2024. Patent Explorer [Custom version of GPT 4.0]. ([https://chatgpt.com/g/g-](https://chatgpt.com/g/g-pwPdZCok6-patent-explorer)

[pwPdZCok6-patent-explorer](https://chatgpt.com/g/g-pwPdZCok6-patent-explorer))

References

- Aggarwal, V. A. 2020. Resource congestion in alliance networks: How a firm's partners' partners influence the benefits of collaboration. *Strategic Management Journal*, 41: 627-655.
- Aggarwal, V. A., Siggelkow, N., & Singh, H. 2011. Governing collaborative activity: Interdependence and the impact of coordination and exploration. *Strategic Management Journal*, 32: 705-730.
- Almeida P., Grant, R., & Phene, A. 2002. Knowledge acquisition through alliances: Opportunities and challenges. In *The Blackwell Handbook of Cross-Cultural Management*, Gannon, M. J. & Newman K. L. (Eds.). Blackwell Publishers Ltd.: Oxford, UK; 67-77.
- Anand, B. N. & Khanna, T. 2000. Do firms learn to create value? The case of alliances. *Strategic Management Journal*, 21: 295-315.
- Argyres, N. S. & Liebeskind, J. P. 1999. Contractual commitments, bargaining power, and governance inseparability: Incorporating history into transaction cost theory. *Academy of Management Review*, 24: 49-63.
- Arkhangelsky, D. & Imbens, G. W. 2024. Fixed effects and the generalized Mundlak estimator. *Review of Economic Studies*, 91: 2545-2571.
- Asgari, N., Singh, K., & Mitchell, W. 2017. Alliance portfolio reconfiguration following a technological discontinuity. *Strategic Management Journal*, 38: 1062-1081.
- Asgari, N., Tandon, V., Singh, K., & Mitchell, W. 2018. Creating and taming discord: How firms manage embedded competition in alliance portfolios to limit alliance termination. *Strategic Management Journal*, 39: 3273-3299.
- Asgari, N., Lévesque, M., Soh, P.-H., & Subramanian, A. M. 2025. It's time to break up: Dynamics surrounding young-established firm alliance duration. *Production and Operations Management*, 34(6): 1276-1305.
- Asgari, N., Nayak, D., Ranganathan, R., & Tandon, V. 2026. Knowledge behind firewalls: How rivalry among alliance partners constrains innovation inside firms. *Organization Science*, forthcoming, <https://doi.org/10.1287/orsc.2022.17230>
- Balachandran, S. & Hernandez, E. 2018. Networks and innovation: Accounting for structural and institutional sources of recombination in brokerage triads. *Organization Science*, 29: 80-99.
- Behr, P. & Faiola, A. 1996. USAir sues to break up with British Airways. *The Washington Post*, July 31, 1996.
- Blackburn, M. 2015. The relative performance of Poisson and negative binomial regression estimators. *Oxford Bulletin of Economics and Statistics*, 77: 605-616.
- Casciaro, T. 2003. Determinants of governance structure in alliances: The role of strategic, task and partner uncertainties. *Industrial and Corporate Change*, 12: 1223-1251.
- Ceccagnoli, M. & Jiang, L. 2013. The cost of integrating external technologies: Supply and demand drivers of value creation in the markets for technology. *Strategic Management Journal*, 34: 404-425.
- Correia, S., Guimarães, P., & Zylkin, T. 2020. Fast Poisson estimation with high-dimensional fixed effects. *Stata Journal*, 20: 95-115.
- de Rond, M. 2003. *Strategic Alliances as Social Facts: Business, Biotechnology and Intellectual History*. Cambridge, UK: Cambridge University Press.
- Devarakonda, R., Reuer, J. J., & Tadikonda, H. 2022. Founder social capital and value appropriation in R&D alliance agreements. *Research Policy*, 51: 104474.
- Duysters, G., Lavie, D., Sabidussi, A., & Stettner, U. 2020. What drives exploration? Convergence and divergence of exploration tendencies among alliance partners and competitors. *Academy of Management Journal*, 63: 1425-1454.

- Doz, Y. L. 1996. The evolution of cooperation in strategic alliances: Initial conditions or learning processes? *Strategic Management Journal*, 17: 55-83.
- Dyer, J. H. & Singh, H. 1998. The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review*, 23: 660-679.
- Firth, D. 1993. Bias reduction in maximum likelihood estimates. *Biometrika*, 80: 27-38.
- Frankort, H. T. W. 2014. Open innovation norms and knowledge transfer in interfirm technology alliances: Evidence from information technology. *Advances in Strategic Management*, 30: 239-282.
- Frankort, H. T. W. 2016. When does knowledge acquisition in R&D alliances increase new product development? The moderating roles of technological relatedness and product-market competition. *Research Policy*, 45: 291-302.
- Frankort, H. T. W. & Hagedoorn, J. 2019. Characteristics of innovation-driven interfirm alliances, 1957-2006: Analysis and research directions. In *Frontiers of Strategic Alliance Research: Negotiating, Structuring and Governing Partnerships*, Contractor, F. J. & Reuer, J. J. (Eds.). Cambridge University Press: Cambridge, UK; 370-392.
- Frankort, H. T. W., Hagedoorn, J., & Letterie, W. 2012. R&D partnership portfolios and the inflow of technological knowledge. *Industrial and Corporate Change*, 21: 507-537.
- Friedmann, J.-C. & Kavusan, K. 2026. Knowledge bridging: How acquirers leverage the knowledge of their targets' prior alliance partners. *Academy of Management Journal*, forthcoming, <https://doi.org/10.5465/amj.2024.1203>
- Friedmann, J.-C., Lavie, D., & Rademaker, L. 2025. Does the predator become the prey? Knowledge spillover and protection in alliances. *Journal of Management*, 51: 3391-3425.
- Friedmann, J.-C., Lavie, D., Rademaker, L., & Shipilov, A. 2025. The hidden battle for IP protection in alliances. *MIT Sloan Management Review*, 66: 35-41.
- Friedmann, J.-C. & Pedersen, T. 2023. National innovation policies and knowledge acquisition in international alliances. *Global Strategy Journal*, 14: 116-151.
- Garcia-Canal, E. 1996. Contractual form in domestic and international strategic alliances. *Organization Studies*, 17: 773-794.
- Gomes-Casseres, B., Hagedoorn, J., & Jaffe, A. B. 2006. Do alliances promote knowledge flows? *Journal of Financial Economics*, 80: 5-33.
- Gulati, R. 1995. Does familiarity breed trust? The implications of repeated ties for contractual choice in alliances. *Academy of Management Journal*, 38: 85-112.
- Gulati, R. & Higgins, M. C. 2003. Which ties matter when? The contingent effects of interorganizational partnerships on IPO success. *Strategic Management Journal*, 24: 127-144.
- Gulati, R., Lavie, D., & Madhavan, R. 2011. How do networks matter? The performance effects of interorganizational networks. *Research in Organizational Behavior*, 31: 207-224.
- Hagedoorn, J., Cloudt, D., & van Kranenburg, H. 2005. Intellectual property rights and the governance of international R&D partnerships. *Journal of International Business Studies*, 36: 175-186.
- Hagedoorn, J. & Hesen, G. 2007. Contract law and the governance of inter-firm technology partnerships – An analysis of different modes of partnering and their contractual implications. *Journal of Management Studies*, 44: 342-366.
- Hall, B. H., Jaffe, A. B., & Trajtenberg, M. 2001. The NBER patent citation data file: Lessons, insights and methodological tools. NBER Working Paper Series, WP 8498.
- Hawk, A., Reuer, J. J., & Garofolo, A. 2024. Intrinsic speed capabilities and alliance partner attractiveness. *Strategic Organization*, 22: 641-67.
- Heckman, J. J. & Borjas, G. J. 1980. Does unemployment cause future unemployment? Definitions, questions and answers from a continuous time model of heterogeneity and state dependence. *Economica*, 47: 247-283.

