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Innovation in the Intra- and Inter-firm Contexts

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Innovation in the Intra- and Inter-firm Contexts

DISSERTATION

submitted in partial satisfaction of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in Management

by

Punit Nath Sharma

Dissertation Committee:
Dean's Professor Margarethe F. Wiersema, Chair
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2021

DEDICATION

To

my one, for everything she is to me

my parents, all four of them,

for all they have given me, the tangible, but mostly intangible

my brother, so I never had to wander in the dark alone

and to my boys

may they have half as much fun (pain) in the reading of this as I have had in its writing

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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Undertaking this PhD has been a truly life-changing experience for me. It would not have been possible without the support and guidance that I received from many people. First, I would like to express the deepest appreciation to my committee chair, Professor Margarethe Wiersema, without whom I would not have made it across the finish line. She was instrumental in challenging me to think through the theoretical logic of the core ideas in my dissertation. Her ability to provide clarity vastly improved how I viewed my own research and scholarship. Without her guidance and persistent help this dissertation would not have been possible.

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ABSTRACT OF THE DISSERTATION

Innovation in the Intra- and Inter-firm Contexts

by

Punit Nath Sharma

Doctor of Philosophy in Management

University of California, Irvine, 2021

Dean's Professor Margarethe F. Wiersema, Chair

As a result of the rapid advances being made in technology, innovation has become a key concept in the strategic management of firms. Firms must innovate in order to achieve and maintain competitive advantage. For example, firms rely on the introduction of improvements in products to respond to changes in the environment. This dissertation explores some of the ways firms achieve innovation.

Paper 1 examines innovation-related behaviors within the firm, namely the entry of new technology features in products following a pioneering firm's market entry. Specifically, it examines how a manager's position within the organizational structure biases their response to risk in the context of innovation. The results indicate that the interaction between organizational structure and firm risk is critical for understanding entry timing and contributes to theories of entry timing, risk, and organization design. This study aligns with recent research suggesting that cognitive biases may be affected, and in some cases circumvented, by the organizational context in which learning and decision making occur and how it might shape innovation within the firm.

But while organizational processes conducted within the firm can lead to innovation, firms also rely heavily on inter-firm collaborations to develop R&D that can enable successful innovation. The following two papers examine innovation between firms. Paper 2 seeks to develop a framework to better understand how elements of the design of the contract may impact the performance of R&D collaborations. Using the literature on innovation and R&D, the paper identifies management and interfirm relationship factors that can enhance or inhibit innovation that are likely to be affected by contract design. The paper then uses the literature on interfirm contracts to identify the control and coordination provisions of contracts that are highly pertinent to understanding interfirm behavior and outcomes, and augments it with recent research on contract framing to identify how certain provisions can play additional roles by psychologically impacting the exchange and ongoing relationship between firms. The paper integrates these two literature streams and develops a framework and a set of propositions for understanding how contract design elements impact innovative performance through their effect on the management and interfirm relationship factors that enhance or inhibit innovation in R&D collaborations.

Paper 3 empirically tests predictions on a sample of 305 biopharmaceutical partnerships at various stages of research and development and finds some evidence that elements of the design of the contract may impact the innovative performance of R&D partnerships. These studies contribute to the literature on both R&D partnerships by improving our understanding of the factors that may lead to innovative performance, and innovation by examining a more robust set of measures for innovative performance than previously operationalized. In doing so, this study posits a role for the specification of

contract design elements that provide a control or coordinating role between partners that enhances or inhibits collaborative innovative performance in exploratory and exploitative R&D partnerships.

PAPER 1

CORPORATE PROXIMITY, FIRM RISK, AND ENTRY TIMING OF NEW TECHNOLOGIES

ABSTRACT

This study examines the effects of corporate proximity and firm risk on the entry timing of new technologies. Using quarterly product-level data on the world's major mobile handset manufacturers for the period 1994–2008, we analyze how a business unit's proximity to the corporate office, in terms of hierarchical distance, and firm risk influence technology entry timing following a pioneering firm. We argue that corporate proximity influences entry timing in two ways: directly through oversight and indirectly by shaping managerial response to firm risk. We find that in firms where the business unit responsible for handsets is far from the corporate office, the probability of entry increases substantially with firm risk. When the business unit is proximate to the corporate office, the probability of entry decreases slightly with greater firm risk. Our results indicate that the interaction between organizational structure and firm risk is critical for understanding entry timing and contributes to theories of entry timing, risk, and organization design.

1 | INTRODUCTION

Strategy and organizational scholars have long been interested in firm risk and its impact on firm performance (Fiegenbaum and Thomas, 1986, 1988; March and Shapira, 1987; Bromiley, 1991; Greve, 1998; Ketchen and Palmer, 1999; Hu et al., 2011; Kacperczyk et al., 2015; Jeong and Harrison, 2017). Yet researchers have not considered how firm risk—what we define as the uncertainty of the firms' income stream—influences firm behaviors other than performance (cf. Bromiley et al., 2017). In strategy, risk has mostly been studied as an outcome rather than the cause of behaviors (Miller and Bromiley, 1990; Ruefli, Collins, and LaCunga, 1999; Bromiley and Rau, 2010; Hoskisson, Chirico, Zyung, and Gambeta, 2017). For example, a number of studies examine how performance relative to aspirations influences risk-taking activities including those related to both upstream research (e.g., Chen and Miller, 2007, Bromiley and Rau, 2010; Gentry and Shen, 2013) and commercialization activities (e.g., Greve, 2003; Keizer and Halman, 2007; Cabrales et al., 2008). Many organizational studies use such behaviors as proxies for risk, and correspondingly explain these proxies for risk, rather than explain the influence of risk per se (see Bromiley and Rau, 2010 for a review of these papers).

Moreover, prior risk research mainly operates at the organizational level. Thus, it does not address how the interpretation, processing, and response to firm risk may vary across organization designs. However, organizational research indicates that organizational structure may drive variation in the cognitive processes that underlie how managers notice, encode, and respond to environmental stimuli (Ocasio, 1997, 2011). For example, studies demonstrate that properties of organizational structure alter responses to uncertainty (Dutt and Joseph, 2019), performance feedback (Vissa et al., 2010; Gaba and

Joseph, 2013; Rhee et al., 2018), stakeholder demands (Crilly and Sloan, 2013), and regulatory change (Barreto and Patient, 2013). Research shows that even individual managers will have different risk preferences across different decision contexts (March and Shapira, 1987; MacCrimmon et al., 1988; Bromiley et al., 2017). In this study, we suggest that the corporate hierarchy may create variation in organizational change efforts in response to firm risk—in particular the entry timing of new technologies.

Firm risk and corporate hierarchy may be especially important for change-related decisions concerning technology entry timing. Despite mixed findings on whether early or late entry is better for performance (Golder and Tellis, 1993; Klingebiel and Joseph, 2016; VanderWerf and Mahon, 1997), the literature acknowledges that both strategies involve substantial risk (Klingebiel, 2017). Late movers often cede revenue premiums or market share to early entrants (Banbury and Mitchell, 1995). Early movers face technical and demand uncertainty and might allocate attention to the wrong technologies (Klingebiel and Rammer, 2014; Vidal and Mitchell, 2013). Moreover, firms vest entry timing decisions at different levels in the organization, and managers' hierarchical proximity to the corporate office—what we define as corporate proximity—may modify risk-related behaviors (McNamara and Bromiley, 1997, 1999).

In this study, we examine firm risk, corporate proximity, and the implications for how firms respond to pioneers who launch new technologies: whether to be an early or late mover.[1] That is, we examine how firms react to another firm introducing a new technology. We test our predictions using a data set of technology and product launches in the global mobile phone industry between 1994 and 2008. The mobile phone industry

[1] We abstract from concerns of the pioneer in this study.

during this period is a suitable setting for our analysis because the introduction of new technologies is an important change related behavior (Ginsberg, 1988; Lilien and Yoon, 1990; He et al., 2006). Moreover, the large established corporations that dominated the industry exhibit substantial structural variation, and firms generally competed based on frequent product feature introductions (e.g., cameras, Bluetooth, USB, GPS). This single-industry context limits ancillary heterogeneity, since technology commercialization is a roughly similar process across firms in the sample.

We theorize that a business unit's proximity to the corporate office influences organizational change as indicated by entry timing decisions both directly by regulating information processing and indirectly by modifying how managers assess and respond to firm risk. Our results indicate that firm risk significantly increases the likelihood of market entry in response to a pioneer, especially when the locus of decision making is far—hierarchically—from the corporate office. That is, entry timing decisions made in units with greater hierarchical distance from the corporate office amplifies the positive relation between firm risk and the timing of technology entry.

Our study makes several contributions to the literature. First, we contribute to theories of organizational change (Van de Ven and Poole, 1995; Poole and Van de Ven, 2004) by positing a role for firm risk and corporate proximity. In high-tech industries, rapid technological change requires that firms actively manage their product portfolio by carefully timing the introduction of new products and technologies. Entry timing is an important aspect of technology strategy because moving early or late in response to a pioneering firm significantly influences firm performance (e.g., Fosfuri et al., 2013; Gomez and Maícas, 2011; Lieberman and Montgomery, 1988; Mitchell, 1991; Suarez and Lanzolla,

1998). Despite the potential risk inherent in such decisions, the rich body of work on entry timing has not considered firm risk or organizational structure as correlates of entry decisions. Thus, decomposing their influence on how quickly firms respond to pioneering technological entry is an important contribution.

Second, we contribute to the literature on firm risk and decision making. We emphasize how firm risk may influence business decisions, and how corporate proximity may modify that influence. In recent years, the role of risk in organizations has gained increased recognition as scholars have made and tested risk-related arguments in a wide variety of contexts (Bromiley and Rau, 2010). However, research on firm risk has largely attempted to explain risk rather than its relationship to other firm behaviors (except performance) and has largely ignored the role of organizational structure. Importantly, our study clarifies how firm risk is processed and responded to within corporate hierarchies and how corporate proximity may explain systematic differences in organizations' responses to firm risk. Toward this end, we develop a model for risk processing in a large corporate hierarchy in support of change-related decision making.

Third, we contribute to theories of information processing and organization design. Much of the literature on information processing focuses on the performance implications of either the different incentives that managers have regarding information sharing (Gulati et al., 2012), or the overall information processing capacity of the firm (Tushman and Nadler, 1978). However, researchers have given much less attention to the possibility that differences in behavior stem from differences in the interpretation of information (in this case risk estimates). While a new stream of research has begun to examine how differences in what information managers attend to and how their interpretation of such

information influences firm outcomes (cf. Jacobides, 2007; Eggers and Kaul, 2018; Maula et al., 2013; Shepherd et al., 2017), no studies have examined potential differences in the interpretation of firm risk across different organization designs in particular.

2 | ORGANIZATIONAL CHANGE AND THE RISKS OF EARLY ENTRY

Organizational change has long been viewed as difficult because managers often face uncertainty on what opportunities to pursue (March and Olsen, 1979; March, 1981; Reichers et al., 1997). In addition, organizational change inherently involves risk because managers have a greater difficulty predicting the consequences of changing than the consequences of not changing. The study of organizational change has drawn on theories and empirical results of individual risk-taking behavior (e.g., March and Shapira, 1987; Miller and Leiblein, 1996; Shapira, 1995) by integrating individual risk-taking behavior with decision-making processes in organizations (e.g., Milliken and Lant, 1991; Ocasio, 1995).

Many observers view new technology or product introductions as a key aspect of organizational change (March, 1981; Ramanujam and Varadarajan, 1989; Leonard-Barton, 1992; Haveman, 1992). Organizational change through early entry (of a new product or technology) constitutes an especially "high risk–high return strategy" (Kalyanaram et al., 1995: 219), making firm risk a potential regulator of such decisions. Early entry entails high risk for three reasons. First, entry before the emergence of a dominant design entails technological and demand uncertainty (Garud et al., 1997). An earlier entrant risks the technology not working as anticipated and the potential that better solutions of later entrants eclipse the firm's specific technological solution. Early entrants also face uncertainty concerning whether and to what extent the market will value the capability the

technology provides. As the industry cycle for the technology proceeds, firms can predict demand more accurately and the "bugs" associated with first generations of a technology get worked out. Over time, the dominant technology for providing a given capability becomes clear, and the risky choice of entry becomes less so.

Second, early entry incurs greater upfront financial costs and requires more resources and knowledge than later entry. Early entry costs include the production or procurement of a more expensive technology earlier in its life cycle and the costs of educating a consumer base about the new technology (cf. Scherer and Ross, 1990). Early entrants often must invest in physical or knowledge-based assets (Lieberman and Montgomery, 1988; 1998) that could become worthless if the technology does not work as intended or customers do not want it.

Third, early entry timing may have reputational consequences. Fast following a pioneer into a technology that fails either technical or market tests can damage both firm and managers' reputations. A commission error (i.e., early entry with a flop) has greater visibility than an omission error, i.e., late adoption of a hit, (Shapira, 1995) which management can quickly correct with subsequent entry. A late follower can catch up to an early entrant, often with a superior version of the technology (Argote et al., 1997), particularly if it possesses complementary assets (Tripsas, 1997) such as tight links to channel partners. Overall, research shows that in the first few years of a new technology area, early entrants have lower survival rates than later entrants (Mitchell, 1991) because of the technological uncertainties in the market.

We should note that late entry also involves risk. Early entrants may establish a brand or market presence the later entrant has difficulty overcoming. As a result, late

entrants may forfeit market share or future revenue streams. However, we see the risks associated with early entry as substantially greater than the risks associated with later entry.

2.1 | Firm risk and entry timing decisions

Since entry timing decisions often involves substantial risk, it should depend in part on firm risk (i.e., uncertainty of the firm's income stream) – in our case, measured by variance in *ex ante* analyst estimates of firm earnings (Bromiley, 1991). Because high firm risk focuses managers on the relative likelihood of substantial loss (Shapira, 1986; Sanders and Hambrick, 2007; Mannor et al., 2016), greater firm risk motivates managers to make changes (such as new product introductions) that they believe will reduce the likelihood of negative outcomes (March and Shapira, 1987) and increase mean performance.

For managers, risk is not primarily a probability concept. Managerial surveys suggest that managers emphasize potential negative outcomes more than potential positive outcomes (Mao, 1970; March and Shapira, 1987; Baird and Thomas 1990). Shapira (1986) reported that ninety-five percent of the executives responding to his managerial risk survey described risk in terms of the magnitude of potential loss, such as "the loss of reputation, or the consequences of not meeting a target." In the survey, one senior vice president of a high-tech corporation in Silicon Valley said that his company was most worried about the "Johnny-come-lately syndrome" of arriving in the market after their competitors were already there. Consequently, as firm risk (income stream uncertainty) increases, managers focus on the dangers of negative outcomes, and act to counteract the downside threat. In other words, when there is variance in firm risk, managers will emphasize the potential negative outcomes in that variance.

