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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 and Eisenhardt, 2009; Wassmer et al., 2017). These additional gains derive from portfolio interdependencies—the interplay of the synergies and conflicts in an alliance portfolio (Hoehn-Weiss et al., 2017; Wassmer and Dussauge, 2012). Recent research shows that newly formed alliances can reshape the synergies and conflicts 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 et al., 2017; Kavusan and Frankort, 2019; Sen and 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 and 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 outputs, 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

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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 and Liebeskind, 1999; Gulati, 1995; Oxley, 1997; Oxley and 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 Fig. 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.

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 et al., 2020; Howard et al., 2016; Verginer et al., 2025), and alliance portfolios in particular (Asgari et al., 2017, 2018, 2025; Kavusan and 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 and 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 and 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 synergies and conflicts influence not only activity and partner selection in newly formed alliances (Asgari et al., 2017; Kavusan and Frankort, 2019; Sen and Puranam, 2022), but also governance decisions. Second, we contribute to research on innovation through alliances (e.g., Friedmann et al., 2025a; Kavusan et al., 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 et al., 2005; Oxley, 1997, 1999; Oxley and Sampson, 2004; Sampson, 2004a, 2004b), 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 and 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 and Wada, 2009). Moreover, contrary to a typical contractual agreement, the employees of a joint venture's parent firms tend to collocate. This facilitates personal interactions between 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 and 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 et al., 2006; Mowery et al., 1996; Oxley and Wada, 2009), and their propensity to generate new technologies and products (Jiang and Li, 2009; Nicholls-Nixon and Woo, 2003; Sampson, 2007). Key in this literature is the notion that no one governance arrangement constitutes the optimal choice in all circumstances (Aggarwal et al., 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 in which 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 and 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

[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.

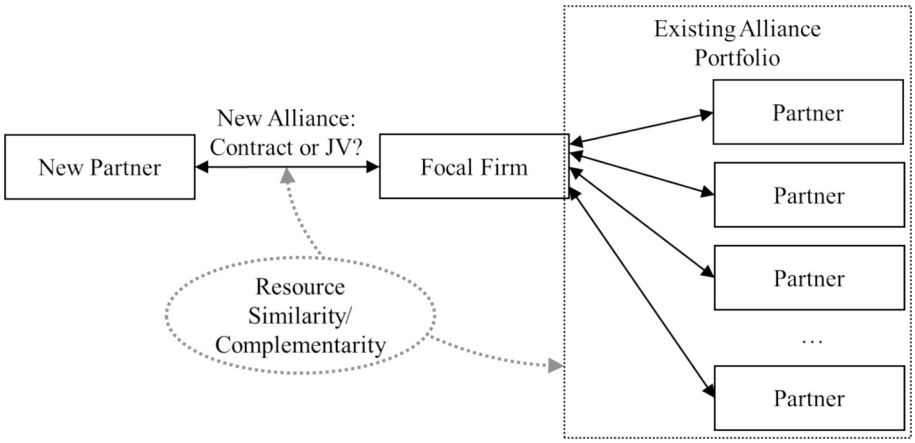

Fig. 1. Alliance portfolio interdependencies and governance choice.

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 and 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, affects 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 et al., 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 and Singh, 1998; Milgrom and Roberts, 1990).[2] A firm can realize synergies to the extent it can leverage its portfolio resources, 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 and 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 and 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 and 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 and Dussauge, 2012) and generate substantial learning benefits (Frankort et al., 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 these 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

[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.

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

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 Rummidgen, a biotech firm, 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% 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 and 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 and 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 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 between 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 and 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, 2001b;

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

Rothaermel and 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 et al., 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 and 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 and 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 that are 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 could enhance, rather than reduce, the firm's engagement with existing partners because complementary resources require the 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 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, so it is better positioned to learn and innovate in the partner's complementary resource domains (Sampson, 2007). This is the case especially because the larger-scale but more-focused exchange of knowledge in a joint venture (Oxley and 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 and 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 and 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 and Devarakonda, 2016; Ryu et al., 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 and Frankort, 2019).

[5] We thank an anonymous reviewer for suggesting this interpretation.

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 and Higgins, 2003; Higgins and Gulati, 2006). We used ReCap to identify all 1060 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 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 and Frankort, 2019; Robinson and 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] 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 1405 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 et al., 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 et al., 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., 2025b). 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 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.