- Hernandez, E., Lee, J. K., & Shaver, J. M. 2025. Toward an improved causal test of network effects: Does alliance network position enhance firm innovation? *Strategic Management Journal*, 46: 863-897.
- Hernandez, E., Sanders, G., & Tuschke, A. 2015. Network defense: Pruning, grafting, and closing to prevent leakage of strategic knowledge to rivals. *Academy of Management Journal*, 38: 1233-1260.
- Higgins, M. C. & Gulati, R. 2006. Stacking the deck: The effects of top management backgrounds on investor decisions. *Strategic Management Journal*, 27: 1-25.
- Hoehn-Weiss, M. N., Karim, S., & Lee, C. H. 2017. Examining alliance portfolios beyond the dyads: The relevance of redundancy and nonuniformity across and between partners. *Organization Science*, 28: 56-73.
- Hoffmann, W. H. 2007. Strategies for managing a portfolio of alliances. *Strategic Management Journal*, 28: 827-856.
- Hohberger, J., Kruger, H., & Almeida, P. 2020. Does separation hurt? The impact of premature termination of R&D alliances on knowledge acquisition and innovation. *Research Policy*, 49: 103944.
- Howard, M., Steensma, H. K., Lyles, M., & Dhanaraj, C. 2016. Learning to collaborate through collaboration: How allying with expert firms influences collaborative innovation within novice firms. *Strategic Management Journal*, 27: 2092-2103.
- Iacus, S. M., King, G., & Porro, G. 2012. Causal inference without balance checking: Coarsened exact matching. *Political Analysis*, 20: 1-24.
- Jaffe, A.B. 1986. Technological opportunity and spillovers of R&D: Evidence from firms' patents, profits and market value. *American Economic Review*, 76: 984-999.
- Jiang, X., & Li, Y. 2009. An empirical investigation of knowledge management and innovative performance: The case of alliances. *Research Policy*, 38: 358-368.
- Kavusan, K. & Frankort, H. T. W. 2019. A behavioral theory of alliance portfolio reconfiguration: Evidence from pharmaceutical biotechnology. *Strategic Management Journal*, 40: 1668-1702.
- Kavusan, K., Noorderhaven, N. G., & Duysters, G. M. 2016. Knowledge acquisition and complementary specialization in alliances: The impact of technological overlap and alliance experience. *Research Policy*, 45: 2153-2165.
- Kogut, B. 1988. Joint ventures: Theoretical and empirical perspectives. *Strategic Management Journal*, 9: 319-332.
- Kosová, R., Lafontaine, F., & Perrigot, R. 2013. Organizational form and performance: Evidence from the hotel industry. *Review of Economics and Statistics*, 95(4): 1303-1323.
- Kosová, R. & Sertsios, G. 2018. An empirical analysis of self-enforcement mechanisms: Evidence from hotel franchising. *Management Science*, 64: 43-63.
- Lavie, D. 2007. Alliance portfolios and firm performance: A study of value creation and appropriation in the U.S. software industry. *Strategic Management Journal*, 28: 1187-1212.
- Lerner, J., Shane, H., & Tsai, A. 2003. Do equity financing cycles matter? Evidence from biotechnology alliances. *Journal of Financial Economics*, 67: 411-446.
- Li, D., Eden, L., Hitt, M. A., & Ireland, R. D. 2008. Friends, acquaintances, or strangers? Partner selection in R&D alliances. *Academy of Management Journal*, 51: 315-334.
- Lincoln, J. R. 1984. Analyzing relations in dyads: Problems, models, and an application to interorganizational research. *Sociological Methods & Research*, 13: 45-76.
- MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G. & Sheets, V. 2002. A comparison of methods to test mediation and other intervening variable effects. *Psychological Methods*, 7: 83-104.
- Masten S. E. 1993. Transaction costs, mistakes, and performance: Assessing the importance of governance. *Managerial and Decision Economics*, 14: 119-129.

- Milgrom, P. & Roberts, J. 1990. The economics of modern manufacturing: Technology, strategy, and organization. *American Economic Review*, 80: 511-528.
- Mowery, D. C., Oxley, J. E., & Silverman, B. S. 1996. Strategic alliances and interfirm knowledge transfer. *Strategic Management Journal*, Winter Special Issue 17: 77-91.
- Mundlak, Y. 1978. On the pooling of time series and cross section data. *Econometrica*, 46(1): 69-85.
- Raviart, D. 2018. IBM Bluewolf – Salesforce Services. *NelsonHall Analyst Report*, October 12, 2018.
- Nicholls-Nixon, C. L. & Woo, C. Y. 2003. Technology sourcing and output of established firms in a regime of encompassing technological change. *Strategic Management Journal*, 24: 651-666.
- Nightingale, P. 2000. Economies of scale in experimentation: Knowledge and technology in pharmaceutical R&D. *Industrial and Corporate Change*, 9: 315-359.
- Oxley, J. E. 1997. Appropriability hazards and governance in strategic alliances: A transaction cost approach. *Journal of Law, Economics, & Organization*, 13: 387-409.
- Oxley, J. E. 1999. Institutional environment and the mechanisms of governance: The impact of intellectual property protection on the structure of inter-firm alliances. *Journal of Economic Behavior & Organization*, 38: 283-309.
- Oxley, J. E. 2009. Alliances and performance. *Advances in Strategic Management*, 26: 147-164.
- Oxley, J. E. & Sampson, R. C. 2004. The scope and governance of international R&D alliances. *Strategic Management Journal*, 25: 723-749.
- Oxley, J. & Wada, T. 2009. Alliance structure and the scope of knowledge transfer: Evidence from U.S.-Japan agreements. *Management Science*, 55: 635-649.
- Ozcan, P. & Eisenhardt, K. M. 2009. Origin of alliance portfolios: Entrepreneurs, network strategies, and firm performance. *Academy of Management Journal*, 52: 246-279.
- Persidis, A. 1997. Combinatorial chemistry. *Nature Biotechnology*, 15: 391-392.
- Persidis, A. 1998. High-throughput screening. *Nature Biotechnology*, 16: 488-489.
- Phelps, C. C. 2010. A longitudinal study of the influence of alliance network structure and composition on firm exploratory innovation. *Academy of Management Journal*, 53(4): 890-913.
- Reuer, J. J. & Devarakonda, S. V. 2016. Mechanisms of hybrid governance: Administrative committees in non-equity alliances. *Academy of Management Journal*, 59: 510-533.
- Robinson, D. T. & Stuart, T. E. 2007. Network effects in the governance of strategic alliances. *Journal of Law, Economics, & Organization*, 23: 242-273.
- Roijakkers, N. & Hagedoorn, J. 2006. Inter-firm R&D partnering in pharmaceutical biotechnology since 1975: Trends, patterns, and networks. *Research Policy*, 35: 431-446.
- Rothaermel, F. T. 2001a. Complementary assets, strategic alliances, and the incumbent's advantage: An empirical study of industry and firm effects in the biopharmaceutical industry. *Research Policy*, 30: 1235-1251.
- Rothaermel, F. T. 2001b. Incumbent's advantage through exploiting complementary assets via interfirm cooperation. *Strategic Management Journal*, 22: 687-699.
- Rothaermel, F. T. & Boeker, W. 2008. Old technology meets new technology: Complementarities, similarities, and alliance formation. *Strategic Management Journal*, 29: 47-77.
- Runge, S., Schwens, C., & Schulz, M., 2022. The invention performance implications of cooptation: How technological, geographical, and product market overlaps shape learning and competitive tension in R&D alliances. *Strategic Management Journal*, 43: 266-294.
- Ryu, W., McCann, B. T., & Reuer, J. J. 2018. Geographic co-location of partners and rivals: Implications for the design of R&D alliances. *Academy of Management Journal*, 61: 945-965.
- Ryu, W., Reuer, J. J., & Brush, T. H. 2020. The effects of multimarket contact on partner selection for technology cooperation. *Strategic Management Journal*, 41: 267-289.
- Sampson, R. C. 2004a. Organizational choice in R&D alliances: Knowledge-based and transaction cost perspectives. *Managerial and Decision Economics*, 25: 421-436.