This logic aligns with work by Miller and Leiblein (1996) who argue that downside risk focuses managers' attention on problem solving, and that the ensuing search results in the identification and implementation of performance-enhancing alternative organizational strategies. That is, managerial focus on the down side of risk suggests that high risk should lead to organizational change. In industries where performance depends on effective incremental product development and rapid product introductions, organizational change in response to high firm risk should associate with earlier launch of new technologies and features. In an often-ignored feature of *The Behavioral Theory of the Firm*, Cyert and March (1963) propose that firms react to *expected* performance whereas most researchers have used actual performance. By extension, firms should react to potential negative outcomes because they define potential problems and trigger search.

In other words, because managers emphasize the downside of the distribution of earnings estimates (rather than the entire distribution), high firm risk will motivate efforts to improve expected performance. In what may appear as a paradox, such change will often include actions that, in and of themselves, are risky. If product entry with a new technology constitutes a major way to improve performance, high risk should therefore result in firms entering the market with new technologies in response to a pioneer's entry. This suggests our first hypothesis.

Hypothesis (H1) *Firm risk associates positively with faster introduction of new technology features following a pioneer's entry (i.e., earlier entry).*

3 | CORPORATE PROXIMITY AND DECISION MAKING

A long tradition of research recognizes that organizational structure influences decision-making processes in organizations and the pattern of outcomes that follows

(Simon, 1947; Burton and Obel, 2004; Gulati *et al.* 2012; Karim and Kaul, 2014; Puranam, 2018). Large firms typically involve a vertical hierarchy with operating units addressing specific businesses and a coordinating unit of corporate managers (Chandler, 1962). A hierarchical structure delineates the authoritative lines of command and establishes divisionalized communication infrastructure and vertical information processing (Galbraith, 1977).

In this study, we introduce a new concept that describes how far a business unit is from top management —what we call corporate proximity— measured by the number of hierarchical layers between a business unit and the corporate headquarters. As a structural property of the firm, corporate proximity reflects the vertical distance between the locus of authority and operations for a particular business segment and the corporate office. For example, business units which report directly to the corporate headquarters would reflect the highest degree of corporate proximity (or the shortest hierarchical distance). Business units at lower levels would reflect lower degrees of corporate proximity (at greater hierarchical distances).

Corporate proximity may influence how quickly the firm may enter the market with a new technology. Subunits far from the corporate office are able to respond more quickly to technology pioneers. This is because distant subunits tend to reflect organic or decentralized structures, which have greater information processing capacity than a centralized structure (Burns and Stalker, 1961; Tushman and Nadler, 1978). Divisional autonomy and loose coupling to other business units focuses line managers' attention on unique markets and facilitates the development of products tailored to respond to competitors (Ocasio, 2011).

However, close corporate proximity may slow entry because it increases the likelihood of corporate involvement in subunit decision making. Closeness in hierarchical distance to the corporate office increases the potential for corporate-level attention and oversight of the division or subsidiary. While greater attention or oversight provides some benefits to the subunit such as resources (Galunic and Eisenhardt, 2001; Bouquet and Birkinshaw, 2008), it sometimes comes with a cost on the decision speed (Kownatzki et al., 2013). Corporate managers may be more likely to micro-manage more proximate lower levels. Fewer layers give senior managers more opportunity to weigh in on all types of decisions including operational decisions and activities (McGrath, 2001). Illustratively, Bouquet and Birkinshaw (2008) note that subunits may receive too much attention, which may lead to "high and often unreasonable expectations for subsidiary performance and a constant drain on time from visits of corporate executives" (p. 594).

By extension, close proximity may force subunit managers to conduct greater due diligence on their proposals. For subunit managers, closer oversight and greater attention from proximate senior managers may lead to potential concerns about evaluation and monitoring and a reduced sense of control. Especially near the top of the hierarchy of an organization, subunit managers face evaluation apprehension due to self-censoring or internal filtering that leads to a reduced willingness to share projects or proposals during the innovation process that they feel may not conform to firm-wide performance goals (Reitzig and Maciejovsky, 2015). Subunits far from the corporate office may have an easier time escaping direct monitoring and can exist "under the radar" of corporate management (Galunic and Eisenhardt, 2001). As a result of the reduced decision-making burden, we are

more likely to see earlier launch of new technologies. These arguments suggest the following hypothesis.

Hypothesis (H2) *Corporate proximity is associated with slower introduction of new technology features following a pioneer's entry (i.e., later entry).*

3.1 | Corporate proximity, risk assessment, and entry timing decisions

Corporate proximity may also influence the speed of entry by affecting the way managers react to firm risk. With few exceptions (e.g., McNamara and Bromiley, 1997, 1999), most strategy research has implicitly assumed that firm uncertainty or risk is uniformly processed within organizations or has avoided the issue by dealing solely with corporate-level variables. However, we argue that internal structure may create variations in how managers perceive and respond to risk. Our logic parallels results from studies demonstrating that subunits (relative to other subunits or the corporate office) may differentially process feedback or external signals in the environment (Durand and Jacqueminet, 2015; Gaba and Joseph, 2013; Obloj and Sengul, 2012; Audia, Sorenson, and Hage, 2001; Vissa, Greve, and Chen, 2010; Dutt and Joseph, 2019).

Accordingly, we suggest that managers proximate to the corporate office are going to pay less attention to the negative extreme of the distribution (of earnings estimates) and will therefore be less likely to act in response to firm risk. This is because of their experience and the normative pressure they impose on lower level managers.

Managers who reach higher levels of an organization have experienced positive outcomes on their activities for many years. Since promotion depends on measured performance and measured performance equals true performance plus error (i.e., *Measured Performance* = *True Performance* + *e*), those who are promoted will have had high

performance and also high *e* (Denrell, 2003). That is, they've been good, *and* they've been lucky. Consequently, they are likely to over-estimate their abilities and under estimate potential problems. This suggests that they are more likely to pay most attention to the positive range of values while underweighting potential negative outcomes. If, in perceiving risks with greater optimism, senior level managers are less likely than lower level managers to perceive the threat inherent in downside risks, or the negative values of the risk distribution, they are thus faced with less cause to make changes.

Accordingly, we argue that distant or lower level managers are motivated to a greater degree than proximate managers to act in response to the negative extreme of the distribution. Lower level managers, in allocating greater attention on the down side values in earnings estimates, perceive the extreme negative values of the distribution as a significant threat and cause of action. More attention to down side estimates may give lower level managers a greater sense for loss, motivating a faster response to pioneers.

This is compounded by normative pressures within the organization. Shapira (1995) reported that higher level managers have a definite need to educate new managers on the importance of risk taking, and the inclination to *encourage others* to take risks increased as one moved up the hierarchy. Shapira argued that this reflects a normative vision of proper senior management as promoting risk taking; a view that executives *qua* executives should encourage more risk taking at lower levels in the firm.

In sum, we suggest that managers in business units far from the corporate office will perceive high firm risk as a salient threat and seek to change—counteracting this threat by moving quickly into the market with new technologies in response to a pioneer's entry. However, business unit managers proximate to the corporate office are more likely to

discount the negative extremes and focus on upside earnings estimates, alleviating pressures to respond to competitive pressures such as pioneer technology entries. Consequently, we offer the following hypothesis.

Hypothesis (H3) *Corporate proximity attenuates the association between firm risk and faster introduction of new technology features following a pioneer's entry.*

4 | SAMPLE AND METHODS

Our data sample covers the worldwide mobile phone industry from 1994-2008 (often termed the feature-phone era), an era of rapid new product introductions based on technological advances. This is an appropriate setting for our analysis for several reasons. First, firm success during this period required frequent technology introductions on products because technological advances ahead of the competition only offered temporary performance advantages. By 1994, products of all competitors in the mobile phone industry offered similar levels of voice call quality. Consequently, competition in this period depended heavily on feature innovation. Manufacturers added functionality and equipped products with numerous technological features (Giachetti, 2013), such as the ability to take a picture with an in-built camera, to send a multimedia message, to connect the phone to a data source using USB connectivity, or to autonomously control another device using a built-in infrared blaster.

Second, studying a single industry limits unrelated heterogeneity, especially since the technical process of introducing a mobile device is roughly similar across firms. While firms competed by adding new technologies to their phones, handset manufacturers acted largely as technology takers (Paulson Gjerde et al., 2002: 1269). In doing so, the cell phone manufacturers' patent positions during this period referred more to integration solutions

rather than the underlying technologies (Giachetti and Marchi, 2010). Upstream suppliers or industry standard consortia generally held the base patents for new technologies, which meant that one phone manufacturer's patents did not prevent other manufacturers from adding specific features.

Our 1994-2008 observation period thus provides a timeframe during which the dynamics of competition remained largely unchanged, an important control parameter for the reliable estimation of the determinants of entry timing (Lieberman and Montgomery, 1998). By 2009, with the advent of the smartphone era, by contrast, legal barriers—by way of patents—increased. The move toward smartphones as the dominant design had intensified and manufacturers began to differentiate their products through applications, computing power, and software integration rather than through added technology features. Finally, our sample uses quarterly data and so there is sufficient variation over time in our dependent and independent variables to enable identification of the hypothesized effects.

4.1 | Sample and Data

The sample covers the largest cellular phone manufactures, including the device makers of most of the cellular phones introduced during the period 1994-2008. The analysis comprises 13 firms, including the world's largest cellular phone manufacturers during this period. Together these firms accounted for more than 85 percent of worldwide mobile phone sales during the study period. We deliberately excluded the Japanese firms of Kyocera, Mitsubishi, NEC, Panasonic, Sanyo, and Sharp. Their phones evolved to proprietary cellular standards available only in Japan, and as a result, these firms did not compete in global markets to the extent of the major players.

We combined data from several sources. We collected quarterly data on phone feature entry into the market by the sample firms. Our primary sources of product-level technology feature data are the World Cellular Information Service, the Informa World Cellular Handset Tracker, and the Strategy Analytics SpecTRAX database of mobile phones. To ensure accuracy, we supplemented, checked, and cleaned our data using various websites such as gsmarena.com, phoned.net, and manufacturer websites. A combination of LexisNexis Corporate Affiliations, annual reports, and publicly available articles let us determine the position of the mobile phone unit within the overall hierarchy of each sample firm. Firm financial data used for controls came from Compustat and the firms' quarterly reports. Security analysts' earnings-per-share forecasts from Thomson Reuters Institutional Brokers Estimate System (I/B/E/S) were used to calculate the variance in future earnings estimates, our measure for firm risk.

Overall, our dataset tracked 5,280 products launched globally from 1994-2008. We tracked 43 unique technology feature innovations introduced to the worldwide market through these products, with each firm launching a different subset of technology features in subsequent phone models. From this, we developed a timeline of pioneers that launched the first phone models exhibiting each technology feature into the market and their followers. Data were analyzed quarterly; the result was 4,120 firm-technology-quarter observations comprising 419 follower entries within the sample. That is, our focal firms in the sample responded in 419 instances to a pioneering firm by entering the market with a competing product containing the given technology during the observation period in our study.

To illustrate the data, Figure 1.1 depicts two of the 43 feature innovations integrated into the phone models that we tracked in our sample: built-in camera and Wi-Fi antenna. Motorola entered as a pioneer of camera capabilities in Q1 of 2000. Both Nokia and Sony responded to Motorola in the following quarter with phone models that included cameras. Nokia pioneered Wi-Fi capabilities in Q1 of 2003. Sony Ericsson responded in the following quarter, followed by Motorola six quarters later in Q4 of 2004. We track similar timelines of all 43 feature innovations in the dataset.

4.2 | Measures

4.2.1 | *Dependent Variables*

To test our predictions, we model the entry timing probability of our sample firms as a function of the *ex ante* firm (and downside) risk and the corporate proximity of its entry decision making units. Because we use a discrete time event history of entry timing, our dependent variable, *entry*, takes a value of one for the firm-technology-quarter observation in which a follower's entry is recorded for a focal firm and zero otherwise. The sample tracks when the pioneering firm entered the market with a phone model exhibiting a given technology. Beginning in this quarter and for each subsequent quarter, the dependent variable takes on the value of zero for each firm-technology-quarter observation until a focal firm enters the market with a phone model exhibiting this same technology feature, upon which the dependent variable takes on the value of 1. That is, entry into the market is tracked in this variable based on followership, which is contingent on pioneer's entry. The data is set up, in effect, as an unbalanced panel. When coded this way, the coefficients can be used to calculate an entry probability, where the results can be

interpreted as the probability that a firm will enter the market in a subsequent quarter with a particular technology feature.

4.2.2 | *Independent Variables*

Firm risk

Following convention in the firm risk literature, we have adopted and tested as a proxy to measure firm risk, the *ex ante* uncertainty of a firm's earnings stream. Bromiley (1991) measured risk as the *ex ante* uncertainty of a firm's earnings stream using the standard deviation of security analysts' earnings per share (EPS) forecasts. Applications of this measure appear in Bromiley (1991), Conroy and Harris (1987), Washburn and Bromiley (2012), Kuusela et al. (2017), and Bromiley et al. (2017).

We use financial analysts' forecasts from I/B/E/S because they are generally regarded as a good proxy for the uncertainty associated with the firm's future income stream. Bromiley (1991) argues that *ex ante* measures of risk are preferable to *ex post* measures because decisions depend on *ex ante* perceptions regarding risk, which may differ substantially from the *ex post* experienced variability in outcomes. This measure associates unpredictability of future earnings with risk and is based on forecasts of earnings per share in quarters prior to the one being explained. I/B/E/S reports detailed company earnings forecasts for both U.S. and international firms. From this, we can derive the mean estimate and standard deviations of stock analysts' quarterly forecasts of EPS. Since the number of analysts varies across firms, we dropped observations based on fewer than three analysts' forecasts from the data.

Downside Risk

Although many studies in strategic management research use income stream uncertainty to proxy for firm risk (e.g., Bowman, 1982; Fiegenbaum, 1990; Fiegenbaum and Thomas, 1986, 1988), Miller and Reuer (1996) provide several rationales for moving from conventional variance-based measures of risk to downside conceptualizations. As we noted above, empirical research documents that decision makers tend to consider risk in terms of negative outcomes or hazards rather than as variance in outcomes, as reflected by standard risk measures (e.g., Baird and Thomas, 1990; March and Shapira, 1987).

Downside risk is a probability-weighted function of below-target performance outcomes and has been tested in a variety of strategy contexts (Miller and Reuer, 1996; Miller and Leiblein, 1996; Reuer and Leiblein, 2000). In contrast to conventional, variance-based measures of risk that capture the entire distribution of firm performance, downside risk emphasizes performance outcomes falling below a target level. For this study's purposes, we specified downside risk as a function of a firm's quarterly earnings-per-share (EPS) forecasts falling below the mean EPS for the firm in the preceding year. The downside risk variable implicitly reflects the interests of managers and others concerned about income stream risk. Thus, for comparison purposes, we tested a measure reflecting the negative distribution of the risk proxy against the full distribution of firm risk.