[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 and 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 et al., 2022; Hohberger et al., 2020; Runge et al., 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 and 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 1516 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).

[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).

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 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 and 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.

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 and Khanna, 2000; Argyres and 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 and 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 and Stuart, 2007). Thus, a track record of alliances may influence governance decisions. Because governance choice also depends 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 and 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 and 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 et al., 2003), the increasing preference for contractual agreements (Frankort and 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 and Hernandez, 2018; Duysters et al., 2020; Hernandez et al., 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 and Frankort, 2019; Robinson and 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 through the focal firm's number of patent applications in the 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.

[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.

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., 2025b). The index is defined as $F_iF_j'/[(F_iF_i')(F_jF_j')]^{1/2}$, where the vector $F_i = \left(f_i^1 \ldots f_i^k\right)$ 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 influence alliance governance choice (Oxley and 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 and Hagedoorn, 2019; Roijakkers and Hagedoorn, 2006). In a maximum likelihood framework, such a lower incidence of equity joint ventures might produce upwardly biased point estimates. Thus, as in other recent alliance studies (e.g., Hawk et al., 2024; Ryu et al., 2018; Ryu et al., 2020), we use a conservative penalized likelihood method to estimate the logistic model (Firth, 1993; Woo et al., 2023).

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 et al., 2020; Santos Silva and Tenreyro, 2006), in line with recent alliance research (e.g., Friedmann and Pedersen, 2023; Friedmann et al., 2025b). PPML estimates are robust to overdispersion and zero-inflation, so they 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 existed with sufficiently overlapping covariate values. Using coarsened exact matching (Iacus et al., 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 the 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 and 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 and Jiang, 2013; Kosová et al., 2013; Kosová and 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 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

[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 0.63 to 0.53.

[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.

Table 1
Summary statistics.

	Full sample ($N = 683$)				Subsample with partner patent data ($N = 466$)			
Variables	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

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.

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 ($\beta = -0.65$; $p = .049$) and supports Hypothesis 1a. As portfolio similarity increases by one resource category, the odds that the focal 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 ($\beta = 0.58$; $p = .006$) 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 ($\beta = 0.61$; $p = .016$). Both Model 3 and Model 6 jointly examine Hypotheses 1a and 2a. The main inferences remain consistent with the ones we drew from the partial models.[15]

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 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 lacked 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 ($\beta = -0.83$; $p = .025$). 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.

Model 2 reveals a significant positive coefficient of *Joint venture* on innovation in complementary domains, in line with Hypothesis 2b ($\beta =$

[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 and Borjas, 1980; Lincoln, 1984).

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	

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 ($\beta = 0.89$; $p = .019$). 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 ($\beta = -0.88$; $p = .004$) 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. Fig. 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).

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 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%).

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.

[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.

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. All equations include a constant term.
*** $p < .001$.
** $p < .01$.
* $p < .05$.
+ $p < .10$.

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*	1.06**	−1.63***	0.89*	−0.88**	1.04**
	(0.37)	(0.41)	(0.14)	(0.38)	(0.30)	(0.34)
Contract experience	0.02*	0.01			0.01	−0.03
	(0.01)	(0.01)			(0.01)	(0.02)
JV experience	−0.24**	0.10			−0.15	−0.07
	(0.08)	(0.08)			(0.17)	(0.53)
Emerging-technology patents	−0.25***	−0.13*	0.27**	−0.19	−0.14+	−0.01
	(0.06)	(0.06)	(0.09)	(0.17)	(0.09)	(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+	−0.08***	−0.02	−0.13**	0.02***	−0.08***
	(0.01)	(0.02)	(0.02)	(0.04)	(0.01)	(0.02)
Partner JV experience	0.07	0.08	0.06	0.37	0.15	−0.04
	(0.25)	(0.39)	(0.18)	(0.34)	(0.19)	(0.30)
Partner emerging-technology patents	−0.02	−0.05	−0.03	0.00	−0.01	−0.03
	(0.02)	(0.05)	(0.04)	(0.07)	(0.01)	(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+	−0.81**	0.84*	−0.36	0.53**	−1.36***
	(0.22)	(0.26)	(0.35)	(0.39)	(0.19)	(0.25)
Repeated ties	0.04	−0.80*	0.25	−0.95+	0.18*	−0.46
	(0.14)	(0.31)	(0.38)	(0.53)	(0.08)	(0.28)
Vertical scope	0.16	0.05			0.21	−0.30
	(0.20)	(0.19)			(0.17)	(0.19)
Horizontal scope	−0.08	−0.18	−0.13	−0.29+	0.06	−0.21
	(0.11)	(0.13)	(0.12)	(0.17)	(0.08)	(0.14)
Lead molecule	−0.77*	0.13	−0.32	0.92**	0.07	0.36
	(0.33)	(0.31)	(0.46)	(0.36)	(0.24)	(0.31)
Formulation	−1.34***	−0.45*	−0.84*	−0.65	−0.47+	−0.09
	(0.20)	(0.22)	(0.35)	(0.47)	(0.28)	(0.27)
Pre-clinical	−1.30**	−0.13	−2.34*	−0.29	−0.14	0.60+
	(0.44)	(0.30)	(0.98)	(0.58)	(0.29)	(0.33)
Phase I/II/III trials	−1.10***	−0.26			−0.16	0.31
	(0.23)	(0.21)			(0.23)	(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	−19,046	−6459	−3423	−1643	−7958	−5112