- Sampson, R. C. 2004b. The cost of misaligned governance in R&D alliances. *Journal of Law, Economics, & Organization*, 20: 484-526.
- Sampson, R. C. 2007. R&D alliances and firm performance: The impact of technological diversity and alliance organization on innovation. *Academy of Management Journal*, 50(2): 364-386.
- Santos Silva, J. M. C., & Tenreyro, S. 2006. The log of gravity. *Review of Economics and Statistics*, 88: 641-658.
- Santoro, M. D. & McGill, J. P. 2005. The effect of uncertainty and asset co-specialization on governance in biotechnology alliances. *Strategic Management Journal*, 26: 1261-1269.
- Schilling, M. A. 2009. Understanding the alliance data. *Strategic Management Journal*, 30: 233-260.
- Sen, P. & Puranam, P. 2022. Do alliance portfolios encourage or impede new business practice adoption? Theory and evidence from the private equity industry. *Strategic Management Journal*, 43: 2279-2312.
- Singh, J. 2005. Collaborative networks as determinants of knowledge diffusion patterns. *Management Science*, 51(5): 756-770.
- Singh, K. & Mitchell, W. 1996. Precarious collaboration: Business survival after partners shut down or form new partnerships. *Strategic Management Journal*, 17: 99-115.
- Stuart, E. A., 2010. Matching methods for causal inference: A review and a look forward. *Statistical Science*, 25: 1-21.
- Teece, D. J. 1986. Profiting from technological innovation: implications for integration, collaboration, licensing, and public policy. *Research Policy*, 15: 285-305
- Thomke, S. & Kuemmerle, W. 2002. Asset accumulation, interdependence and technological change: Evidence from pharmaceutical drug discovery. *Strategic Management Journal*, 23: 619-635.
- Van de Vrande, V. 2013. Balancing your technology-sourcing portfolio: How sourcing mode diversity enhances innovative performance. *Strategic Management Journal*, 34: 610-621.
- Verginer, L., Parisi, F., van Lidth de Jeude, J., & Riccaboni, M. 2025. Acquisitions as catalysts for inventor departures in the biotechnology industry. *Humanities and Social Sciences Communications*, 12: 607.
- Wassmer, U. & Dussauge, P. 2012. Network resource stocks and flows: How do alliance portfolios affect the value of new alliance formations? *Strategic Management Journal*, 33: 871-883.
- Wassmer, U., Li, S., & Madhok, A. 2017. Resource ambidexterity through alliance portfolios and firm performance. *Strategic Management Journal*, 38: 384-294.
- Williamson, O. E. 1991. Comparative economic organization: The analysis of discrete structural alternatives. *Administrative Science Quarterly*, 36: 269-296.
- Wilson, N. E. 2015. Vertical separation increases gasoline prices. *Economic Inquiry*, 53: 1380-1391.
- Woo, H.-S., Berns, J. P., & Solanelles, P. 2023. How rare is rare? How common is common? Empirical issues associated with binary dependent variables with rare or common event rates. *Organizational Research Methods*, 26: 655-677.
- Wooldridge, J. M. 2010. *Econometric Analysis of Cross Section and Panel Data, Second Edition*. Cambridge, MA: MIT Press.
- Yzerbyt, V., Muller, D., Batailler, C., & Judd, C. M. 2018. New recommendations for testing indirect effects in mediational models: The need to report and test component paths. *Journal of Personality and Social Psychology*, 115: 929-943.

Table 1
Summary Statistics

Variables	Full sample (N = 683)				Subsample with partner patent data (N = 466)			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Joint venture	0.04	0.19	0	1	0.03	0.18	0	1
Portfolio similarity	1.23	0.82	0	4	1.25	0.82	0	4
Portfolio complementarity	0.43	0.92	0	7	0.39	0.86	0	7
Innovation in similar domains	–	–	–	–	60.97	118.11	0	617
Innovation in complementary domains	–	–	–	–	19.53	46.90	0	389
Contract experience	15.78	16.32	1	88	15.57	15.58	1	88
JV experience	0.51	1.08	0	5	0.47	1.02	0	5
Emerging-technology patents	0.44	1.23	0	9	0.37	1.07	0	9
Other patents	85.71	160.09	0	686	81.13	152.39	0	686
Partner contract experience	3.99	6.08	0	36	5.15	6.83	0	36
Partner JV experience	0.13	0.54	0	7	0.08	0.30	0	2
Partner emerging-technology patents	–	–	–	–	1.77	4.25	0	28
Partner other patents	–	–	–	–	670.89	970.80	0	4567
Technological relatedness	–	–	–	–	0.42	0.32	0	1
Repeated ties	0.11	0.36	0	3	0.11	0.36	0	2
Vertical scope	0.13	0.34	0	1	0.14	0.35	0	1
Horizontal scope	1.66	0.71	1	3	1.68	0.73	1	3
Discovery	0.69	0.46	0	1	0.69	0.46	0	1
Lead molecule	0.07	0.26	0	1	0.07	0.26	0	1
Formulation	0.07	0.26	0	1	0.07	0.25	0	1
Pre-clinical	0.06	0.23	0	1	0.05	0.21	0	1
Phase I/II/III trials	0.11	0.32	0	1	0.12	0.33	0	1

Table 2
 Bivariate Correlations: Full sample below diagonal (N = 683); Subsample with partner patent data above diagonal (N = 466)

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.
1. Joint venture		-0.13	0.11	-0.06	0.09	-0.06	-0.05	-0.03	-0.05	-0.03	-0.01	-0.04	-0.03	-0.00	0.01	0.21	-0.04	-0.09	-0.00	-0.05	0.02	0.16
2. Portfolio similarity	-0.09		0.02	0.14	-0.08	0.09	-0.02	0.10	0.05	0.09	0.01	0.14	0.15	-0.02	0.07	-0.10	0.67	0.26	-0.05	-0.25	-0.04	-0.11
3. Portfolio complementarity	0.08	0.01		-0.06	0.01	0.07	0.09	0.15	0.03	-0.06	-0.03	-0.06	0.02	0.04	-0.06	0.04	0.08	0.06	0.08	-0.09	-0.07	-0.04
4. Innovation in similar domains	-	-	-		0.06	0.21	0.16	0.10	0.33	0.09	-0.00	0.09	0.19	0.03	0.04	-0.06	-0.02	0.18	-0.05	-0.11	-0.06	-0.11
5. Innovation in complementary domains	-	-	-	-		0.43	0.47	0.23	0.48	-0.21	-0.07	-0.13	-0.22	-0.03	-0.10	0.02	-0.09	-0.03	-0.06	0.04	0.04	0.03
6. Contract experience	-0.05	0.14	0.12	-	-		0.70	0.62	0.82	-0.10	-0.08	-0.02	-0.09	0.12	0.05	0.02	0.03	-0.02	-0.07	-0.00	0.07	0.03
7. JV experience	-0.02	0.02	0.09	-	-	0.71		0.43	0.71	-0.08	-0.07	-0.06	-0.08	0.08	0.02	0.02	-0.01	-0.10	-0.01	0.06	0.13	0.03
8. Emerging-technology patents	-0.03	0.12	0.24	-	-	0.64	0.43		0.65	-0.07	0.06	-0.02	-0.03	0.09	-0.01	0.01	0.07	0.06	-0.04	-0.05	-0.02	0.00
9. Other patents	-0.02	0.08	0.09	-	-	0.83	0.71	0.70		-0.09	-0.06	0.01	-0.08	0.13	0.00	0.00	0.01	0.02	-0.06	-0.00	0.03	0.01
10. Partner contract experience	-0.05	0.10	-0.07	-	-	-0.10	-0.08	-0.08	-0.09		0.31	0.32	0.32	-0.02	0.12	0.01	0.03	-0.11	0.10	-0.11	0.05	0.13
11. Partner JV experience	0.11	0.05	0.02	-	-	-0.03	-0.03	0.00	-0.03	0.20		0.10	0.17	0.03	0.09	0.01	0.03	-0.11	0.15	-0.02	0.04	0.03
12. Partner emerging-technology patents	-	-	-	-	-	-	-	-	-	-	-		0.44	-0.01	0.18	-0.04	0.09	-0.01	0.01	-0.11	0.01	0.08
13. Partner other patents	-	-	-	-	-	-	-	-	-	-	-	-		-0.16	0.17	-0.02	-0.02	0.03	0.09	-0.12	0.01	-0.03
14. Technological relatedness	-	-	-	-	-	-	-	-	-	-	-	-	-		0.01	0.12	0.03	-0.10	0.05	0.04	0.03	0.05
15. Repeated ties	0.00	0.10	-0.05	-	-	0.05	0.02	-0.02	0.01	0.13	0.16	-	-	-		0.03	0.02	-0.11	0.12	-0.06	0.01	0.10
16. Vertical scope	0.21	-0.08	0.01	-	-	0.04	0.02	-0.01	0.02	0.02	0.03	-	-	-	0.04		-0.11	-0.38	0.01	0.04	0.17	0.38
17. Horizontal scope	-0.03	0.68	0.07	-	-	0.06	0.00	0.09	0.03	0.04	0.04	-	-	-	0.03	-0.10		0.27	-0.11	-0.16	-0.04	-0.15
18. Discovery	-0.15	0.21	0.08	-	-	-0.03	-0.11	0.07	-0.00	-0.10	-0.11	-	-	-	-0.07	-0.36	0.22		-0.41	-0.41	-0.33	-0.56
19. Lead molecule	0.00	-0.03	0.04	-	-	-0.02	0.05	-0.03	-0.03	0.09	0.08	-	-	-	0.07	0.01	-0.06	-0.41		-0.07	-0.06	-0.10
20. Formulation	0.04	-0.21	-0.10	-	-	-0.04	0.01	-0.07	-0.03	-0.09	0.05	-	-	-	-0.07	0.04	-0.17	-0.41	-0.08		-0.06	-0.10
21. Pre-clinical	0.05	-0.01	-0.05	-	-	0.06	0.06	-0.03	0.01	0.02	0.01	-	-	-	0.05	0.20	0.00	-0.37	-0.07	-0.07		-0.08
22. Phase I/II/III trials	0.15	-0.10	-0.03	-	-	0.06	0.08	0.01	0.04	0.13	0.04	-	-	-	0.06	0.34	-0.14	-0.53	-0.10	-0.10	-0.09	