Corporate Proximity

The hierarchical structure of an organization represents the vertical structure that coordinates organization units (Holmstrom and Tirole 1989; Zhou, 2013). *Corporate proximity* measures the closeness (in terms of hierarchical distance) between the mobile phone business unit and the corporate headquarters. Because firms seldom make structural information publicly available, we use multiple sources to develop our measure,

including annual reports, books, news articles, and LexisNexis Corporate Affiliations directories. Major reporting changes (i.e., reorganizations) are infrequent and so changes following a launch are highly unlikely.

To be clear, *corporate proximity* is a reverse ordering of the number of hierarchical levels between the corporate office and the mobile unit. *Corporate proximity* ranged from 5 (i.e., unitary firm without corporate-business unit divisionalization) to 0 (i.e., mobile device business unit decisions made 5 levels down in the organization). A *corporate proximity* score of 4, for example, indicates a business unit that reports directly to the corporate office. Thus, a *greater* corporate proximity value indicates the firm's mobile phone unit is *closer* to the corporate office.

4.2.3 | *Control Variables*

To isolate the impact of theorized variables on firm response time, we control for several other factors when estimating the model. In line with previous research on the determinants of entry timing decisions, our controls address both firm characteristics and competitive market conditions.

First, we consider the importance of firm resources and capabilities. We control for *mobile experience*: the number of quarters since the firm produced its first mobile phone because as firms spend more time producing mobile phones, they acquire experience in introducing new technological features (Sorenson and Stuart, 2000). Because firm capabilities appear to explain the variance in research productivity across firms (cf. Henderson and Cockburn, 1994), we control for firm capabilities and count the total *number of phone models introduced* into the market by the focal firm prior to the quarter of entry under investigation. We also control for *sales, general, and administrative expenses*

(*SG&A*) in hundreds of millions of the firm prior to the quarter preceding market entry to account for the complementary assets available to the firm to aid in market entry (Tushman and Anderson, 1986), as well as the general information processing capacity of headquarters. We control for firm size measured by *total assets* in billions of dollars, since firm size has been shown to associate with a variety of firm features (cf. Cohen and Levin, 1989) including the availability of financial and human resources.

We use a firm's quarterly *R&D expenditure* in hundreds of millions as a proxy for a firm's total R&D inputs to the innovation process. While these data can also describe the amount of the firm's search activities (Chen, 2008), higher levels of R&D intensity lead to greater stocks of knowledge and hence to more new products and technologies (Cohen and Levinthal, 1990). While slack reserves are not directly helpful in the development of innovations, they may affect decisions to continue or discontinue R&D projects and lengthen the time that firms will take to introduce new technologies. Greater levels of absorbed slack make it easier to continue R&D projects and increase R&D intensity (Greve, 2003). We therefore control for *absorbed slack*, measured as the ratio of a firm's selling, general, and administrative expenses to sales.

We also control for the competitive environment. Because the intensity of competition affects the innovative behavior of firms (e.g., Nelson, 1993; Shane, 1992), we control for the effects of *competitive intensity* by measuring the total number of phone models introduced into the market by competitors in the six quarters preceding market entry.

4.3 | Corporate proximity and firm risk

In Figure 1.2, we plotted the mean values for firm risk and corporate proximity over the study period for the 13 firms in our sample. A few aspects of Figure 1.2 are worth noting. First, Philips' mobile unit exhibits, on average, the lowest degree of corporate proximity among the firms in our sample. By the start of our observation period, Philips had transformed itself into a multinational, decentralized company with a broad product line in the electronics industries (Bartlett, 2009). In contrast, for example, Nokia and Motorola have mobile phone units closer to the corporate office. In terms of firm risk, Benq, on average, exhibited the lowest standard deviation in income stream forecasts. In contrast, for example, Samsung Electronics exhibited much greater deviation in its earnings forecasts. Although Figure 1.2 highlights average scores for corporate proximity and firm risk, both measures vary over time by firm in our data. Figure 1.2 does not indicate a strong association between corporate proximity and firm risk. There is also not a strong association between firm size and risk. For example, Palm and RIM, the smallest firms in our sample did not exhibit, on average, the lowest or highest values of risk. We find reasonable variation in the sizes, and even types, of firms in each quadrant. Figure 1.2 is consistent with the weak positive correlation of firm risk and corporate proximity shown in Table 1.1.

4.4 | Model Specification

Since our dependent variable is a binary variable and there are multiple observations for sample firms during the observation period of 1994-2008, we used logistic regression for panel data analysis, using the xtlogit procedure in Stata 14. The binary dependent variable is equal to '1' if a follower's entry for a given technology occurs in a given quarter. The risk set of potential entrants includes all mobile phone firms

existing in a particular quarter that have not introduced a mobile phone with a given technology feature. That is, firms enter the risk set when a pioneer enters with a given technology and firms remain at risk until they enter the market with the same technology feature or until the end of the observation period. In estimating the predicted probability of entry for each quarter, we include the aforementioned controls and our independent variables (*firm* or *downside risk* and *corporate proximity*) lagged by three quarters. We lag all the independent and control variables by three quarters to account for the time mobile feature integrators take to clear decision gates and near completion (cf. Campbell-Smith, 2008). We note that in addition to the three-quarter lags reported here, all models were run with two-quarter and four-quarter lagged variables, and while the results were not substantially different to those reported here, they had a weaker effect.

5 | RESULTS

Table 1.1 presents summary statistics and piecewise correlations among the ten variables and Table 1.2 presents the results of coefficients predicting the probability of a firm's entry following the pioneer of a given technology feature into the market.

In Table 1.2, Model 1 includes just the control variables. Some firm-specific characteristics are significant when explaining entry decisions and their timings. Firms' *total assets* and *competitive intensity* slowed market entry significantly. Analyzing the average discrete change in the baseline model shows that a one standard deviation increase in total assets of a firm, nearly $25.5B, associates on average with a 2.9% decrease in the predicted probability of market entry of a new technology feature. A one standard deviation increase in *competitive intensity*, approximately 79 phone models introduced into

the market by competitors in the six quarters preceding the quarter of entry by the focal firm, correlated on average with a 1.4% decrease in the probability of market entry.

As a test of hypothesis 1, or the direct effect of firm risk on market entry timing by firms in response to a pioneer, Model 2 indicates that firm risk is in the hypothesized direction but is not significant in its effect. The same is true for Model 3, which tests the direct effect of downside risk, though the coefficient is larger and its p-value is smaller. As a test of hypothesis 2, or the direct effect of corporate proximity on market entry timing by firms in response to a pioneer, Model 4 indicates that corporate proximity is in the hypothesized direction but is not significant in its effect. Therefore, in order to explain the effect of risk and corporate proximity on followers' market entry timing, we will examine the full models (5 and 6) below.

Model 5 in Table 1.2 shows the impact of corporate proximity on the relation between the full distribution of firm risk and market entry in response to a pioneer. We find that Model 5 confirms H3 that corporate proximity negatively moderates the influence of firm risk on speed of entry following the pioneer. The coefficient of the two-way interaction term, firm risk and corporate proximity, is negative and statistically significant (β = -0.407; p = 0.004). This is in contrast to the coefficient of firm risk when corporate proximity is zero (or when the entry decision making unit is farthest from the corporate office), which is opposite in sign, 1.195, and significant (p = 0.008). The coefficient of corporate proximity alone when firm risk is zero is not statistically significant (β = -0.014; p = 0.959).

What this suggests is that firm risk and corporate proximity, while they influence entry, result in such different influences that the simple models presented in Models 2-4

found no effect. We therefore use the full models, 5 and 6, to explain the influence of risk and proximity on entry. We find a substantial effect in Model 6 in Table 1.2 where we test the impact of corporate proximity on the relation between downside risk, or the negative distribution of firm risk, and market entry in response to a pioneer. Model 6 confirms H3 that corporate proximity negatively moderates the influence of risk on speed of entry following the pioneer. The coefficient of the two-way interaction term, downside risk and corporate proximity, is negative and statistically significant (β = -1.202; $p < 0.001$). This is in contrast to the coefficient of downside risk when corporate proximity is zero (or when the entry decision making unit is farthest from the corporate office), which is opposite in sign, 3.266, and significant ($p < 0.001$). The coefficient of corporate proximity alone when downside risk is zero is not statistically significant (β =0.100; $p = 0.729$). This further suggests that downside risk does influence entry but that influence is highly contingent on corporate proximity, consistent with our theory.

To elucidate the impact that risk has on speed of entry following the pioneer at different levels of corporate proximity, we analyze the corresponding average marginal effects (see Table 1.3) in Model 5 and 6, and the graphs of their predicted probabilities at the extreme values of corporate proximity (see Figure 1.3).

In Table 1.3, we calculate the predicted probabilities of follower's entry by corporate proximity and across the range of firm risk. Table 1.3 shows that for firms with high corporate proximity (close to the corporate office) entry probabilities decline with risk from 3.4% at risk of zero to 0.9% at risk three standard deviations above the mean. However, at lower levels of proximity (far from the corporate office), predicted entry increases with risk. At proximity of 1 (reporting directly to corporate office), predicted

entry probability increases from 3.6% at risk of zero to 11.2% at risk three standard deviations above the mean. At higher levels of risk, predicted entry probability declines with closeness to the corporate office although the decrease is not significant across all reported values. The second half of Table 1.3 for downside risk reports similar patterns.

Analyzing the marginal effects of firm risk and downside risk on both the linear prediction and predicted probabilities of entry at different values of corporate proximity shows that for the full distribution of risk (see Table 1.4), the slopes of the linear prediction of entry on risk is significant when corporate proximity equals 1 (five hierarchical levels away from the corporate headquarters), 2 (four hierarchical levels away from the corporate headquarters), and 5 (at the corporate headquarters). Further, for these values of corporate proximity, the slope is significantly greater the farther away from the corporate office the entry decision is vested (though these slopes were not significant when using the predicted probabilities of entry). The slopes follow a similar pattern and are even more pronounced when analyzing the marginal effect of downside risk on both the linear prediction and predicted probabilities of entry at different values of corporate proximity.

For illustrative purposes, Figure 1.3 shows that for lower-level managerial decision makers, probability of entry increases substantially with firm risk. This effect is even more pronounced when we consider downside risk in place of the full distribution of firm risk. In contrast, for high proximity (close to corporate office), the probability of entry declines slightly as risk increases. In sum, risk shows a positive association with follower's entry of new technology features when decision making units are far from the corporate office.

Note that we use Table 1.3 and Figure 1.3 for illustrative purposes only because xtlogit only allows prediction conditional on the random effect being zero. For this, we also

tested our models using logit robust to standard errors. We received identical coefficients with similar standard errors. Further, a graph of the predicted probabilities was virtually identical to the graphs presented in Figure 1.3.

6 | DISCUSSION

This study explains the effects of organizational structure and firm risk on organizational change by tracking the timing of technology commercialization decisions by firms. In particular, we examine the effects of corporate proximity and firm risk on feature entry timing in the mobile phone industry. Our results generally suggest that greater firm risk speeds timing decisions when corporate proximity is low, that is, when the business unit is far from the corporate headquarters.

Our study makes several contributions. The first principal contribution of this paper is to document that the role of organizational structure in decision making involves more than information processing efficiency. In particular, we establish that corporate structure moderates the influence of firm risk on firm behavior. Corporate proximity situates decision makers in a particular part of the organization, and naturally reflects certain aspects of their incentives, roles and power within the firm, and hence variations in how they respond to firm risk reflected in analysts' earnings estimates.

Our study aligns with recent research suggesting that cognitive biases may be affected, and in some cases circumvented, by the organizational context in which learning and decision making occur (Lave and Wenger, 1991; Elsbach et al., 2005). For instance, McNamara and Bromiley (1997) found that both organizational and cognitive factors influence risky decision making but that, when both are present, organizational factors (e.g., goals) tend to dominate cognitive biases. This suggests that models of decision making and cognition that

fail to consider such important situational factors as the decision-making structure of complex organizations may be inaccurate in their predictions of real-life processes. Indeed, we found no effect when we considered the direct influences of proximity and risk, even though we find substantial effects when we allow proximity to moderate the influence of risk. The insights we provide on this score suggest that the importance of structure may lie not only in its capacity for information flow—as documented in prior research—but also in its ability to shape the context by which managers perceive and respond to firm risk.

Thus, this study augments the growing scholarship on organizational risk by considering some important conditional effects imposed by how managers process and respond to risk, normative behaviors of managers at different levels of the organization (Shapira, 1995), and the influence associated with the structural position of organizational units (March and Shapira, 1987). In particular, managers make differential choices among uncertain alternatives depending on their degree of corporate proximity.

Second, we offer new insights into the determinants of organizational change by measuring the timing of market entry of new technologies by firms. Prior research has identified several inter-firm differences in entry timing, including efforts to capture uncertain opportunities (Eggers, 2012; Wernerfelt and Karnani, 1987), firm capabilities (De Figueiredo and Kyle, 2006; Lee, 2008; Mitchell, 1991; Hawk et al., 2013; Robinson and Chiang, 2002), industry characteristics (Giachetti and Lampel, 2010; Koski and Kretschmer, 2010; Putsis and Bayus, 2001), and competitors' attempts to capture new product categories (Giachetti and Dagnino 2013; Sorenson et al., 2006). Surprisingly, little attention has been given to firm risk as a determinant. The importance of risk has been well established in the literature derived from, among others, the Carnegie School, behavioral

decision theory and agency theory (Bromiley and Rau, 2010). In particular, risk seeking has been established as an important mechanism leading to organizational change (March and Shapira, 1987; Greve, 1998; Kacperczyk et al., 2015), R&D intensity and innovation (Baird, 1986). Yet our theoretical apparatus that links firm risk, corporate proximity, and change is novel and provides a greater understanding of firm characteristics that result in early entry.

Much of the risk and innovation literatures either ignore internal decision-making environments or implicitly assume internal decision-making environments are relatively uniform. Consequently, these studies do not address variations in where and how firms make specific decisions. The present paper differs from this research in that it establishes a relation between variations in corporate proximity and technology commercialization decisions. Our study of leading mobile handset manufacturers suggests that the locus of decision making varies, and that variation influences technology launch patterns. We offer a model that accommodates the diversity, within and across firms, in position of the decision making business unit within the corporate hierarchy.

We should note that this also points to a number of limitations. First, the global mobile phone industry has relatively few, mostly large players. Our results may not generalize to fragmented industries with many small players characterized by flat hierarchies. Future research might usefully investigate whether the level of decision making and the extent of consultation during that process account for meaningful variance in smaller firms, too. Third, while our study offers a variety of controls, our model captures the impact of architecture on only one aspect of organizational change: the product development cycle and the decision to introduce a technology following that of a pioneer.