Standard errors clustered by alliance in parentheses. All equations include a constant term.
*** $p < .001$.
** $p < .01$.
* $p < .05$.

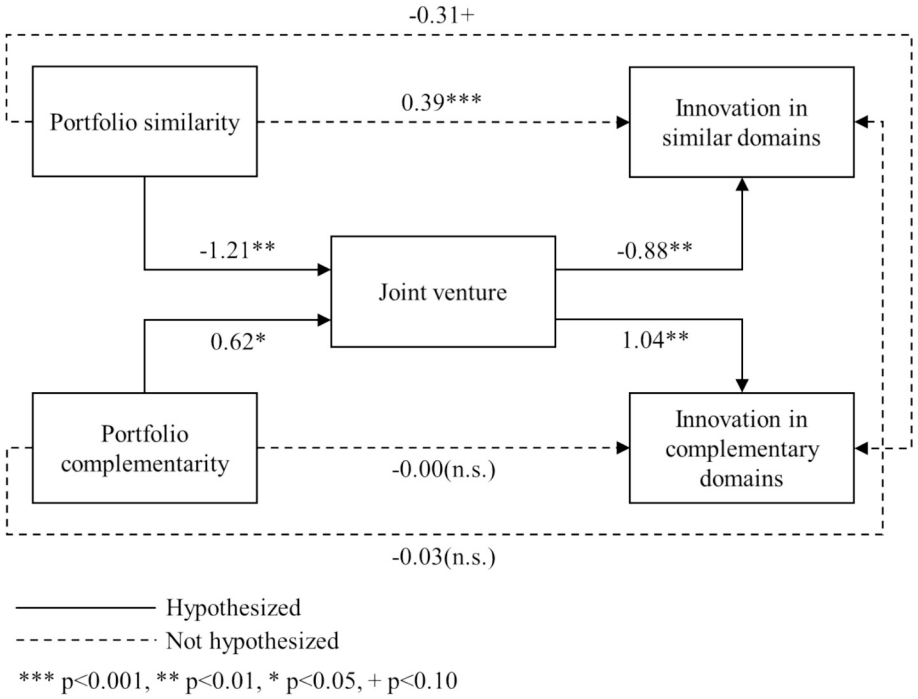

Fig. 2. Path diagram of generalized structural equation model.

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.

Finally, reverting to Fig. 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 and 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 in 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 and Frankort, 2019; Sen and 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 and Sampson, 2004; Santoro and 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 and 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 and Frankort, 2019; Sen and 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 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 and 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 and 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 and 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 and Frankort, 2019; Robinson and 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 and 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 et al., 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

[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 and Liebeskind, 1999; Gulati, 1995).

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, historical or contemporary, 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 and 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.

CRediT authorship contribution statement

Hans T.W. Frankort: Writing – review & editing, Writing – original draft, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jens-Christian Friedmann:** Writing – review & editing, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Korcan Kavusan:** Writing – review & editing, Writing – original draft, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of Generative AI and AI-assisted technologies in the writing 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.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendices. Supplementary materials

Supplementary materials to this article can be found online at https://doi.org/10.1016/j.respol.2026.105475.

Data availability

The authors do not have permission to share data.

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