Table 3
 Penalized Logistic Regression Estimates of Alliance Governance Choice
 (1 = JV; 0 = Contractual Agreement)

		(1)	(2)	(3)	(4)	(5)	(6)
Portfolio similarity	H1a	-0.65*		-0.65+	-1.05*		-1.03*
		(0.33)		(0.34)	(0.41)		(0.43)
Portfolio complementarity	H2a		0.58**	0.55**		0.61*	0.53*
			(0.21)	(0.21)		(0.25)	(0.24)
Contract experience		-0.04+	-0.05*	-0.05+	-0.01	-0.03	-0.01
		(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
JV experience		0.10	0.04	0.03	-0.14	-0.30	-0.32
		(0.31)	(0.33)	(0.32)	(0.49)	(0.51)	(0.52)
Emerging-technology patents		0.01	-0.21	-0.15	0.32	0.01	0.15
		(0.30)	(0.30)	(0.29)	(0.33)	(0.37)	(0.34)
Other patents		0.00	0.00	0.00	-0.00	0.00	0.00
		(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.01)
Partner contract experience		-0.09	-0.09+	-0.08	-0.03	-0.03	-0.03
		(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Partner JV experience		0.57***	0.49**	0.54**	-0.02	0.34	0.04
		(0.17)	(0.17)	(0.17)	(0.91)	(0.85)	(0.90)
Partner emerging-technology patents					-0.02	-0.02	-0.00
					(0.10)	(0.09)	(0.09)
Partner other patents					0.00	-0.00	0.00
					(0.00)	(0.00)	(0.00)
Technological relatedness					-0.41	-0.29	-0.27
					(0.92)	(0.87)	(0.90)
Repeated ties		0.19	0.33	0.29	0.14	0.64	0.31
		(0.54)	(0.53)	(0.55)	(0.64)	(0.61)	(0.66)
Vertical scope		1.55**	1.38**	1.49**	1.63*	1.47*	1.52*
		(0.48)	(0.48)	(0.49)	(0.68)	(0.62)	(0.66)
Horizontal scope		0.50	0.07	0.43	0.74	-0.05	0.59
		(0.37)	(0.34)	(0.38)	(0.48)	(0.44)	(0.50)
Lead molecule		0.89	0.91	0.87	0.61	0.53	0.60
		(0.76)	(0.76)	(0.76)	(0.93)	(0.97)	(0.93)
Formulation		0.53	1.13	0.86	-1.24	-0.32	-0.82
		(0.70)	(0.72)	(0.72)	(1.51)	(1.51)	(1.50)
Pre-clinical		0.90	1.23	1.18	0.52	1.05	0.86
		(0.74)	(0.77)	(0.76)	(1.07)	(1.08)	(1.08)
Phase I/II/III trials		1.24*	1.57**	1.36*	0.77	1.14	0.97
		(0.59)	(0.60)	(0.61)	(0.74)	(0.74)	(0.76)
Year fixed effects		Y	Y	Y	Y	Y	Y
Observations		683	683	683	466	466	466
Penalized log-likelihood		-61.31	-59.77	-56.87	-19.04	-19.51	-15.56

Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05, + p<0.10. All equations include a constant term.

Table 4
PPML Regression Estimates of Innovation during New Alliance

Sample:	Full sample		Matched sample		Full sample	
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Innovation in similar domains (H1b)	Innovation in complementary domains (H2b)	Innovation in similar domains (H1b)	Innovation in complementary domains (H2b)	Innovation in similar domains (H1b)	Innovation in complementary domains (H2b)
Joint venture	-0.83* (0.37)	1.06** (0.41)	-1.63*** (0.14)	0.89* (0.38)	-0.88** (0.30)	1.04** (0.34)
Contract experience	0.02* (0.01)	0.01 (0.01)			0.01 (0.01)	-0.03 (0.02)
JV experience	-0.24** (0.08)	0.10 (0.08)			-0.15 (0.17)	-0.07 (0.53)
Emerging-technology patents	-0.25*** (0.06)	-0.13* (0.06)	0.27** (0.09)	-0.19 (0.17)	-0.14+ (0.09)	-0.01 (0.15)
Other patents	0.00*** (0.00)	0.00*** (0.00)			-0.00*** (0.00)	0.00 (0.00)
Partner contract experience	0.02+ (0.01)	-0.08*** (0.02)	-0.02 (0.02)	-0.13** (0.04)	0.02*** (0.01)	-0.08*** (0.02)
Partner JV experience	0.07 (0.25)	0.08 (0.39)	0.06 (0.18)	0.37 (0.34)	0.15 (0.19)	-0.04 (0.30)
Partner emerging-technology patents	-0.02 (0.02)	-0.05 (0.05)	-0.03 (0.04)	0.00 (0.07)	-0.01 (0.01)	-0.03 (0.05)
Partner other patents	0.00*** (0.00)	-0.00*** (0.00)	0.00*** (0.00)	-0.00+ (0.00)	0.00*** (0.00)	-0.00*** (0.00)
Technological relatedness	0.43+ (0.22)	-0.81** (0.26)	0.84* (0.35)	-0.36 (0.39)	0.53** (0.19)	-1.36*** (0.25)
Repeated ties	0.04 (0.14)	-0.80* (0.31)	0.25 (0.38)	-0.95+ (0.53)	0.18* (0.08)	-0.46 (0.28)
Vertical scope	0.16 (0.20)	0.05 (0.19)			0.21 (0.17)	-0.30 (0.19)
Horizontal scope	-0.08 (0.11)	-0.18 (0.13)	-0.13 (0.12)	-0.29+ (0.17)	0.06 (0.08)	-0.21 (0.14)
Lead molecule	-0.77* (0.33)	0.13 (0.31)	-0.32 (0.46)	0.92** (0.36)	0.07 (0.24)	0.36 (0.31)
Formulation	-1.34*** (0.20)	-0.45* (0.22)	-0.84* (0.35)	-0.65 (0.47)	-0.47+ (0.28)	-0.09 (0.27)
Pre-clinical	-1.30** (0.44)	-0.13 (0.30)	-2.34* (0.98)	-0.29 (0.58)	-0.14 (0.29)	0.60+ (0.33)
Phase I/II/III trials	-1.10*** (0.23)	-0.26 (0.21)			-0.16 (0.23)	0.31 (0.22)
Year fixed effects	Y	Y	Y	Y	Y	Y
Match-strata fixed effects	N	N	Y	Y	N	N
Mundlak controls (unit means)	N	N	N	N	Y	Y
Observations	466	466	220	220	466	466
Log pseudo-likelihood	-19046	-6459	-3423	-1643	-7958	-5112

Standard errors clustered by alliance in parentheses. *** p<0.001, ** p<0.01, * p<0.05, + p<0.10. All equations include a constant term.

Table 5
Median Incidence Rate Ratios for Effects Mediated by Joint Venture

Indirect effect				Median IRR	95% CI	
Portfolio similarity	→	Joint venture	→	Innovation in similar domains	2.71	[1.22; 8.98]
Portfolio complementarity	→	Joint venture	→	Innovation in complementary domains	1.79	[1.11, 3.56]
Portfolio similarity	→	Joint venture	→	Innovation in complementary domains	0.31	[0.07; 0.78]
Portfolio complementarity	→	Joint venture	→	Innovation in similar domains	0.62	[0.42; 0.89]

Median IRRs and 95% confidence intervals are based on Monte Carlo resampling with 10,000 repetitions.