By extension, our paper is a correlational analysis, and we cannot draw strong causal relationships in the results. Although the temporal sequencing of firm risk and entry accommodates some of these concerns, we cannot entirely rule out endogeneity—firms may plan to launch technologies and therefore adjust risk. However, given that the timing of development in this industry was 12 to 18 months, and starting a major research program within the R&D organizations of these firms would have been a considerable undertaking, it is unlikely this was the case.

More generally, we offer new insights into theories of organization design. The growing body of research on organization design is beginning to recognize efficiency-based explanations of structure's impact on firm outcomes, as well as structure's more nuanced impact on cognition and behavior in support of performance outcomes. Much of the former's stream of research examines organizations whose members compute and execute optimal communication and decision rules to maximize organizational efficiency (Marshak and Radner, 1972).

However, structure may also influence decisions via different interpretations of information rather than different sharing patterns. We elaborate the mechanisms which shape information processing under different perceptions of risk so that we may better understand when firms may avoid risk and when they may proactively respond. Thus, we complement work that examines the impact of structure on proposal screening (Csaszar, 2012; Knudsen and Srikanth, 2014; Keum and See, 2017), uncertainty (Dutt and Joseph, 2019), search (Siggelkow and Rivkin, 2005), and performance feedback (Hu et al, 2017). Here we emphasize structure's regulation of risk-taking behavior. Our results indicate that

the forces inducing quick responsiveness vary across levels of the firm, which suggests it may be a source of performance heterogeneity.

Although our research design does not provide us with the ability to derive any performance implications, our theory offers managers insights into how they might approach designing the firm to promote product technological innovation. However, our results suggest that structural variation may only matter at high levels of risk, especially at long vertical distances from the corporate office. That is, when firm risk is low, it might not matter who makes risky technology decisions – the result is largely the same. However, especially when firm risk is high, the interpretive qualities of structure may be especially important, and distance from the corporate office may be an especially potent mechanism to ensure needed change and early entry timing. In industries where early movership is essential to firm performance (cf. Kim and Lee, 2011), this combination could be especially potent for providing an advantage. Given these insights, more work linking structural and behavioral drivers of innovation-related outcomes could be illuminating.

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FIGURE 1.1 Sample firms' entry timing of camera and Wi-Fi technology features.

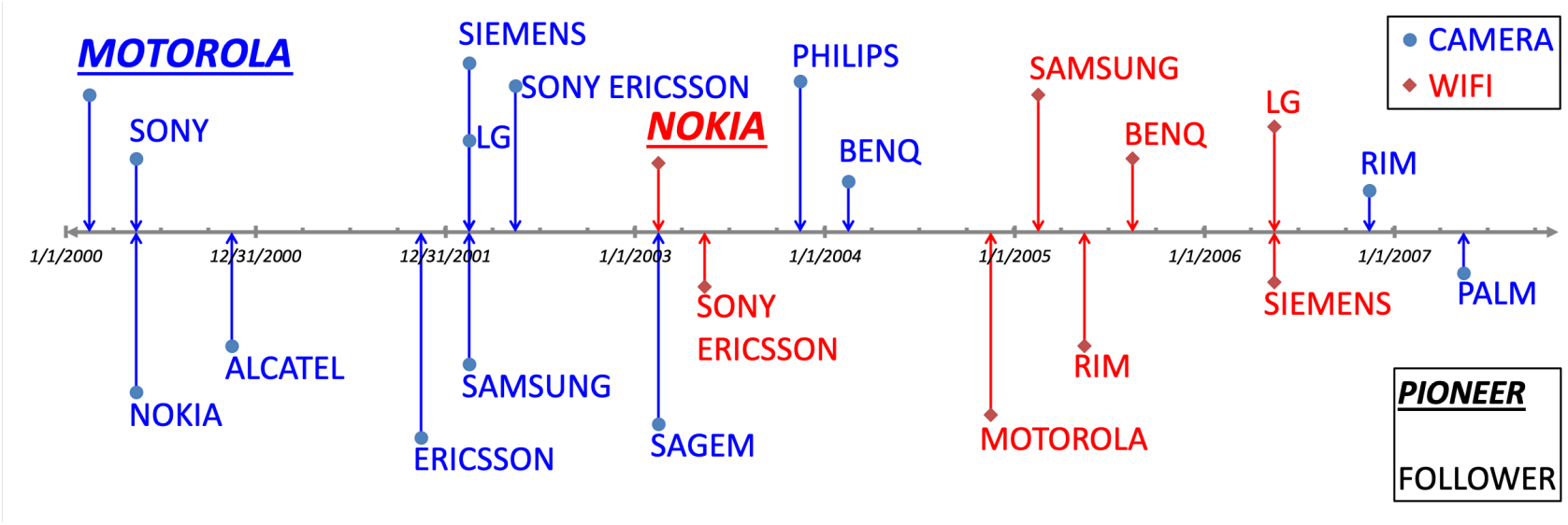
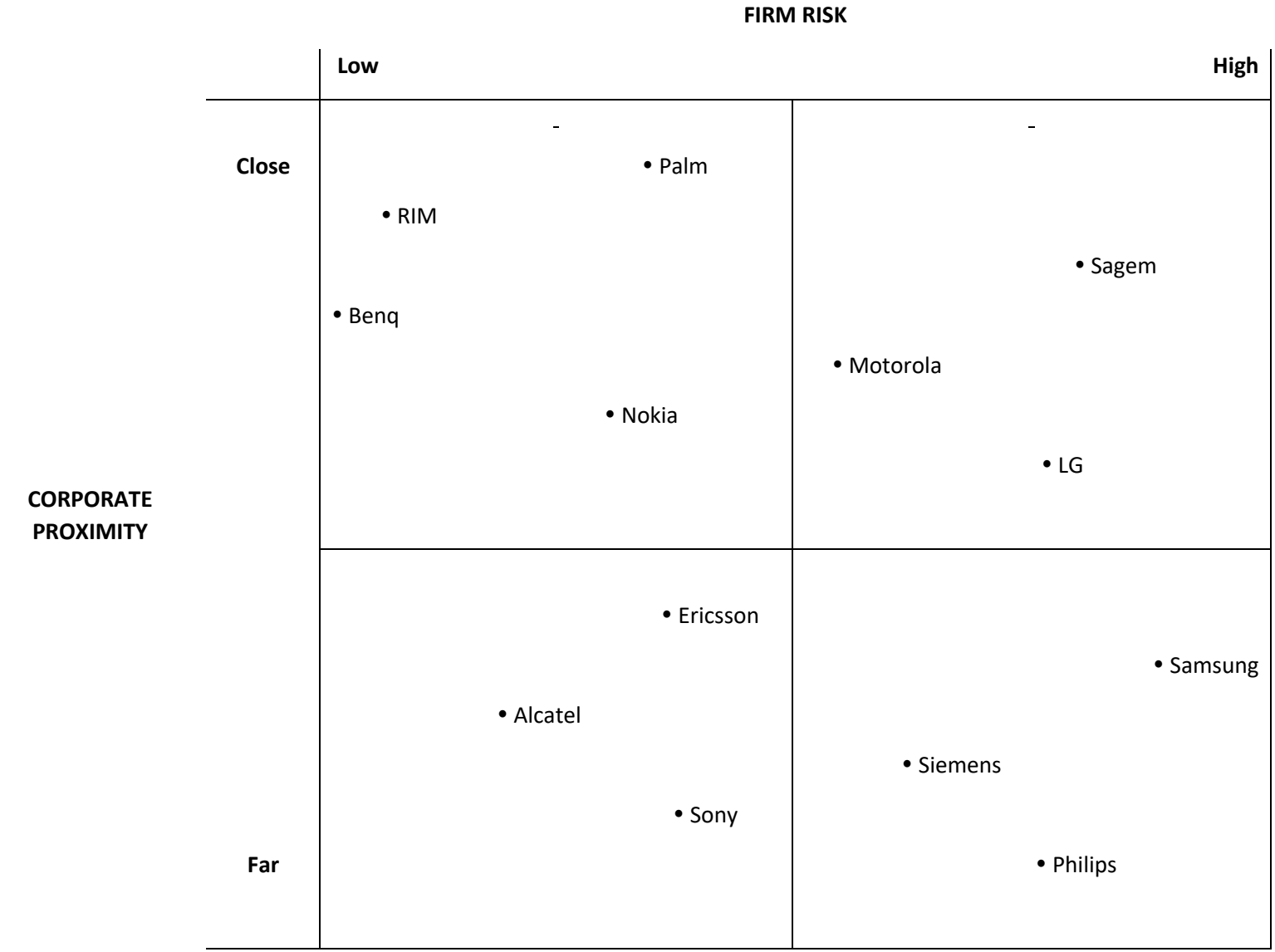


FIGURE 1.2 Matrix of mean values of corporate proximity and firm risk by firm.



T A B L E 1.1 Summary statistics and pairwise correlations

	Variables	Obs	M	*SD*	Min	Max	1	2	3	4	5	6	7	8	9	10
1.	Entry	4,120	0.04	0.19	0	1										
2.	Firm Risk	4,120	0.35	0.47	0.01	3.40	0.022									
3.	Downside risk	3,911	0.24	0.28	0.01	3.08	-0.012									
4.	Corporate Proximity	4,120	2.95	1.57	0	5	0.012	**-0.276**	**-0.160**							
5.	Focal firm phone models	4,120	83.43	99.75	0	705	**0.069**	0.013	0.001	**-0.340**						
6.	Competitive intensity	4,120	186.94	78.73	17	356	**-0.097**	-0.024	**-0.043**	**0.091**	-0.025					
7.	Total assets	4,120	23.21	25.56	0.58	132.40	0.015	**0.314**	**0.170**	**-0.833**	**0.428**	-0.006				
8.	SG&A	4,120	5.24	6.27	0.07	32.75	**0.033**	**0.435**	**0.263**	**-0.757**	**0.415**	-0.027	**0.933**			
9.	Mobile experience	4,120	43.07	28.42	0	139.57	**0.119**	**0.148**	**0.033**	**-0.244**	**0.583**	-0.016	**0.480**	**0.501**		
10.	Absorbed slack	4,120	0.31	0.10	0.14	0.92	-0.022	**-0.254**	**-0.276**	**0.045**	**-0.209**	**-0.297**	**-0.199**	**-0.250**	**-0.324**	
11.	R&D	4,120	0.73	1.07	0.01	6.17	0.029	**0.530**	**0.287**	**-0.609**	**0.278**	**-0.152**	**0.661**	**0.739**	**0.210**	**-0.100**

T A B L E 1.2 Panel xtlogit results for follower's entry probability

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Study variables						
Firm Risk		0.202			**1.195**	
		[0.210]			[0.448]	
		(0.336)			(0.008)	
Downside risk			0.377			**3.266**
			[0.287]			[0.691]
			(0.189)			(0.000)
Corporate proximity				-0.381	-0.014	0.100
				[0.265]	[0.285]	[0.289]
				(0.151)	(0.959)	(0.729)
Firm risk x Corporate proximity					**-0.407**	
					[0.141]	
					(0.004)	
Downside risk x Corporate proximity						**-1.202**
						[0.234]
						(0.000)
Controls						
Focal firm phone models	-0.004	-0.003	-0.004	-0.005	-0.004	**-0.006**
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
	(0.153)	(0.218)	(0.178)	(0.082)	(0.119)	(0.035)
Competitive intensity	**-0.006**	**-0.006**	**-0.007**	**-0.006**	**-0.007**	-0.006
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
	(0.023)	(0.021)	(0.024)	(0.022)	(0.014)	(0.052)
Total assets	**-0.076**	**-0.071**	**-0.081**	**-0.077**	**-0.065**	**-0.085**
	[0.021]	[0.020]	[0.024]	[0.020]	[0.018]	[0.023]
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
SG&A	0.056	0.038	0.046	0.057	0.011	0.067
	[0.067]	[0.067]	[0.072]	[0.066]	[0.063]	[0.059]
	(0.406)	(0.571)	(0.522)	(0.391)	(0.864)	(0.255)
Mobile experience	0.073	0.057	0.001	0.078	0.089	0.002
	[0.073]	[0.076]	[0.079]	[0.072]	[0.074]	[0.082]
	(0.317)	(0.453)	(0.994)	(0.277)	(0.230)	(0.985)
Absorbed slack	-0.595	-0.297	0.118	-0.758	-0.168	0.362
	[0.897]	[0.868]	[0.837]	[0.887]	[0.871]	[0.837]
	(0.507)	(0.732)	(0.888)	(0.392)	(0.847)	(0.666)
R&D	-0.087	-0.118	0.022	-0.078	-0.305	-0.230
	[0.167]	[0.164]	[0.269]	[0.165]	[0.163]	[0.208]
	(0.604)	(0.472)	(0.934)	(0.637)	(0.062)	(0.270)
Year fixed effects included	Y	Y	Y	Y	Y	Y
Firm fixed effects included	Y	Y	Y	Y	Y	Y
N	4,120	4,120	3,911	4,120	4,120	3,911
Wald chi^2	158.74	159.16	148.37	158.60	159.97	156.89

Notes: This table reports coefficients. Robust standard errors are in square bracket. Two-tailed *p*-values are in parentheses.