Figure 1
Alliance Portfolio Interdependencies and Governance Choice

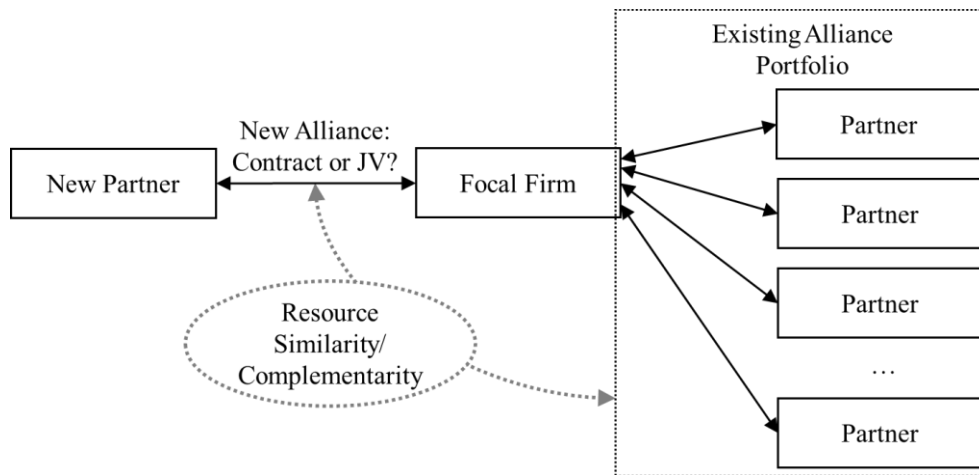
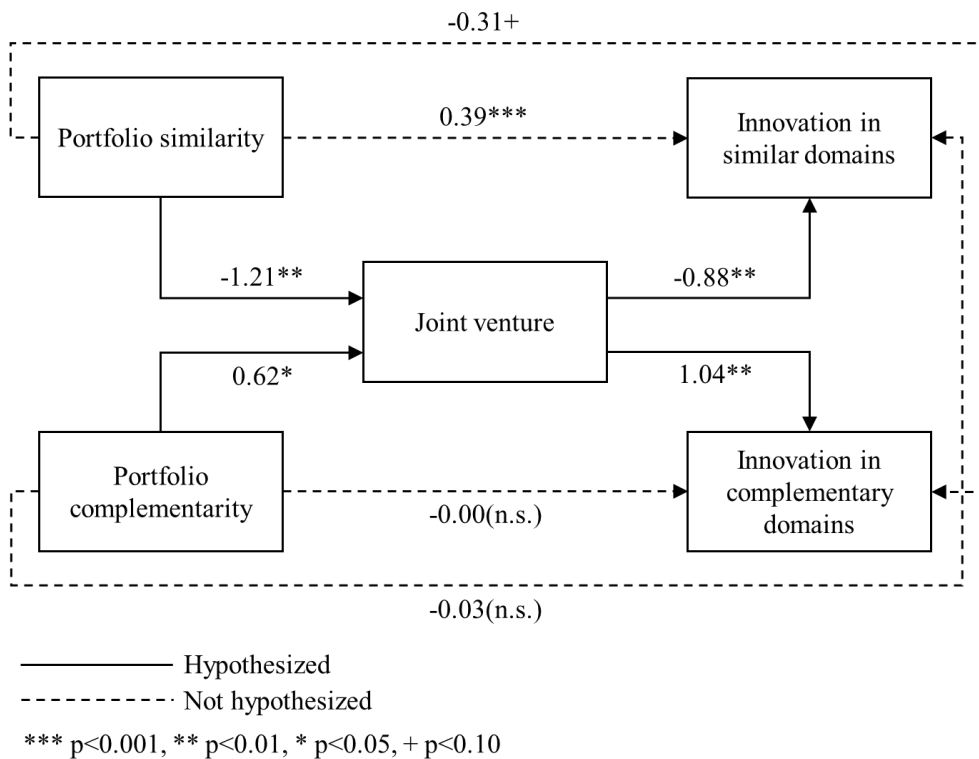


Figure 2
Path Diagram of Generalized Structural Equation Model



APPENDIX

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Appendix A: Identifying Patent Classes of Emerging and Reinforced Technologies

To compile a comprehensive list of IPC categories associated with the two emerging and 13 reinforced technology categories identified by Asgari et al. (2017), we proceeded in several steps.

First, we inputted the list of emerging and reinforced ReCap technologies into three generative AI applications: (a) ChatGPT 4.0 (OpenAI, 2024), (b) “Biotechnology Research Assistant,” a biotech-specific custom version of ChatGPT (Aisautov, 2024), and (c) “Patent Explorer,” a patent-research-specific custom version of ChatGPT (Root, 2024). We prompted each application to provide a list of relevant IPC classes, along with explanations of how each class relates to the technologies. For instance, we used prompts such as: “Consider the following technologies common to the biopharma industry. List all IPC patent classes in which inventions related to each technology would typically be patented. Minimize overlap between identified patent classes and provide an explanation for each match.”

Second, after consolidating the lists of IPC classes identified by the three applications, we reversed the matching procedure. We re-entered shuffled lists of the identified IPC classes and ReCap technologies into the applications. We initiated new “chats” to prompt each application to match technologies with corresponding IPC classes. The prompt used in this step was: “Consider two lists of (a) IPC patent classes and (b) technologies in the biopharma industry. Match each patent class to technologies commonly patented within it. Aim to minimize overlap, and provide a brief justification for each match.” We then compared the results and discarded patent classes that were mismatched or inconsistently matched by the different AI applications. When we encountered discrepancies, we requested additional justifications from the applications, which we evaluated by cross-referencing USPTO patent applications during the sampling period in those patent classes.

Third, we manually verified each matched IPC class to confirm it existed within the 2008 version of the IPC and ensure that the AI-provided descriptions aligned with the official IPC

descriptions. We used the 2008 IPC version because patent classifications change over time and the NBER patent data rely on the 2008 classification. We removed any classes from the list that could not be unequivocally identified or whose IPC description conflicted with the AI-generated descriptions. We ensured that while some overlap among IPC classes for the reinforced technologies was permissible, there was no overlap between IPC classes belonging to the emerging technologies and those belonging to the reinforced technologies.

Finally, we consulted five industry experts—two experienced biopharma R&D practitioners and three scientists working in academia. Through their experience of fundamental and applied research on biotechnologies, all have extensive knowledge of patenting in this context. Based on the list of ReCap technologies linked to IPC classes resulting from the above process, we asked them to flag any potential mismatches. Overall, they found the AI-generated matches reasonable and agreed that activities in the various ReCap technologies plausibly relate to patenting in the matched patent classes. One expert raised some concern, particularly regarding the match of G01N 27/327 to High-throughput Screening, suggesting this patent class might match the Service Laboratory technology. This patent class turned out to be only minimally relevant to our sample because only one focal firm applied for a single patent in this class, out of a total of just 49 applications in that class across nearly 5 million USPTO patent applications between 1901 and 2006. Given this context, the effect of this potential misclassification is negligible. Indeed, even when we take the extreme precaution of conservatively excluding this entire focal firm (Chiron Corporation) from the dataset—despite the minimal relevance of the potential misclassification—our inferences remain identical.

Table A1 shows the final IPC class list for the various emerging and reinforced technologies, which we used to construct measures of innovation in similar and complementary domains.

Table A1
IPC Classes for Emerging and Reinforced ReCap Technologies

ReCap Technology	Category	IPC class	IPC class name	Description
Combinatorial Chemistry	Emerging	C40B	Combinatorial chemistry; libraries, e.g. chemical libraries, in silico libraries	General category for combinatorial chemistry.
High-throughput Screening	Emerging	C12N 15/10	Processes for the isolation, preparation or purification of DNA or RNA	Relates to genetic engineering, often seen in HTS for drug development and genetic screenings.
High-throughput Screening	Emerging	C12Q 1/00	Measuring or testing processes involving enzymes or micro-organisms; compositions therefor; processes of preparing such compositions	Biological material testing, involving rapid screening biological samples (e.g., proteins, nucleic acids) for specific properties.
High-throughput Screening	Emerging	C12Q 1/68	Genetic testing involving nucleic acids	Genetic testing using microarray technology, which is often used in HTS to simultaneously analyze thousands of genetic sequences or protein interactions.
High-throughput Screening	Emerging	G01N 27/327	Investigating or analysing materials by the use of biochemical electrodes	Investigation or analysis of biological material using electrochemical sensors.
High-throughput Screening	Emerging	G01N 33/00	Investigating or analysing materials by specific methods not covered by groups G01N 1/00-G01N 31/00	Chemical and biological analysis, including the analysis of biochemical reactions.
High-throughput Screening	Emerging	G01N 33/48	Biological material	Analytical methods for testing biological samples (such as cell-based assays or molecular interactions).
High-throughput Screening	Emerging	G01N 33/49	Blood, urine, gaseous biological material, e.g., breath	Analytical methods for testing biological samples (such as cell-based assays or molecular interactions).
High-throughput Screening	Emerging	G01N 33/50	Chemical analysis of biological material, e.g. blood, urine; testing involving biospecific ligand binding methods; Immunological testing	Analytical methods for testing biological samples (such as cell-based assays or molecular interactions).
High-throughput Screening	Emerging	G06F 19/00	Digital computing or data processing equipment or methods, specially adapted for specific applications	Data processing in bioinformatics.