T A B L E 1.3 Predicted probabilities of firm and downside risk on follower's entry by corporate proximity

Range of *corporate proximity*	Range of *firm risk*				
	0	Mean	+1 S.D.	+2 S.D.	+3 S.D.
0 (Far)	0.037	0.053	0.083	0.126	0.184
	[0.030]	[0.040]	[0.056]	[0.080]	[0.110]
	(0.230)	(0.185)	(0.140)	(0.112)	(0.094)
1	0.036	0.046	**0.063**	**0.084**	**0.112**
	[0.021]	[0.025]	[0.031]	[0.041]	[0.056]
	(0.087)	(0.062)	(0.044)	(0.040)	(0.044)
2	**0.036**	**0.040**	**0.047**	**0.054**	**0.063**
	[0.012]	[0.012]	[0.014]	[0.017]	[0.023]
	(0.003)	(0.001)	(0.001)	(0.002)	(0.006)
3	**0.035**	**0.035**	**0.034**	**0.034**	**0.034**
	[0.004]	[0.003]	[0.005]	[0.007]	[0.010]
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
4	**0.035**	**0.030**	**0.025**	**0.021**	**0.017**
	[0.007]	[0.006]	[0.006]	[0.007]	[0.008]
	(0.000)	(0.000)	(0.000)	(0.003)	(0.024)
5 (Close)	**0.034**	**0.026**	**0.018**	**0.013**	0.009
	[0.015]	[0.011]	[0.009]	[0.004]	[0.006]
	(0.024)	(0.022)	(0.036)	(0.007)	(0.150)
Range of *corporate proximity*	Range of *downside risk*				
	0	Mean	+1 S.D.	+2 S.D.	+3 S.D.
0 (Far)	0.027	0.053	0.108	0.162	0.325
	[0.024]	[0.043]	[0.079]	[0.057]	[0.177]
	(0.248)	(0.215)	(0.173)	(0.122)	(0.066)
1	0.030	0.046	0.073	0.097	0.166
	[0.018]	[0.026]	[0.041]	[0.029]	[0.088]
	(0.097)	(0.084)	(0.074)	(0.067)	(0.059)
2	**0.033**	**0.039**	**0.048**	**0.055**	**0.071**
	[0.011]	[0.013]	[0.017]	[0.014]	[0.029]
	(0.004)	(0.003)	(0.004)	(0.007)	(0.014)
3	**0.036**	**0.033**	**0.030**	**0.030**	**0.026**
	[0.004]	[0.004]	[0.005]	[0.008]	[0.007]
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
4	**0.039**	**0.028**	**0.019**	**0.016**	**0.009**
	[0.008]	[0.005]	[0.005]	[0.002]	[0.004]
	(0.000)	(0.000)	(0.000)	(0.005)	(0.020)
5 (Close)	**0.042**	**0.024**	**0.012**	0.008	0.003
	[0.018]	[0.011]	[0.006]	[0.004]	[0.002]
	(0.020)	(0.026)	(0.050)	(0.102)	(0.176)

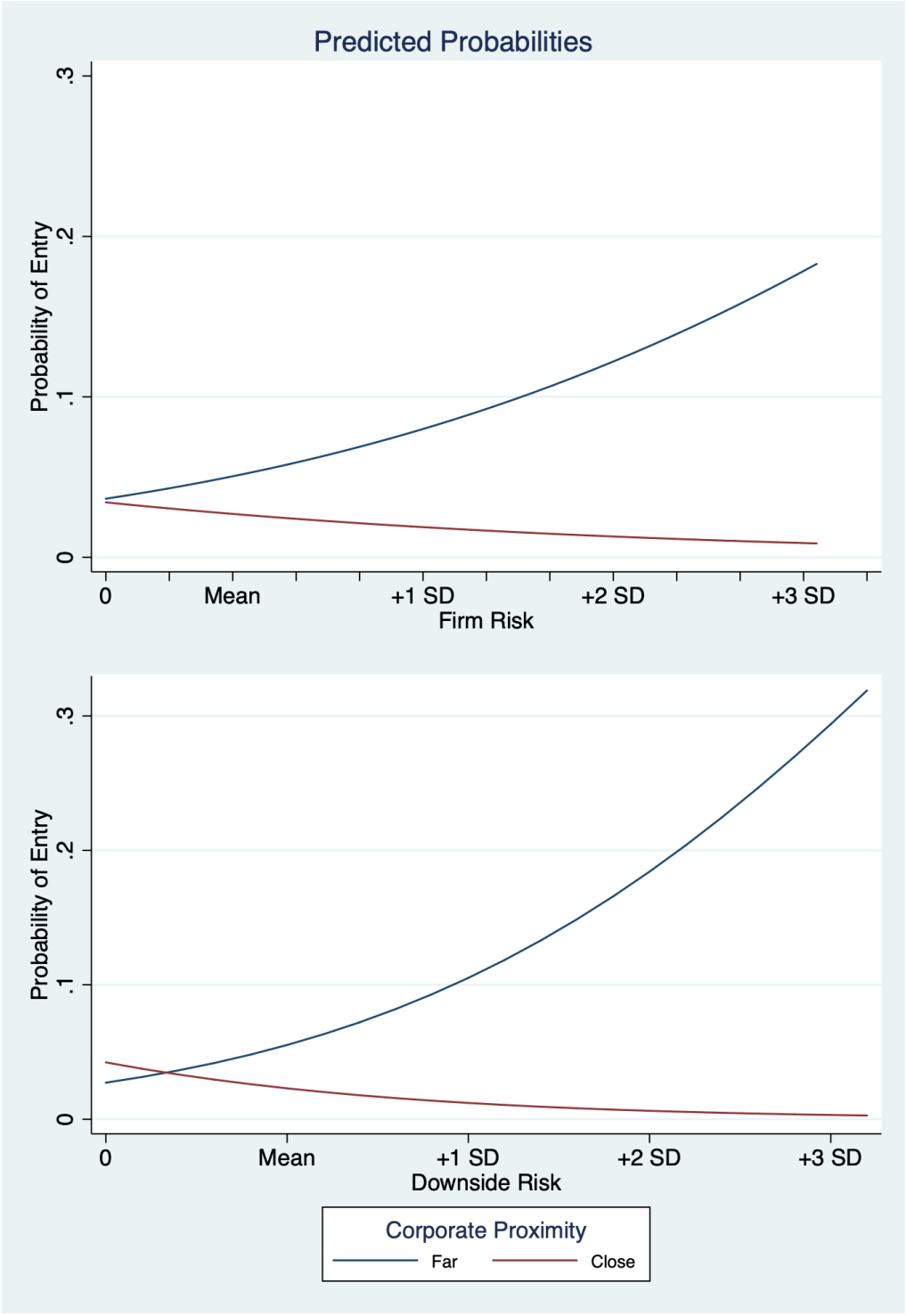
Note: Standard errors are in square bracket. Two-tailed *p*-values are in parentheses.

TABLE 1.4 Average marginal effect of firm risk and downside risk on linear prediction and predicted probabilities of entry at different values of corporate proximity

Range of *corporate proximity*	dy / dx			
	Firm Risk		*Downside Risk*	
	Linear prediction	Predicted Probability	Linear prediction	Predicted Probability
0 (Far)	**1.195**	0.053	**3.266**	0.142
	[0.448]	[0.032]	[0.691]	[0.088]
	(0.008)	(0.102)	(0.000)	(0.104)
1	**0.788**	0.031	**2.063**	0.080
	[0.333]	[0.016]	[0.494]	[0.043]
	(0.018)	(0.056)	(0.000)	(0.064)
2	0.380	0.013	**0.861**	0.029
	[0.248]	[0.008]	[0.346]	[0.015]
	(0.124)	(0.119)	(0.013)	(0.053)
3	-0.027	-0.001	-0.341	-0.010
	[0.227]	[0.007]	[0.323]	[0.010]
	(0.906)	(0.906)	(0.292)	(0.293)
4	-0.434	-0.012	**-1.542**	**-0.042**
	[0.285]	[0.008]	[0.446]	[0.014]
	(0.128)	(0.143)	(0.001)	(0.003)
5 (Close)	**-0.841**	-0.022	**-2.745**	**-0.071**
	[0.389]	[0.139]	[0.634]	[0.033]
	(0.030)	(0.119)	(0.000)	(0.028)

Note: Standard errors are in square bracket. Two-tailed *p*-values are in parentheses.

FIGURE 1.3 Two-way interaction of corporate proximity with firm risk and downside risk on predicted probabilities of follower's entry.



PAPER 2

DESIGNING COLLABORATIVE R&D CONTRACTS FOR INNOVATIVE PERFORMANCE

ABSTRACT

Strategic management scholars have long emphasized the importance of innovation for a firm's competitive advantage. While firms have looked to interfirm collaborations as a common way to achieve innovative performance, R&D partnerships often fail to meet their expectations. The literature on interfirm collaborations has found that the design of the contract is a significant factor in explaining transaction outcomes. Thus, to understand why R&D partnerships fail or succeed it is important to examine the design of the contract. This paper seeks to develop a framework to better understand how elements of the design of the contract may impact the performance of R&D collaborations. Using the literature on innovation and R&D, the paper identifies management and interfirm relationship factors that can enhance or inhibit innovation that are likely to be affected by contract design. The paper then uses the literature on interfirm contracts to identify the control and coordination provisions of contracts that are highly pertinent to understanding interfirm behavior and outcomes, and augments it with recent research on contract framing to identify how certain provisions can play additional roles by psychologically impacting the exchange and ongoing relationship between firms. Finally, the paper integrates these two literature streams and develops a framework and a set of propositions for understanding how contract design elements impact innovative performance through their effect on the management and interfirm relationship factors that enhance or inhibit innovation in R&D collaborations.

1 | INTRODUCTION

Firm innovation is important to achieve and maintain competitive advantage (Butler, 1988; Anderson and Tushman, 1991). While research conducted within the firm can lead to innovation, firms also rely heavily on interfirm collaborations to develop R&D that can enable successful innovation (Arora and Gambardella, 1990; Pisano, 1991, Gulati, 1995b; Powell, Koput, and Owen-Smith, 2005).

R&D collaborations represent one of the most common forms of interfirm collaboration (Hagedoorn, 2002) and are especially prevalent in technology-intensive industries such as pharma and biotechnology (Powell, Koput, and Smith-Doerr, 1996; Roijakkers and Hagedoorn, 2006). Types of R&D collaborations include equity-based forms, such as equity investment or operating joint ventures, and non-equity forms, such as licensing, technology development or commercialization alliances (Contractor and Lorange, 2002).

Despite the best intentions, R&D collaborations don't always succeed. Prior research reports high failure rates of collaborative R&D (Reuer and Zollo, 2005; Dyer, Powell, Sakikabara, and Wang, 2006; Sampson, 2007). And R&D collaborations do not always lead to positive innovative performance (Deeds and Hill, 1996; Weck and Blomqvist, 2008). Failure to realize positive innovation outcomes is due to a variety of factors that are associated with the nature of the collaboration and ongoing partner relationship (e.g., Ryall and Sampson, 2009).

The literature on interfirm collaborations has found that the design of the contract is a significant factor in explaining transaction outcomes (e.g., its success or failure; Weber, Mayer, and Wu, 2009; Schepker, Oh, Martynov, and Poppo, 2013). Thus, to understand why

R&D partnerships fail or succeed it is important to examine the design of the contract. But the impact of contract design on innovative performance has remained largely unexplored. This is because scholars have traditionally viewed the role of contracts as preventing a negative (i.e., limiting opportunism, mitigating hazards, and preventing misunderstanding between partners; Williamson, 1985; Mayer and Argyres, 2004) and not as promoting a positive (fostering an environment that facilitates innovation; Malhotra and Murninghan, 2002; Ring and Van de Ven, 1992). As a result, the focus has not been on how the design of the contract may impact the performance of R&D partnerships, even though contracts specify the nature of the interactions between partners in ways that may enhance or inhibit innovation.

This paper seeks to develop a framework to better understand how elements of the design of the contract may impact the performance of R&D partnerships. Using the literature on innovation and R&D, the paper identifies management and interfirm relationship factors that can enhance or inhibit innovation that are likely to be affected by contract design. Specifically, this section addresses management factors, such as formalization, flexibility, autonomy, knowledge assets, and communication. It also addresses factors involving interfirm relationships, such as cooperation and trust. Together, these factors are important in understanding how firms conduct collaborative R&D to achieve innovative performance depending on the type of R&D carried out in the collaboration.

Next, using the literature on interfirm collaborations, the paper identifies the control and coordination provisions of contracts that are highly pertinent to understanding interfirm behavior and outcomes. Specifically, this section examines control and

coordination provisions from the transaction cost economics (TCE) and resource-based view (RBV) perspectives, and then identifies additional provisions by reviewing more recent research that examines the psychological impact of contract framing on exchange outcomes. Overall, this section identifies contract design elements that are likely to influence performance outcomes in interfirm collaborations and how scholars have studied them. Based on this literature, the elements of contract design that may impact partnership success or failure include management oversight and monitoring provisions, performance milestones, payment and incentive structures, and duration safeguards.

Finally, the paper integrates these two literature streams and develops a framework and a set of propositions for understanding how contract design elements impact innovative performance through their effect on the management and interfirm relationship factors that enhance or inhibit innovation in R&D collaborations.

2 | THE DETERMINANTS OF INNOVATION IN R&D COLLABORATIONS

For firms in technology-intensive industries, external R&D collaboration for innovation has become a pervasive phenomenon (Hagedoorn, 1993). As a result, research on collaborative R&D has burgeoned, with one stream of research focusing on the relationship between R&D collaborations and innovative performance (Shan, Walker, and Kogut, 1994; Kotabe and Swan, 1995; Deeds and Hill, 1996; Lerner, Shane, and Tsai, 2003).

In general, R&D collaborations have been found to positively impact innovative performance (e.g., Shan et al., 1994). Research has advanced our understanding of the innovation process by establishing a link between a firm's R&D collaborations and an intermediate research output or innovative performance indicator, such as patenting propensity (Shan et al., 1994), level of product innovativeness (Kotabe and Swan, 1995),

products under development (Deeds and Hill, 1996), and milestone stages reached (Lerner et al., 2003). This research on R&D collaborations repeatedly stresses the virtues of collaborative innovation (Rothaermel and Deeds, 2004). For example, pooling of knowledge assets, cultivating positive interfirm relationships, and learning from the exchange are all means through which partnering firms achieve innovative performance (Gomes-Casseres, Hagedoorn, and Jaffe, 2006; Hagedoorn, 1993; Powell, Koput and, and Smith-Doerr, 1996; Shan, Walker, and Kogut, 1994; Zidorn and Wagner, 2013).

However, collaborative R&D poses its own important contradictions and challenges concerning the conduct of R&D across firm boundaries. On the one hand, collaborations between firms can provide a way of minimizing the uncertainties and overcoming the difficulties of an increasingly rapid pace of technological advancement in a given domain. This has the potential of bringing innovation performance gains for collaborators. For example, collaborative arrangements in R&D may help firms share costs by accessing wider markets more efficiently or adjusting products more successfully to specific market niches. In this way, collaboration becomes an important method of reducing the risk of a single firm's competitive edge being blunted by the uncertainty created by the rapid pace of technological change. On the other hand, R&D collaborators may fall victim to factors that inhibit these gains. The challenges of conducting R&D across firm boundaries bring to the forefront management and interfirm relationship factors that quite often impact innovation performance both positively and negatively. R&D collaborations blur firm boundaries and create mutual dependence between previously independent firms (McEvily, Perrone, and Zaheer, 2003). As a result, partners have to deal not only with the uncertainty in their

environment but also with the uncertainty arising from each other's behavior (Harrigan, 1985).

Therefore, understanding the role that management and interfirm relationship factors play in impacting innovative performance in R&D collaborations seem particularly salient when considering that most innovations will either never reach the market (Griffin,1997; Stevens and Burley, 1997), or if they do, they are not likely to meet financial expectations (Sampson, 2005). I begin by examining the nature of research and development and the role that joint creativity[2] plays in the R&D process. This section provides a typology of R&D and the factors that affect its success. Based on a review of the innovation and R&D literature, I identify and discuss management factors such as formalization, flexibility, autonomy, knowledge assets, and communication, and interfirm relationship factors such as cooperation and trust.