High-throughput Screening	Emerging	G06F 7/00	Methods or arrangements for processing data by operating upon the order or content of the data handled	Methods for processing sequences of data.
Device	Reinforced	A61B	Diagnosis; surgery; identification	Medical devices for diagnosis and surgery.
Device	Reinforced	A61M	Devices for introducing media into, or onto, the body; devices for transducing body media or for taking media from the body; devices for producing or ending sleep or stupor	Medical devices for drug delivery.
Device	Reinforced	B01L	Chemical or physical laboratory apparatus for general use	General laboratory equipment or machines.
Device	Reinforced	C12M	Apparatus for enzymology or microbiology	Instruments specifically for microbiological or enzymological methods.
Drug Delivery - Liposomes	Reinforced	A61K	Preparations for medical, dental, or toilet purposes	Medical compositions using liposomes for drug delivery.
Drug Delivery - Liposomes	Reinforced	C12N, except C12N 15/10	Micro-organisms or enzymes; compositions thereof; propagating, preserving, or maintaining micro-organisms; mutation or genetic engineering; culture media	Liposomal structures applied in biotechnology.
Drug Delivery - Oral	Reinforced	A61K	Preparations for medical, dental, or toilet purposes	Preparations for oral pharmaceutical administration.
Microarrays	Reinforced	C12M	Apparatus for enzymology or microbiology	Devices used in biotechnological testing, including microarrays.
Microarrays	Reinforced	C12Q, except C12Q 1/00 and C12Q 1/68	Measuring or testing processes involving enzymes or micro-organisms; compositions or test papers therefor; processes of preparing such compositions; condition-responsive control in microbiological or enzymological processes	Techniques using microarrays for nucleic acid analysis.
Microarrays	Reinforced	G01N, except G01N 27/327 and G01N 33/00 and G01N 33/48 and G01N 33/49 and G01N 33/50	Investigating or analysing materials by determining their chemical or physical properties	Analytical instruments for biological microarray analysis.
Microspheres	Reinforced	A61K	Preparations for medical, dental, or toilet purposes	Drug delivery systems using microspheres.
Microspheres	Reinforced	B82Y	Specific uses or applications of nanostructures	Nanostructured materials like microspheres for medical applications.
Monoclonals - Conjugates	Reinforced	A61K	Preparations for medical, dental, or toilet purposes	Therapeutic monoclonal antibodies conjugated to drugs.

Monoclonals - Conjugates	Reinforced	C07K	Peptides	Specific peptides, including monoclonal antibodies.
Monoclonals - Conjugates	Reinforced	C12N, except C12N 15/10	Micro-organisms or enzymes; compositions thereof; propagating, preserving, or maintaining micro-organisms; mutation or genetic engineering; culture media	Biotechnology methods related to monoclonal antibodies.
Natural Product	Reinforced	A61K	Preparations for medical, dental, or toilet purposes	Medicinal compositions derived from natural sources.
Natural Product	Reinforced	C07D	Heterocyclic compounds	Organic compounds, including those derived from natural products.
Natural Product	Reinforced	C07K	Peptides	Peptides derived from natural products.
Natural Product	Reinforced	C12P	Fermentation or enzyme-using processes to synthesise a desired chemical compound or composition or to separate optical isomers from a racemic mixture	Industrial production of natural products via biotechnology.
Peptides	Reinforced	A61K	Preparations for medical, dental, or toilet purposes	Medicinal preparations containing peptides.
Peptides	Reinforced	C07K	Peptides	General category for peptides.
Peptides	Reinforced	C12N, except C12N 15/10	Micro-organisms or enzymes; compositions thereof; propagating, preserving, or maintaining micro-organisms; mutation or genetic engineering; culture media	Peptides produced by biotechnology.
Rational Drug Design - Computational	Reinforced	G06F, except G06F 7/00 and G06F 19/00	Electric digital data processing	Computational methods for rational drug design, especially in bioinformatics.
Rational Drug Design - Small Molecules	Reinforced	C07C	Acyclic or carbocyclic compounds	Small molecule organic compounds for therapeutic applications.
Rational Drug Design - Small Molecules	Reinforced	C07D	Heterocyclic compounds	Heterocyclic small molecules used in drug design.
Rational Drug Design - Small Molecules	Reinforced	A61K	Preparations for medical, dental, or toilet purposes	Medicinal compositions containing small molecules.
Service Laboratory	Reinforced	B01L	Chemical or physical laboratory apparatus for general use	Laboratory services and devices for biological testing.
Service Laboratory	Reinforced	C12M	Apparatus for enzymology or microbiology	Biotechnology laboratory equipment.
Service Laboratory	Reinforced	C12Q, except C12Q 1/00 and C12Q 1/68	Measuring or testing processes involving enzymes or micro-organisms; compositions or test papers therefor; processes of preparing such	Laboratory techniques for analyzing biological samples.

			compositions; condition-responsive control in microbiological or enzymological processes	
Service Laboratory	Reinforced	G01N, except G01N 27/327 and G01N 33/00 and G01N 33/48 and G01N 33/49 and G01N 33/50	Investigating or analysing materials by determining their chemical or physical properties	Devices used in scientific or biological testing and analysis.
Small Molecules (Synthetics)	Reinforced	A61K	Preparations for medical, dental, or toilet purposes	Synthetic pharmaceutical compositions.
Small Molecules (Synthetics)	Reinforced	C07C	Acyclic or carbocyclic compounds	Organic small molecules for medicinal purposes.
Small Molecules (Synthetics)	Reinforced	C07D	Heterocyclic compounds	Heterocyclic compounds relevant for synthetic drug design.
In-Licensed Products	Reinforced	No specific corresponding IPC class.		

Appendix B:
Numerical Example: Innovation in Similar vs. Complementary Resource Domains

Suppose a hypothetical focal firm, Firm A, formed an alliance with a new partner, Firm B, in 1996. We then calculate patenting activity in two steps, using two time windows:

1. Pre-alliance period (1986–1995) – Identifies past patenting activity by Firm A’s existing partners and the new partner Firm B
2. Post-alliance period (1996–2000) – Measures Firm A’s innovation outputs in similar and complementary domains

Step 1: Identify Past Patent Activity by Existing and New Partners (1986–1995)

In the decade before the focal alliance, Firm A’s portfolio partners and the new partner, Firm B, patented in the following domains:

	IPC Class	Category
Firm A’s portfolio partners:	C40B A61J	Emerging technology Other technology
Firm B (new partner):	C40B A61J C12M B82Y	Emerging technology Other technology Reinforced technology Reinforced technology

Step 2: Define the Two Innovation Measures (1996–2000)

1. Innovation in Similar Domains (Hypothesis 1b)
 - The shared IPC classes between Firm B and Firm A’s existing portfolio partners are C40B (emerging technology) and A61J (other technology).
 - Thus, if Firm A patents in C40B and/or A61J during 1996–2000, these patents count toward innovation in similar resource domains.
 - Suppose Firm A successfully applied for 3 new patents in C40B and 6 new patents in A61J during 1996–2000.
 - Then *Innovation in similar domains* = 3 + 6 = 9.
2. Innovation in Complementary Domains (Hypothesis 2b)
 - Firm B patented in C12M and B82Y, in which Firm A’s portfolio partners did not patent.
 - However, C12M and B82Y are reinforced resource domains that complement C40B, the emerging resource domain in which Firm A’s portfolio partners did patent.
 - Thus, if Firm A patents in C12M and/or B82Y during 1996–2000, these patents count toward innovation in complementary resource domains.
 - Suppose Firm A successfully applied for 11 new patents in C12M and 24 new patents in B82Y during 1996–2000.
 - Then *Innovation in complementary domains* = 11 + 24 = 35.
 - This measure is specific. It only counts Firm A’s patents in complementary resource domains in which the new partner has been active. It does not count Firm A’s patents in resource domains complementing C40B in which the new partner has not been active.

Appendix C: Further Analyses on Governance Choice

C1. Alternative Operationalizations of Portfolio Similarity and Complementarity

We predicted governance choice considering alternative operationalizations of portfolio similarity and portfolio complementarity. These analyses are shown in Table C1. Model 1 includes the same measures of similarity and complementarity also used in the main analysis. These measures can be considered to represent the “breadth” of resource similarities and complementarities in resource categories between the focal and portfolio alliances. In Model 2, we replace these measures with their frequency-weighted versions, that indicate the “depth” of resource similarities and complementarities. *Portfolio similarity (depth)*, counts the number of times resource categories appear in a firm’s existing alliance portfolio that also appear in the focal alliance. Similarly, *Portfolio complementarity (depth)* counts the number of times resource categories appear in a firm’s existing alliance portfolio that have complementarities with ones in the focal alliance. The corresponding estimates reveal broadly consistent results for the depth measures, although the negative coefficient on the similarity measure is noisier, so we find no clear evidence that the depth of portfolio similarity predicts alliance governance.

Models 3 and 4 split out the breadth and depth measures of portfolio complementarity by whether a firm’s portfolio supplies reinforced resources that complement emerging resources in the focal alliance (*Portfolio complementarity – emerging focal*), or the firm’s portfolio instead supplies emerging resources that complement reinforced resources in the focal alliance (*Portfolio complementarity – reinforced focal*). In those estimates, *Portfolio complementarity – reinforced focal* has meaningful associations with governance choice in line with Hypothesis 2a, while *Portfolio complementarity – emerging focal* does not. This finding suggests that portfolio complementarity is associated with a greater likelihood that the focal alliance is an equity joint venture when an alliance containing reinforced resources is added to a portfolio at least containing

one emerging resource. Reinforced resources had been in common use prior to the discontinuity and so were familiar to many industry players relative to emerging resources. Thus, mere unfamiliarity seems implausible as a driver of the effect of portfolio complementarity on alliance governance choice.

To probe this issue further, we can move beyond the generic familiarity with kinds of resources to consider the familiarity of the focal firm with such resources. The estimates in Models 5-8 achieve exactly this, by restricting the sample: They consider only observations for firms that already, through their existing alliance portfolio, have access to the emerging or reinforced resource categories accessed through the focal alliance. By restricting the sample this way, we can more conclusively rule out the possibility that the effects of portfolio complementarity are driven by a firm's unfamiliarity with the resources in the focal alliance. Models 5 and 6 consider *Portfolio complementarity (breadth)* and *Portfolio complementarity (depth)* as in Models 1 and 2. Models 7 and 8 instead consider the disaggregated measures as in Models 3 and 4. The results remain broadly consistent.

C2. Using a Measure of Distinctiveness instead of Complementarity

To test Hypothesis 2a, we required a measure of the extent to which the resources in a firm's existing alliance portfolio complement the resources in the focal alliance. For two resource categories to be complementary, they must be not only be distinct but also known to be superadditive. Thus, we tested Hypothesis 2a focusing on resources with known complementarities during our sampling window. Of course, distinct resources per se determine the *potential* for synergies (e.g., Gulati et al., 2011): the greater the number of distinct resource categories a firm accesses through its portfolio, the greater the scope for synergistic combinations.

This more generic argument permits a less precise test of Hypothesis 2a, based on measures of portfolio distinctiveness rather than complementarity. The measure for portfolio distinctiveness,

Portfolio distinctiveness, counts the number of resource categories in a firm's existing alliance portfolio that do not appear in the focal alliance.¹ The estimates in Table C2 reveal that results for the breadth of portfolio distinctiveness resemble the results for complementarity in Table 3 in the main document.

C3. Considering a More Granular Governance Spectrum

Finally, we examined a more granular governance spectrum. Compared to contractual agreements, joint ventures imply greater monetary and organizational commitments. Yet intermediate mechanisms exist in the form of minority equity stakes, which constitute a subset of contractual agreements containing explicit monetary commitments (Gulati & Singh, 1998). Might portfolio considerations differentially determine the choice among a nonequity contractual agreement, contractual agreement plus minority equity, and an equity joint venture? Table C3 shows multinomial logit estimates, which compare the choice of either a contract plus minority equity or an equity joint venture against the baseline of a nonequity contract. These estimates suggest that portfolio similarity determines the choice between contractual agreements and equity joint ventures (Model 1), as does portfolio complementarity (Model 2). Yet, strikingly, no evidence exists that portfolio considerations also determine the choice between contractual agreements with and without equity stakes. Clearly, the sampled firms dealt with the portfolio considerations of similarity and complementarity through a combination of monetary and organizational mechanisms.

¹ Portfolio distinctiveness is not by definition the mirror image of portfolio similarity because a firm's alliance portfolio may contain both resources that resemble, yet also resources that are distinct from, the resources exchanged in a new alliance. The correlation between portfolio similarity and portfolio distinctiveness is -0.28.

Table C1
 Penalized Logistic Regression Estimates of Alliance Governance Choice (1 = JV; 0 = Contractual Agreement):
 Alternative Specifications

Sample:		Full sample				New alliances containing emerging and/or reinforced resources, provided the focal firm has such resources in its existing portfolio			
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Portfolio similarity (breadth)	H1a	-0.65+ (0.34)		-0.78* (0.36)		-1.14+ (0.62)		-1.18+ (0.63)	
Portfolio similarity (depth)	H1a		-0.03 (0.04)		-0.03 (0.04)		-0.01 (0.06)		-0.02 (0.06)
Portfolio complementarity (breadth)	H2a	0.55** (0.21)				0.58+ (0.32)			
Portfolio complementarity (depth)	H2a		0.12** (0.05)				0.16+ (0.10)		
Portfolio complementarity - emerging focal (breadth)	H2a			-0.03 (0.42)				0.26 (0.47)	
Portfolio complementarity - reinforced focal (breadth)	H2a			1.43*** (0.35)				1.65** (0.63)	
Portfolio complementarity - emerging focal (depth)	H2a				-0.08 (0.26)				-0.03 (0.32)
Portfolio complementarity - reinforced focal (depth)	H2a				0.12** (0.04)				0.18+ (0.10)
Control variables		Y	Y	Y	Y	Y	Y	Y	Y
Year fixed effects		Y	Y	Y	Y	Y	Y	Y	Y
Observations		683	683	683	683	247	247	247	247
Penalized log-likelihood		-56.87	-55.70	-50.22	-53.34	-9.402	-8.523	-5.681	-6.508

Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05, + p<0.10. All equations include a constant term.

Table C2
 Penalized Logistic Regression Estimates of Alliance Governance Choice
 (1 = JV; 0 = Contractual Agreement): Alternative Test of Hypothesis 2a

		(1)	(2)	(3)
Portfolio similarity	H1a	-0.65* (0.33)		-0.49 (0.35)
Portfolio distinctiveness	H2a		0.23* (0.09)	0.19* (0.10)
Control variables		Y	Y	Y
Year fixed effects		Y	Y	Y
Observations		683	683	683
Penalized log-likelihood		-61.31	-59.10	-57.04

Standard errors in parentheses. ***p<0.001, **p<0.01, *p<0.05, +p<0.1. All equations include a constant term.

Table C3
 Multinomial Logistic Regression Estimates of Alliance Governance Choice
 (2 = JV; 1 = Minority-Equity Contract; 0 = Non-Equity Contract)

Governance choice:		(1)		(2)		(3)	
		Minority equity	Joint venture	Minority equity	Joint venture	Minority equity	Joint venture
Portfolio similarity	H1a	-0.16 (0.19)	-0.73* (0.35)			-0.17 (0.19)	-0.74* (0.37)
Portfolio complementarity	H2a			-0.17 (0.17)	0.57* (0.23)	-0.19 (0.17)	0.55* (0.23)
Control variables		Y	Y	Y	Y	Y	Y
Year fixed effects		Y	Y	Y	Y	Y	Y
Observations		683		683		683	
Pseudo R-squared		0.17		0.18		0.18	
Log-likelihood		-338.9		-337.5		-335.3	

Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05, + p<0.10. All equations include a constant term.

Appendix D: Replication Study to Establish External Validity

Our main analysis relies on the technological discontinuity marked by the emergence of new technologies in the biopharma industry during the mid-1990s. Here, we replicate our analysis on firms active in the global chemical and pharmaceutical (C&P) industry (SIC 28, Chemicals and Allied Products) during the period 2000–2019, the two decades following the sampling window in our main analysis. Because recent research acknowledges that alliances with various functions facilitate knowledge access (e.g., Friedmann et al., 2025), this broader sample includes different alliance types beyond R&D alliances.