2.1 | The nature of research and development

A review of the R&D and innovation literature suggests that R&D is not uniform. Scholars have identified two types of innovation along the research and development value chain: exploratory and exploitative R&D (see Gilsing and Nooteboom, 2006; Jansen et al., 2006; Andriopoulos and Lewis, 2009). Exploratory R&D requires new knowledge or departure from existing knowledge (Benner and Tushman 2002; Levinthal and March, 1993; McGrath, 2001). Exploitative R&D involves incremental innovations that broaden existing knowledge and skills, improves established designs, and expands existing products and technologies (Abernathy and Clark, 1995). In order to understand innovative

[2] Joint creativity is creativity that manifests in cooperative business arrangements (Bidault and Castello, 2009).

performance, it is important to recognize that the antecedents to innovation are likely to be different depending on the type of R&D.

Exploratory R&D is undertaken with the motivation to discover something new; a focus on the 'R' in the research and development process. During the early stages of the R&D process, firms are prospecting for new wealth-creating opportunities in a given area. Exploratory R&D involves conducting activities such as improvisation and experimentation, which implies generating and addressing differences in opinion (Dutton and Duncan 1987). In this discovery period, the collaboration pursues an exploratory search involving basic research, invention, risk-taking, and building new capabilities with the goal of developing new knowledge or capabilities which it can subsequently exploit to create value (Cohen and Levinthal, 1990). Exploratory activities include searching for new possibilities, evaluating diverse options, and activities requiring the learning of new skills or knowledge (March, 1991). It is in this type of R&D where creativity is most salient. Here, innovative performance first depends on having a good idea—and developing that idea beyond its initial state. In this view, creativity is the starting point for innovation and is needed before achieving successful innovation outcomes.

The hoped-for outcome for collaborators in the exploration process is the embodiment of new knowledge learned through exploratory research into a prototype product that can be extended into the testing and development process or the codification of new knowledge through patenting. In the biotechnology industry, for example, collaborations in exploratory R&D are motivated by a desire to acquire basic knowledge that can be used to create novel molecular entities which are then entered into the development and regulatory process.

Exploitative R&D focuses on the 'D' in the research and development process and is undertaken with the goal to use existing competencies in order to further develop and refine an existing technology (Levinthal and March, 1981). Once potentially valuable knowledge and skills have been acquired through exploration, the process then turns to exploitative R&D activities. Exploitative activities are those which are generally performed as if they are routine, activities that an organization generally knows how to conduct, and activities that the organization can properly conduct by using present knowledge (March, 1991). The filing of a patent or the entry of a product into the development and regulatory process signals that further new knowledge must be accessed and imbued into the product in order to exploit the knowledge gained through exploration. The completion of a prototype product creates an immediate need for certain complementary capabilities (e.g., legal and regulatory competence, manufacturing, marketing, and distribution). At this juncture, exploitative R&D addresses the commercialization of the new product. Thus, successful exploitative R&D often enables a firm to commercialize the knowledge gained through exploratory research and development.

From the generation of new ideas through the launch of a new technologies and products, the exploration and exploitation of knowledge is a core function of R&D. It is important to make the distinction between exploratory and exploitative R&D because they differ in terms of the factors that are likely to lead to innovative performance by type of R&D.

2.2 | Antecedents of successful innovation in collaborative R&D

Firms are increasingly reliant on R&D collaborations both to explore new opportunities and to leverage existing skills (Gulati, 1995b; Koza and Lewin 1998;

Rothaermel 2001). Applying the exploration-exploitation dichotomy, researchers within the collaborative R&D literature (e.g., Faems et al., 2005; Koza and Lewin, 1998; Rothaermel and Deeds, 2004) make a distinction between exploratory and exploitative collaborations based on the motivation to enter a collaboration and the activities performed. Previous research has asserted that organizational antecedents differentially influence exploratory and exploitative R&D (e.g., Benner and Tushman 2003, Hill and Rothaermel 2003), and this has implications for understanding what factors may impede or promote the success of collaborative R&D. Koza and Lewin (1998: 257) argue that "the intent behind entering an exploration alliance involves a desire to discover new opportunities," while "an exploitation alliance involves the joint maximization of complementary assets." Following this logic, this paper considers an exploratory R&D collaboration as an agreement between otherwise independent firms that pool their capabilities for the purpose of discovering new technological opportunities, and an exploitative R&D collaboration for the purpose of commercializing the technology.

The challenges of conducting research and development across firm boundaries bring to the forefront factors that serve to either enhance or inhibit innovative performance (Galunic and Rodan, 1998; Mitchell and Singh, 1992; Mowery et al., 1996; Dutta and Weiss, 1997; Stuart, 2000). In the following sub-sections, I review the antecedents of innovative performance specifically as it relates to collaborative R&D, and in particular those factors that are likely to be important in understanding the design of contracts between partners. Specifically, I address management factors, such as formalization, flexibility, autonomy, knowledge assets, and communication. I also address factors involving interfirm relationships, such as cooperation and trust. Together, these

factors have been shown to be important in the success of collaborative R&D and thus are important in understanding how firms can achieve innovative performance depending on the type of R&D activities performed. Overall, these sub-sections find that management and interfirm relationship factors that promote joint creativity and the acquisition and recombination of knowledge are likely to lead to innovative performance in exploratory R&D collaborations, whereas management and interfirm relationship factors that focus efforts on carrying out predefined tasks are likely to lead to innovative performance in exploitative R&D collaborations.

2.2.1 | *Management Factors*

The ability of collaborators to create new knowledge and innovate is critical to successful R&D partnerships. In these collaborations, ideas are first conceived and evaluated, potential concepts are formulated, and projects are progressively planned. The higher need for novelty in exploratory R&D requires partners to focus on how they can maximize their joint creative potential. Conversely, mechanistic workflows in such predefined tasks as manufacturing, regulatory approval, marketing, and distribution, require deliberate structures in order to realize innovative performance in exploitative R&D. Management factors, such as formalization (Miner et al., 2001; Tatikonda and Rosenthal, 2000), flexibility (Harryson et al., 2008), autonomy (Olson et al., 1995; Mainemelis, 2001), knowledge assets (Grant and Baden-Fuller, 2004; Perry-Smith, 2006), and communication (Woodman et al., 1993) have been shown to affect collaborative innovative performance.

Reviewing prior research on how management factors affect innovation in an interfirm context, the presence of heterogeneous knowledge assets and interfirm

communication has been shown to facilitate exploration (Faems et al., 2006). Different degrees of formalization, flexibility, and autonomy, which are somewhat interrelated, have been shown to influence innovation between collaborators (Tatikonda and Rosenthal, 2000). One major dilemma in the context of innovation is the tension between providing collaborators with enough autonomy and flexibility for creativity and the need for formalization to reduce the risks and uncertainties present in the interfirm context. I start the review of management factors that impact innovation in collaborative R&D by first examining these factors individually.

Formalization

Formalization refers to the degree to which explicit rules, policies, guidelines, instructions, procedures, or workflow descriptions have been formulated and established (Tatikonda and Rosenthal, 2000). Prior research on formalization has yielded mixed findings (e.g., Luo, 2007; Lui, Wong, and Liu, 2009). As such, scholars differ on their view of how formalization impacts R&D activities overall. However, based on a review of the literature, a high degree of formalization is likely to benefit exploitative R&D, while a low degree of formalization is likely to benefit exploratory R&D.

In one view of the literature, formalization within R&D units is used to ensure that activities are aligned with cooperative strategy and goals (Persaud, 2005). Here, formalization is used to retain control in order to reduce risks and uncertainties (Poskela and Martinsuo, 2009). Formalization entails gates and reviews, and is likely to support pre-planned, detailed, concrete, and structured R&D activities (Tatikonda and Rosenthal, 2000). In this view, a high degree of formalization would likely benefit exploitative R&D, which entails development activities that tend to have predetermined workflows, such as

marketing, manufacturing, distribution, and regulatory stage gates. In this context, formalization is aimed at reducing variance through incremental improvements in processes and outputs (Benner and Tushman, 2003), and facilitates the generation of proposals to improve existing routines (Zollo and Winter, 2002). Once changed, these improved routines become standardized activities that will be performed for existing sets of conditions (Benner and Tushman, 2003). Through formalization, units codify best practices to make them more efficient to exploit, easier to apply, and to accelerate their implementation (Zander and Kogut, 1995).

But some scholars have adopted a more skeptical view on the effect of formalization (Amabile et al., 1996; Woodman et al., 1993). According to these authors, collaborators feel restricted by a high degree of formalization because formalized control can hamper creativity in social settings (Brix and Jakobsen, 2013). They argue that if R&D collaborators can work more flexibly, they will be motivated to try out new things. In addition, explicit processes and rules tie up partners' ability to think and act creatively. In this context, the reliance on rules and procedures hampers experimentation and ad hoc problem-solving efforts (March and Simon, 1958), and reduces the likelihood of individuals deviating from structured behavior (Weick, 1998). A high degree of formalization acts as a frame of reference that constrains exploration efforts and directs attention toward restricted aspects of the external environment (Weick, 1979). It hinders deviation from existing knowledge and a collaborator's variation-seeking behavior. Accordingly, formalization constrains exploratory innovations (Miner, Bassoff, and Moorman, 2001).

Overall, a high degree of formalization enhances exploitative R&D through improvement of current products, services, and processes, but may hamper exploratory R&D where the ability to produce novel and appropriate solutions to problems is required.

Flexibility

Most definitions of flexibility refer to a firm's ability to meet a variety of needs in a task environment (Sanchez, 1995). For instance, Wright and Snell (1998) define flexibility as a firm's ability to quickly reconfigure resources and activities in response to environmental demands.

Dependence is inherent in R&D collaborations. As a result, allying firms lose some control. One way partners attempt to regain control is by instituting a degree of formalization and rigidity that controls behavior and constrains flexibility (Zhou and Wu, 2010). Scholars discuss flexibility in terms of corporate climate, established lines of authority, with explicit rules and instructions. When an organizational makeup is rigid and thus corporate flexibility low, company managers favor conservative decisions, avoid risky behaviors and consequently, stifle the processing of creative ideas (Hirsch, 1990). This is conducive to exploitative R&D, where mechanistic workflows favor adherence to regulatory rules, for example.

On the other hand, exploratory R&D presents task environments that demand flexibility (Sine, Mitsuhashi, and Kirsch, 2006; Zhou and Wu, 2010). This is because flexibility can lead to generation of new ideas and creation of new technologies (Harryson et al., 2008), the ability to adopt new strategies to solve a problem when old methods have led to an impasse (Perkins, 1988), or to redefine the problem in order to find an original solution (Thurston and Runco, 1999). A number of authors have drawn attention to how

flexibility in response to environmental constraints can lead to creative outcomes (Baron, 1998). Flexible organizations facilitate communication and cooperation, and lead to increased organizational innovation by being open to change (Damanpour, 1991). The willingness of managers to change their ways of doing things and to take risk is important for their readiness to help translate new ideas proposed to them into creative and innovative results (Amabile, 1988). For these reasons, a high degree of flexibility, while it enhances exploratory R&D, may hamper exploitative R&D because it may encourage collaborators to deviate from the successful completion of its predefine tasks.

Autonomy

Autonomy has been studied from various perspectives and it has been used to describe the extent to which collaborators are able to independently carry out project-related tasks and decisions with regard to its environment (Tatikonda and Rosenthal, 2000). It comprises the ability to choose the kind of work carried out and the degree of freedom in project-related tasks (Das and Joshi, 2007; Persaud, 2005; Tatikonda and Rosenthal, 2000). A high degree of autonomy means that R&D collaborators can decide how they attain the goals set by the collaboration and also the control structures and processes within the given resources (Das and Joshi, 2007). Based on a review of the literature, a high degree of autonomy is likely to benefit exploratory R&D, while a low degree of autonomy is likely to benefit exploitative R&D.

There is a general agreement among researchers that autonomy has a positive influence on creativity. Collaborators with a high degree of autonomy regarding their task selection are more likely to succeed in generating new innovations (Bissola and Imperatori, 2011; Persaud, 2005; Seibert, Silver, and Randolph, 2004). Autonomy is most effective in

tasks where further development of ideas is required because studies show that the level of creativity increases with the perception of freedom to choose how to accomplish a given task (Amabile et al. 1996). Exploratory R&D collaborations, especially, face high levels of uncertainty and the need to make fast decisions in reacting to turbulences. A lack of autonomy inhibits quick decision making by engendering long bureaucratic processes (Das and Joshi, 2007). Moreover, group autonomy often goes hand in hand with resources for the pursuit of new technologies and external innovation cooperation (Nohria and Gulati, 1996; Persaud, 2005). With a high degree of autonomy, partners have enough freedom to try out new solutions in response to complex problems. Studies show that autonomy is a major factor in increasing creativity and motivating individuals to innovate creatively (Bissola and Imperatori, 2011; McGrath, 2001). For example, a high level of autonomy within the firm is conducive to radical product innovation (Olson, Walker, and Ruekert, 1995). Accordingly, autonomy benefits exploratory R&D.

The effect of autonomy will be weaker in activities requiring less creative potential. Thus, a low degree of autonomy benefits performing predefined tasks where there is less of a need to try out new things. Providing R&D collaborations that require less need of creativity—or those likely to be found in exploitative R&D collaborations—with a high degree of autonomy will have little effect on the degree of product innovativeness and is, in fact, likely to inhibit its success (Bissola and Imperatori, 2011).

Knowledge assets

Knowledge created, transferred, and shared across boundaries and between firms is the main source of innovation in R&D collaborations (Cummings, 2003; Grant, and Baden-Fuller, 2004).

The evidence shows that the R&D process, particularly the complex and radical innovation processes of exploratory R&D, benefits from engagement with a heterogenous and diverse range of partners, which allows for the integration of different knowledge bases, behaviors and habits of thought. For example, Aulawi et al. (2009) argued that sharing knowledge assets stimulates collaborators to think more critically and more creatively, and results in a greater likelihood of producing new knowledge. Perry-Smith and Shalley (2003) established that collaborators that have easy access to each other have more opportunities for new knowledge exchange that fosters joint creativity. This is because relations to heterogeneous others bring in a diversity of information—information that is rated as more creative (Perry-Smith, 2006). Further, formal and informal relations between people with different information, skills and values increases the chance of unforeseen novel combinations of knowledge, which can lead to radical discoveries. The greater the diversity of technical knowledge resources, the more easily can new technical ideas be understood and procedures for their development and implementation be attained, especially in exploratory R&D (Dewar and Dutton, 1986). Prior studies highlight that firms that do not engage in collaborations possess much lower levels of competence in innovation (e.g., Gemünden et al. 1992; Olson, Walker, and Ruekert, 1995; Ritter and Gemünden 2003). Consequently, fostering many (and diverse) connections between R&D collaborators positively impacts innovative performance (Rothwell and Dodgson, 1991; Kaufmann and Tödtling, 2001; Ritter and Gemünden, 2003), especially in exploratory R&D activities.