We relied on SDC Platinum to identify all alliances formed by C&P firms during this 20-year period (a total of 8,862 alliances). We converted multi-party alliances into dyads and, as in the main sample, included two observations for alliances where both parties were C&P firms, giving a set of 13,677 observations. We defined the alliance portfolio to include those alliances formed within a four-year rolling window preceding a focal alliance’s formation, which reduced the sample to 11,491 observations between 2004–2019. Finally, we required that the C&P firms had existing alliance portfolios at the time of the focal alliance’s formation, meaning at least one prior alliance during the preceding four years. The resulting final sample includes 4,012 alliances in 5,050 firm-alliance observations, of which 567 were governed as an equity joint venture.

In this broader, larger, and more recent sample, we lack detailed insights into the specific technologies involved in the alliances and their potential similarities and complementarities. Thus, we compute proxies for resource similarities and complementarities based on the partnering firms’ SIC codes. Specifically, we measure the degree of resource similarity between the firm’s alliance portfolio and the focal alliance by counting the number of partners in the firm’s alliance portfolio that share the same four-digit SIC code as the partner in the focal alliance. Likewise, we measure resource complementarity by counting the number of partners in the firm’s alliance portfolio that

share the same two- or three-digit SIC code as the focal partner but differ in the four-digit SIC code. These two measures use the exact definitions and measures of similarity and complementarity in Makri, Hitt, and Lane (2010), yet applied to the product-market domain. The underlying logic is that a new partner operating in the same narrowly defined business domain as the firm's existing partners likely furnishes access to similar resources. Conversely, new partners operating in related-yet-distinct domains—i.e., different narrowly defined domains within the same broader domain—are likely to furnish access to resources that can yield synergies with those of the existing partners. Thus, these resources are assumed to be complementary.

We use a similar set of control variables as in the main analysis, accounting for the focal firm's and the partner's experience in forming joint ventures and contract alliances, as well as repeated ties with the current partner and the vertical scope of the alliance. Because we lack information about the technologies involved in the alliances, we instead include a set of alliance-specific controls. These include whether the alliance involved production-related activities—such as supply, original-equipment-manufacturing (OEM), and manufacturing activities—and whether the alliance involved marketing, licensing, or R&D activities. Additionally, we control for whether the alliance was formed with a foreign partner, and the number of partners. To account for unobserved temporal heterogeneity, we include year fixed effects.

Descriptive statistics and pairwise correlations are shown in Tables D1 and D2, with penalized logit estimates shown in Table D3. The results provide evidence consistent with the main analysis. Model 1 reveals that firms are less likely to govern new alliances as joint ventures when the alliances offer access to resources similar to the ones in the firm's existing portfolio ($\beta = -.10$, $p = .039$). Specifically, the odds that the focal firm will form a joint venture with a new partner decrease by 10% ($\exp[-0.10] = .90$) for every partner within the focal firm's portfolio operating in a similar industry as the new partner. In turn, Model 2 suggests that firms are more likely to govern

new alliances as joint ventures when the partners provide access to resources that are complementary to the ones in the firm's portfolio ($\beta = .18$ $p = .045$). The odds that the focal firm forms a joint venture with a new partner increase by 20% ($\exp[0.18] = 1.20$) for every partner in the firms' portfolio active within an industry complementary to that of the new partner. Both effects persist when included together in Model 3. Overall, this evidence suggests that Hypotheses 1a and 2a hold in a larger, more recent, and more diverse sample in terms of industry context and alliance function.

Table D1
Summary Statistics (N=5,050)

Variables	Mean	SD	Min	Max
Joint Venture	0.11	0.32	0	1
Portfolio similarity	1.02	1.87	0	13
Portfolio complementarity	0.14	0.48	0	3
JV experience	1.96	5.07	1	52
Contract experience	6.77	9.62	1	69
Partner JV experience	4.55	32.35	1	351
Partner contract experience	6.58	32.60	1	453
Repeated ties	0.05	0.32	0	7
Vertical scope	0.15	0.36	0	1
Production alliance	0.25	0.43	0	1
Marketing alliance	0.17	0.37	0	1
R&D alliance	0.37	0.48	0	1
Licensing alliance	0.29	0.45	0	1
International alliance	0.66	0.48	0	1
Number of partners	1.15	0.56	1	7

Table D2
Bivariate Correlations (N=5,050)

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Joint venture														
2. Portfolio similarity	-0.08													
3. Portfolio complementarity	0.08	0.02												
4. JV experience	0.34	-0.04	0.12											
5. Contract experience	-0.04	0.59	0.14	0.08										
6. Partner JV experience	0.01	-0.04	-0.02	-0.01	-0.04									
7. Partner contract experience	-0.00	-0.02	-0.03	-0.02	-0.04	0.95								
8. Repeated ties	0.06	0.08	0.01	0.08	0.02	0.05	0.06							
9. Vertical scope	-0.12	0.07	-0.03	-0.07	0.06	-0.04	-0.02	-0.04						
10. Production alliance	0.16	-0.07	0.05	0.04	-0.10	0.02	0.00	0.03	-0.01					
11. Marketing alliance	-0.08	0.04	-0.01	-0.06	-0.02	-0.01	0.01	0.01	0.21	-0.06				
12. R&D alliance	-0.17	0.11	-0.05	-0.10	0.15	-0.06	-0.03	-0.05	0.55	-0.27	-0.05			
13. Licensing alliance	-0.21	0.08	-0.04	-0.11	0.00	-0.03	-0.02	-0.01	0.36	-0.14	0.03	-0.02		
14. International alliance	0.03	0.05	-0.00	-0.02	0.01	0.07	0.07	-0.01	-0.04	0.01	-0.01	-0.04	0.01	
15. Number of partners	0.27	-0.01	0.04	0.18	0.05	-0.02	-0.02	0.06	-0.07	0.03	-0.08	-0.09	-0.11	-0.04

Table D3
 Penalized Logistic Regression Estimates of Alliance Governance Choice
 (1 = JV; 0 = Contractual Agreement)

		(1)	(2)	(3)
Portfolio similarity	H1a	-0.10* (0.05)		-0.10+ (0.05)
Portfolio complementarity	H2a		0.18* (0.09)	0.17+ (0.09)
JV experience		0.08*** (0.01)	0.08*** (0.01)	0.08*** (0.01)
Contract experience		-0.02** (0.01)	-0.03*** (0.01)	-0.03** (0.01)
Partner JV experience		0.01* (0.01)	0.01** (0.00)	0.01* (0.01)
Partner contract experience		-0.01* (0.01)	-0.01* (0.01)	-0.01* (0.01)
Repeated ties		0.36** (0.14)	0.31* (0.14)	0.36** (0.14)
Vertical scope		0.36 (0.31)	0.36 (0.31)	0.37 (0.31)
Production alliance		0.49*** (0.12)	0.48*** (0.12)	0.47*** (0.12)
Marketing alliance		-0.68*** (0.18)	-0.69*** (0.18)	-0.68*** (0.18)
R&D alliance		-1.29*** (0.17)	-1.27*** (0.17)	-1.27*** (0.17)
Licensing alliance		-2.77*** (0.34)	-2.79*** (0.34)	-2.77*** (0.34)
International alliance		0.38** (0.12)	0.35** (0.12)	0.37** (0.12)
Number of partners		0.62*** (0.07)	0.62*** (0.07)	0.62*** (0.07)
Year fixed effects		Y	Y	Y
Observations		5,050	5,050	5,050
Penalized log likelihood		-1155	-1156	-1151

Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05, + p<0.10. All equations include a constant term.

References for Appendices

- Aisautov, A. 2024. Biotechnology Research Assistant [Custom version of GPT 4.0]. (<https://chatgpt.com/g/g-9mQGUWr7g-biotechnology-research-assistant>)
- Friedmann, J.-C., Lavie, D., & Rademaker, L. 2025. Does the predator become the prey? Knowledge spillover and protection in alliances. *Journal of Management*, 51: 3391-3425.
- Gulati, R., Lavie, D., & Madhavan, R. 2011. How do networks matter? The performance effects of interorganizational networks. *Research in Organizational Behavior*, 31: 207-224.
- Gulati, R. & Singh, H. 1998. The architecture of cooperation: Managing coordination costs and appropriation concerns in strategic alliances. *Administrative Science Quarterly*, 43: 781-814.
- Makri, M., Hitt, M.A., & Lane, P.J. 2010. Complementary technologies, knowledge relatedness, and invention outcomes in high technology mergers and acquisitions. *Strategic Management Journal*, 31: 602-628.
- OpenAI. 2024. ChatGPT 4.0 (<https://chatgpt.com/?model=gpt-4o>)
- Root, C. 2024. Patent Explorer [Custom version of GPT 4.0]. (<https://chatgpt.com/g/g-pwPdZCok6-patent-explorer>)