Communication

Prior studies suggest that when firms collaborate on complex problems, they are more likely to be successful if they develop processes that facilitate frequent communication (Clark and Fujimoto, 1991; Dyer, 1996). Mohr and Nevin (1990) define communication as the process by which collaborators transmit information, coordinate activities, prompt participatory decision-making, and encourage commitment and loyalty to the alliance. With greater complexity of collaborative research, direct communication and work interaction between partners is important in generating positive innovative outcomes. Frequent communication results in greater knowledge-sharing between partners, which increases the likelihood of success in collaborative efforts. Some research suggests that partners that develop relationship-specific know-how through frequent communication are less likely to misunderstand or misinterpret information (Nishiguchi, 1994; Clark and Fujimoto, 1991). Innovative performance often rests on the extent to which communication can act to reduce uncertainty by ameliorating such factors as risk and complexity by specifically disseminating information across the organization concerning the innovation itself and the operationalization of the innovation (Fidler and Johnson, 1984). Thus, more efficient communication should result in innovative performance.

Interfirm interaction in highly complex, exploratory tasks is described as having high knowledge carrying capacity because it presents immediate feedback opportunities and makes use of both visual and audio modes of communication (Daft and Lengel, 1986; Dyer, 1996). Dyer et al., (2006) showed that more frequent communication and interaction between firms in R&D partnerships (measured categorically through a survey) resulted in

greater knowledge sharing and better performance outcomes. Thus, greater frequency of communication between R&D collaborators is likely to benefit exploratory R&D.

2.2.2 | *Interfirm Relationship Factors*

Because of collaborators' dependence on each other, previous research has emphasized the importance of relational factors for the smooth functioning of R&D collaborations (Powell, 1990). Although various relational mechanisms have been studied, none has received more attention than cooperation and interorganizational trust (Gambetta, 1988; Mayer, Davis, and Schoorman, 1995; McEvily et al., 2003; Sako, 1991; Zaheer, McEvily, and Perrone, 1998; Zand, 1972). Accordingly, a great deal of research in this tradition has identified cooperation and trust as key factors contributing to collaborative innovative performance, the general view being that cooperation and trust have a positive effect on innovative performance (e.g., Dyer and Chu, 2003; Mohr and Spekman, 1994; Zaheer et al., 1998). I explore these two factors below.

Cooperation

Prior studies demonstrate the positive link between cooperation and innovative performance in R&D collaborations (Shan et al., 1994; Robinson and Stuart, 2007). Cooperative firms have, on average, higher overall performance levels than do non-cooperative firms (Shan, Walker, and Kogut, 1994; Abramovsky et al., 2008) and a higher R&D intensity (Becker and Dietz, 2004; Sampson, 2007). The engagement in cooperative activities also increases the profitability of R&D (Belderbos et al., 2003), since they are more likely to share investment costs (Li et al., 2008) and are likelier to take advantage of partners' resources and capabilities (Hitt et al., 2006). R&D partnerships with greater cooperation tend to deal with uncertainty faster and create more flexibility between

partners (Beckman, Haunschild, and Phillips, 2004). For example, cooperation seems to decrease the difficulties involved in predicting exactly what combinations of knowledge, skills, and know-how will be needed in complex innovation (Rycroft, 2007).

Further, studies show that cooperation matters more in exploratory R&D than in exploitative R&D. Several authors, such as Bayona et al. (2001) and Miotti and Sachwald (2003), provide evidence that cooperation in R&D collaborations matter more to firms in more technology-intensive than less-technology-intensive sectors. As Dachs et al. (2008) observe, collaborative behavior matters more in high-technology industries, owing to the higher degree of complexity as well as to the exploratory nature of knowledge generation and use (Pennings and Harianto, 1992; Teece, Pisano, and Shuen, 1997). Put simply, cooperation is an efficient way to improve the success of exploratory innovation projects in R&D collaborations (Belderbos et al., 2003; Becker and Dietz, 2004; Sampson, 2007; Abramovsky et al., 2008).

Trust

Prior studies in collaborative R&D define trust as one party's confidence that the other party in the exchange relationship will not exploit its vulnerabilities (Barney and Hansen, 1994; Zaheer et al., 1998; Dyer and Chu, 2003). This confidence, or trust, is expected to emerge where the "trustworthy" party in the exchange relationship: (1) shows good will and behaves in ways perceived as "fair" by the exchange partner; and (2) does not take advantage of an exchange partner even when the opportunity is available (Mayer et al., 1995). In this perspective, "interorganizational trust describes the extent to which organizational members have a collectively-held trust orientation toward the partner firm" (Zaheer et al, 1998, p.142).

Several scholars (inter alia, Zaheer et al.; 1998; Bstieler, 2006; Bidault and Castello, 2009) have pointed out that the ability of collaborators to rely on trust is a fundamental element in determining the success of R&D collaborations because trust "constitutes a critical ingredient by which partners can weather the conflicts that economic and competitive changes, as well as shifts in corporate priorities, will throw their way" (Ariño et al., 2001). Collaborative experience can generate trust between partner firms (Gulati, 1995a), and trust can reduce transaction costs and uncertainties involved in information sharing and transfer (Barney and Hansen, 1994; Beckman, Haunschild, and Phillips, 2004; Dyer and Chu, 2003; McEvily, Perrone, and Zaheer, 2003; Parkhe, 1993).

Trust is likely to be important in R&D collaborations, which represent situations of risk where there is potential for undesirable knowledge spillovers and opportunistic behavior on the part of collaborators. Scholars have found that trust reduces transaction cost and improves knowledge transfer between partners (Nooteboom, 1996) by improving the effectiveness of coordination between partners (Kulangara, Jackson, and Prater, 2016). When partners trust that payoffs will be fairly divided, they do not have to plan for all future contingencies. They can be confident that equitable adjustments will be made as uncertain conditions change in the R&D process. Trust therefore promotes flexibility in granting concessions because of the expectation that the partner will reciprocate in the future (Dore, 1983). Trust also influences the extent to which partners are willing to share knowledge, especially proprietary knowledge (Kulangara, Jackson, and Prater, 2016). A company will share this information if it trusts that a partner will not steal its ideas or use them in a way that would be inappropriate or damaging. Without trust, partners are less

likely to share knowledge, which is critical to success in R&D partnerships (Oxley and Sampson, 2004).

Schumacher (2006), surveying 67 German R&D collaborations, showed that trust and cooperation are positively correlated and that "cooperative arrangements that are trust-based perform better than do deterrence-based relationships, making trust a good predictor of collaborative success." Schumacher's findings are consistent with, among others, the research of Zaheer et al. (1998), who, studying 107 R&D collaborations in the electrical equipment manufacturing industry, showed that trust has a positive impact on both the negotiation process, thus limiting conflict, and the exchange performance.

Extensive research efforts have also been dedicated to investigating the conditions under which trust is most effective. Several authors observe how mutual trust is conducive to an increase of joint creativity (Jehn, 1995; Simons and Peterson, 2000; Dakhli and De Clercq, 2004). This seems consistent with the findings of Taylor and Greve (2006), whose research indicates that the more experience partners had with each other, the more innovative its output. This is consistent with the view that trust matters more in collaborations involving exploratory R&D than exploitative R&D, where joint creativity is most needed to produce innovative performance.

2.3 | Summary of the determinants of successful innovation by R&D type

The antecedents to successful exploratory and exploitative R&D are summarized in Table 2.1. A high degree of formalization enhances exploitative R&D through improvement of current products, services, and processes, but may hamper exploratory R&D where the ability to produce novel and appropriate solutions to problems is required. In exploratory R&D, a low degree of formalization provides the high degree of flexibility and autonomy

needed to carry out creative endeavors. Likewise, a high degree of flexibility and autonomy may hamper the mechanistic and rules-based activities required of exploitative R&D. Fostering many and more diverse knowledge assets between R&D collaborators positively impacts innovative performance, especially in exploratory R&D activities that benefit from the integration of different knowledge bases. Frequent communication and interaction between firms in R&D partnerships will result in greater knowledge sharing and better innovative performance outcomes overall. Finally, trust and cooperation positively impact innovative performance, especially in collaborations involving exploratory R&D.

3 | UNDERSTANDING CONTRACT DESIGN AND ITS OUTCOMES

Based on Section 2, the management and interfirm relationship factors that lead to successful innovation differ according to the type of R&D activity pursued. Further, many of the factors that affect success in collaborative R&D partnerships pertain to how the collaboration is formally designed. Interfirm contracts play a key role in setting the tone and serving as the blueprint for how partners will interact (Macneil, 1978). There are numerous ways in which a contract for R&D collaboration can be designed since partners have considerable latitude in allocating and specifying obligations, rewards and risks, procedures, and so forth through individual contractual provisions (Nooteboom, 1999). That is, even though contracts have a clear economic impact on an exchange, there is no single template for optimal contract design between partners. Yet its use is ubiquitous in interfirm transactions and it serves as the formal mechanism to design the partnership. A contract between firms can serve many roles. For example, the design of the contract captures the agreed upon terms when one party receives a service in return for valuable consideration from another party, it provides a mechanism to safeguard the exchange, and

it can psychologically influence exchanges. Contracts can set specific expectations about the exchange and relationship (Rousseau and Parks, 1993), which subsequently may be met or violated, leading to additional emotional and behavioral reactions from partners (Weber and Mayer, 2011). Because the way that the contract is written may affect the behaviors of partners in R&D collaborations, it is important to understand how different manifestations of the contract are likely to influence the antecedents to innovative performance.

There are different theoretical perspectives on how scholars have studied and perceived contracts and their effects on partnership outcomes. Transaction cost economics (TCE) scholars, inspired by classical contract theory, argue that formal contractual provisions protect firms against the self-interested behavior by the other party by mitigating against opportunism (Williamson, 1975; Noteboom et al., 1997). The general understanding of this literature is that the characteristics of transactions translate into exchange hazards, which might be managed by drawing more complex contracts by way of control provisions. This view is motivated by efficiency considerations and mitigation against opportunism, (mis)appropriation of value by partner firms, and exchange hazards. In this transaction costs perspective, contracts function as a controlling device. Here, control provisions bring about adherence to a desired outcome through the exercise of authority mechanisms; the purpose being to minimize idiosyncratic and deviant behavior, as well as to hold parties to articulated policy (Etzioni, 1965; Tannenbaum, 1968).

From the resource-based view (RBV) perspective, scholars see contracts as a means of organizing the value creation process through the coordination of partner resources across organizational boundaries (Madhok and Tallman, 1998). Here, the contract clarifies mutual expectations, enables goal congruence, and establishes a basis for shared common

ground (Das and Teng,1998). More specifically, the delineation of roles and tasks enables the coordination of interfaces that are often necessary for the joint endeavor to accomplish collective goals successfully (Mayer and Argyres, 2004). From this resource-based perspective, contracts serve as a coordinating device. Here, coordination provisions provide the appropriate linkages between two partners to coordinate the completion of tasks, joint problem solving, and the resolution of disagreements (Alchian and Allen, 1977; Adler, 1992).

More recent research finds additional contract roles by complementing these theoretical lenses with psychological and sociological perspectives (Weber, 2017). In this view, certain contract frames can induce specific emotions, behaviors, and views of the relationship that lead to positive transaction outcomes and relationships while others negatively impact the focal exchange and ongoing relationship. This perspective provides more nuance to the argument that specific contractual provisions always serve either a controlling or coordinating purpose. By specifying a contract provision in a certain way, a safeguard can provide either a controlling or coordinating purpose without changing its economic impact in the exchange.

By examining these perspectives of interfirm contracts, this section identifies how contract design elements are likely to influence the behavior of partners in interfirm relationships. I first highlight the role that control provisions play in bringing about adherence to a desired outcome through the exercise of authority mechanisms between partners. I then examine how coordination provisions enable desired outcomes by providing the appropriate linkages between partners. Finally, I explore the psychological impact of contracts by examining the role that contract framing plays in managing the

ongoing exchange and relationship. Overall, prior research provides significant evidence that how a contract is written can affect the subsequent coordination of the parties in, and the outcomes of, the relationship. Besides preventing opportunism or misappropriation of assets, contracts can promote coordination across firm boundaries, and align behaviors in driving specific partnership outcomes in interfirm collaborations.

The formal contract manages both the control and coordination of partners in carrying out interfirm activities. Together, TCE, RBV, and the framing perspective influence how one looks at control and coordination that has implications for R&D collaborations. Therefore, this review focuses on provisions that are likely applicable to R&D collaborations in the sub-sections below.

3.1 | Control and coordination by formal contracts

Scholars have looked at the role of interfirm contracts as functions of control and coordination (Faems, Janssens, Madhok, and Van Looy, 2008; Malhotra and Lumineau, 2011). Contractual control and coordination focus on different types of issues. On one hand, contracts may be focused on control issues, whereby through the use of authority mechanisms, as described primarily in the TCE literature (Williamson, 1985), the contract defines the rights and obligations of the parties to support the mitigation of appropriation concerns, manage potential moral hazards, align incentives, and unilaterally monitor problems. By reducing concerns about free riding and opportunism, they constrain the ability of one party to extract additional rents from the other by failing to perform as agreed (Gulati and Singh, 1998; Hoetker and Mellewigt, 2009). In this way, control provisions add rules, regulations, policies, and procedures to contracts (Schepker et al., 2013).

On the other hand, contracts may serve as a framework to guide coordination (Masten and Saussier, 2000). The coordinating dimension of contracts is a means to achieve a desired collective outcome by providing the appropriate linkages between partners (Macneil, 1978), as described primarily in the resource-based literature (Madhok and Tallman, 1998). The coordinating function of contracts refers to desires and expectations between or among the transacting parties that help organize priorities for the future (Ryall and Sampson, 2009). By establishing formal communication and reporting between partners, contractual coordination may facilitate a convergence of expectations (Faems, Janssens, Madhok, and Van Looy, 2008). This is because contractual coordination fosters information sharing and communication to facilitate goal congruence between partners across firm boundaries (Macaulay, 1963). Coordination clauses help to define the objectives of the relationship and assign tasks among partners (Mooi and Ghosh, 2010). Contractual coordination supports a common understanding of what goals partners wish to pursue and how they want to achieve these goals (Ryall and Sampson, 2009). Coordination can be seen more as an enabling process to attain a desired outcome, the purpose being to provide the appropriate linkages between two partners to coordinate the completion of tasks, joint problem solving, and resolving disagreement (Alchian and Allen,1977; Adler, 1992). Coordination-oriented provisions in a contract are aimed at mitigating the risk that misunderstandings will disrupt collaboration among (presumably) well-intentioned parties (Macaulay, 1963).

Both sets of mechanisms seek predictability, but their focus is different. Codification of contract provisions as a control versus coordination function is based on existing

research (e.g., Parkhe, 1993; Reuer and Ariño, 2007) and is described in the following sub-sections.

3.1.1 | *Control provisions of contracts*

In line with TCE theoretical lens, to control against the risk of opportunism that may result from transaction hazards, such as asset specificity, safeguards are designed into contracts, which are manifested through more control provisions in the contract (Mellewight, Madhok, and Weibel, 2007). Control provisions have been shown to influence the development of trust (Lumineau, 2014). Contractual control orients information processing toward the unilateral monitoring and scrutiny of the partners' outcomes (Provan and Skinner, 1989). This facet of contracts helps to check actions that can be verified as being in conflict with the codified contractual terms (Klein and Murphy, 1988). Contractual control may improve the verifiability of outcomes and make easier the detection of divergence from the agreed upon terms of the exchange, which altogether support the internal enforcement of the terms of the agreement between the parties. In this way, the contract enhances the efficiency of rational evaluation to draw inferences about the partner. As such, control provisions do not particularly support trust. This concern with protection, safety, and prevention produces vigilance (Forster, Higgins, and Bianco, 2003; Weber and Mayer, 2011). It reduces the risk of a lack of prudence and fosters healthy suspicion and caution (Lewicki et al., 1998; Luhmann, 1979). Contractual control keeps partners alert to potential dangers or misbehaviors.

Tenbrunsel and Messick (1999) argued that an overreliance on control mechanisms changes the "decision frames" of exchange partners. They argued that including too many control provisions may, ironically, promote opportunistic behavior by inducing a

"business" rather than "ethical" framing of the interaction. Malhotra and Murnighan (2002) argued that overly controlling contracts, which leave little room for discretion, crowd out trust development because they lead to situational rather than personal attributions for the cooperativeness of partners. This crowding out may be especially likely during conflict, because parties are less likely to make generous attributions of each other's behavior when their relationship has turned antagonistic (Ross and Stillinger, 1991). The greater the number of control-oriented provisions in a contract, the lower the subsequent level of goodwill-based trust in the associated relationship and a decrease in the likelihood of relationship continuance (Malhotra and Lumineau, 2011).

Control provisions include specifying the right to regularly audit the partner, defining what is and what is not allowed, or inflicting penalties for the violation of behaviors. For instance, a specification of regular audits of progress assessments focuses attention on the performance of duties or obligations codified in the formal contract. In this way, control provisions increase the level of formalization by explicitly writing rules, policies, guidelines, instructions, and procedures into contracts. This in turn constrains flexibility and autonomy. Legally binding provisions in contracts explicitly state what is and what is not allowed, and therefore appear as control provisions in contracts. Irlenbusch (2005) found that binding provisions appear to "crowd out" cooperative behavior.

Based on my synthesis of the literature in this stream, control provisions of the contract include provisions specifying direct oversight and unilateral process and outcome monitoring (Schepker et al., 2013), and the specification of management roles (Argyres and Mayer, 2007; Ryall and Sampson, 2009).

3.1.2 | *Coordination provisions of contracts*

In line with the RBV theoretical lens, contracts can also formally coordinate the contracting relationship (e.g., Mayer and Argyres, 2004). Firms in contractual relationships are less likely to achieve their objectives when the contracted tasks are highly uncertain and complex (Eckhard and Mellewigt, 2005). When such tasks are completed across organizational boundaries, they require high levels of coordination due to the interface of activities and concerns relating to the division of labor (Dekker, 2004; Gulati and Singh, 1998). To enhance coordination, firms use contracts in several ways: to define roles (Klein Woolthuis et al., 2005; Mayer and Argyres, 2004), to define provisions for reporting or communicating aspects of the collaborative process (Argyres and Mayer, 2007), and to designate who is the project manager or appears in management roles (Klein Woolthuis et al., 2005; Ryall and Sampson, 2009). Mayer and Argyres (2004) note that over time, contracting parties may modify contracts to enhance communication among personnel across firms and to clarify the expectations of both parties. In their survey study, partners did not initially plan for all potential problems in a partnership but responded to problems identified and addressed these problems in future contractual statements of work; this finding supports the idea that parts of the contract can enhance the coordination among partners (Mayer and Argyres, 2004).

Contracts may also coordinate relationships through provisions that monitor processes and outcomes bilaterally, with input from all partners in the exchange. Many contracts contain unverifiable provisions, such as clauses requiring firms to exert the same effort into the alliance as they place into other projects, to have a certain number of full-time employees working on the project, or to assign employees of a certain quality level (Robinson and Stuart, 2007). These are non-binding provisions that are often written into

the formal contract (Irlenbusch, 2005). In addition, provisions that mandate bilateral monitoring of processes employed in the venture appear to increase communication of task-specific activities, which can facilitate greater collaboration (e.g., effective coordination; Faems et al., 2008). Contracts with coordination provisions also affect how parties examine and resolve disputes. In their study of dispute resolutions, Lumineau and Malhotra (2011) found that when contracts emphasize coordination, parties are more likely to use an interests-based approach, which emphasizes collaboration and is less costly for resolving disputes than through litigation.

Based on my synthesis of the literature in this stream, coordinating provisions of the contract include provisions specifying joint oversight (Reuer, Zollo, and Singh, 2002), specification of management roles (Argyres and Mayer, 2007), and bilateral monitoring provisions (Argyres and Mayer, 2007).

3.2 | Contract framing

One tenet of organizational research is that governance mechanisms not only have functional consequences but also fundamentally shape the way in which problems are framed, understood, and ultimately handled (Cyert and March, 1963; Thompson, 1967; Tushman and Nadler, 1978). Contracts are central organizational governance mechanisms (Stinchcombe, 1985), and thus can be viewed as important framing devices, in strategic partnerships (Weber and Mayer, 2011; Foss and Weber, 2016; Lumineau, 2016).

Contract framing has been proposed to offer one potential mechanism to psychologically impact the exchange or ongoing partner relationship (Weber and Mayer, 2011). For example, a duration safeguard can be framed as a shorter contract with an extendibility option (seen as a potential gain) or as a longer contract with an early

termination option (seen as a potential loss). The payoffs are identical regardless of the frame, but the impact on the exchange is still very different (Weber, Mayer, and Macher, 2011). Similar framing could occur if a financial incentive is framed as a bonus or a penalty. If a bonus is missed, partners are less upset than if they have to pay a penalty, even if the net financial impact is the same (i.e., a higher up-front amount with a penalty or a lower up-front amount with a bonus; Weber and Bauman, 2019). Thus, collaborators have very different perceptions of the same contract clause, depending on how it is framed.

The key premise is that contracts have important psychological ramifications that affect the ongoing relationship between partners (Ghoshal and Moran, 1996). According to this view, a contract, like other organizational mechanisms, can act as a frame because its "characteristics organize a vast array of stimuli in the work setting to delimit a situation" (Herman, Dunham, and Hulin, 1975: 231). This indicates that the framing approach to contracting is well aligned with a bounded-rationality perspective while adding a novel information-processing aspect to it (Weber, Mayer, and Macher, 2011). In particular, the types of information included in a contract can induce specific behaviors and views of the relationship. By creating certain expectations about the exchange, contractual provisions affect the way in which partners perceive and interact with each other, which in turn influences exchange success (Weber and Mayer, 2011). As such, the framing perspective suggests that contractual design has an effect on exchange performance that is mediated by relevant social processes characterizing the ongoing relationship.

3.2.1 | *Distinct outcomes of contract frames*

One way that scholars have examined contract framing is by using a theory from cognitive and social psychology: regulatory focus theory (RFT; Weber and Mayer, 2011),

which differentiates between framing contractual provisions as gains/non-gains (promotion frame) or loss/non-loss (prevention frame; Higgins, 1997, 1998). Using RFT enables us to understand why certain contract frames may lead to positive transaction outcomes and relationships while others may negatively impact the focal exchange and ongoing relationship in ways that differentially affect innovation performance.

This research has shown that contract framing using RFT can be used to strategically induce desired behaviors to positively impact innovative performance. Investigators in many fields have examined how regulatory foci impact various organizational phenomena. In entrepreneurship, Baron (2004) has suggested that idea generation is more successful under a promotion view than a prevention view, while others have shown that due diligence performance is enhanced when approached with a prevention focus (Brockner, Higgins, and Low, 2004). Additionally, Galinsky, Leonardelli, Okhuysen, and Mussweiler (2005) have shown that framing negotiation issues as gains/non-gains leads to more integrative, cooperative outcomes than framing them in terms of loss/non-loss. Additionally, greater effort (Roney, Higgins, and Shah, 1995) and greater search for creative solutions (Pham and Higgins, 2005) are evidenced with gain/non-gain frames than with loss/non-loss frames. Weber et al. (2011) used RFT to empirically show that framing duration clauses as extendibility provisions are more likely to minimize issues and protect against exchange hazards in focal exchanges. Finally, Weber and Bauman (2019) showed experimentally that promotion contracts led to more trusting behaviors among exchange partners.

Some common contractual safeguards pertinent to R&D collaborations, such as performance milestones, payment and incentive structures, and duration safeguards, have

been shown in prior literature to be framed in different ways that can lead to alternative perceptions of the exchange. For example, writing performance milestones in higher level, more general terms may provide partners with the leeway to interpret how to achieve certain goals, whereas more specific and detailed language might constrain partners' options for how to achieve certain goals and milestones. Taken together, these examples highlight the importance of understanding how contract framing might impact partners involved in R&D collaborations and lead to partnership success.

3.3 | Summary of contract design elements

Based on the literature, Table 2.2 provides an overview of contract design elements that serve either a control or coordination function that may differentially affect how partners behave and react in an interfirm context. With regard to the management oversight element of the contract design, unilateral or direct oversight provides a control function, while joint oversight provides a coordinating one (Reuer, Zollo, and Singh, 2002). Unilateral monitoring specifying auditing provisions serves a control function, whereas bilateral monitoring that specifies communication terms and meeting provisions serves a coordinating function (Argyres and Mayer, 2007). Writing specific and detailed performance milestones in the contract serves a control function by constraining partners in how they perform specific activities, whereas writing higher level, more general performance milestones serves a coordinating function by providing partners the leeway to perform activities using a myriad of options. Likewise, payment and incentive structures framed as penalties serve to control partners by conforming activities to certain rules, regulations, or policies explicated in the contract, whereas incentives framed as bonuses serve to coordinate by focusing the partner on achieving a desired collective outcome.

Finally, duration safeguards framed as early-termination clauses in the contract serve a controlling function by providing, for example, the option to prematurely end the relationship due to any deviant, nonconforming behavior, whereas extendibility clauses serve a coordinating function by providing partners with a degree of flexibility that allows the option to further continue and extend the performance of contractual duties.

The way these contract design elements are written has consequences for how parties are likely to interact and behave in an ongoing relationship. It is likely to have consequences specifically for the presence of antecedents to innovative performance, such as the degree of formalization, flexibility, and autonomy provided to partners in carrying out the contractual obligations of the R&D collaboration, the heterogeneity of knowledge assets and levels of interfirm communication available to partners, and the degree of trust and cooperation between collaborators. That is, the way contract design elements are written will impact the exchange relationship and consequently innovative performance. I describe this in the following section.

4 | THE IMPACT OF CONTRACT DESIGN ELEMENTS ON INNOVATIVE PERFORMANCE IN R&D COLLABORATIONS

Section 2 of the paper provides a review of the literature on the antecedents to innovation and how these factors are likely to impact collaborative R&D success. Section 3 of the paper examines the literature on interfirm collaboration to understand how certain contract design elements can serve either a control or coordination function and can be framed to elicit different behaviors in the ongoing collaboration. In this section, I integrate these two literature reviews to analyze how contract design elements can impact innovative performance by describing how certain provisions are framed to differentially

influence the antecedents to innovation in exploratory and exploitative R&D. Based on an integration of these two literature streams, I develop propositions that link contract design elements to innovative performance in R&D collaborations. Specifically, I integrate the literature on innovation and interfirm collaboration to examine how each contract design element—management oversight, monitoring, performance milestones, payment and incentive structures, and duration safeguards—will influence innovative performance in R&D collaborations.

4.1 | Management oversight propositions

R&D collaborations allow for many benefits, including spreading R&D costs and pooling different but complementary knowledge (Doz and Williamson, 2002; Rothaermel and Deeds, 2004). Despite these advantages, exploratory and exploitative R&D collaborations face major challenges. Prior literature, relying on insights from both TCE and RBV, suggests the likely emergence of two problems in explorative R&D collaborations: the risk of opportunistic behavior and the difficulty of achieving coordinated action. To address the potential problems of opportunistic behavior and coordination within interfirm collaboration, numerous scholars emphasize the relevance of contract design elements that emphasize oversight (e.g., Parkhe, 1993; Pisano, 1990). But the level of control instituted into management oversight provisions may create problems of rigidity that would hamper innovation outcomes by limiting coordination processes that lead to positive collaboration between partners.

I suggest two contract design elements that may lead to innovative performance in R&D collaborations. First, I discuss joint versus direct oversight provisions and how it impacts R&D processes that lead to innovative performance in exploratory versus

exploitative R&D collaborations. I then discuss the explicit assignment of management roles in the contract and how it leads to innovative performance in general.

4.1.1 | *Joint versus direct oversight*

Partners in R&D collaborations can employ provisions in contracts to support the oversight of a collaborative R&D relationship. Partners can *ex ante* allocate the authority to one of the partners to make all decisions in the event of a contingency (e.g., Arruñada, Garicano, and Vázquez, 2001; Lerner and Merges, 1998), called direct oversight, or allow both partners to be involved in decision making (Palay, 1984), called joint oversight. Such structural interfaces often occur as dedicated administrative oversight or steering committees, which are commonly observed in research collaborations in industries including chemicals, pharmaceuticals, electronics, and airlines (e.g., Deck and Strom, 2002; de Man, Roijakkers, and de Graauw, 2010; Laroia and Krishnan, 2005). In these provisions, partners allocate decision rights, and sometimes include reporting and auditing requirements (Lerner and Merges, 1998; Reuer and Ariño, 2007) that are vested in an administrative apparatus that extends beyond procedural control (e.g., Mayer and Argyres, 2004) to expand the adaptive limits of bilateral contracts. Partners can delegate the specific authority of overseeing and coordinating the activities of the collaboration to a single partner or to a joint administrative structure that is often presumed to be available only to equity-based collaborations. In joint oversight of R&D collaborations, partners can establish jointly staffed oversight committees that control the activities of the collaboration and contractually stipulate the design, functions and performance of these board-like structures (Reuer and Devarakonda, 2016; Smith, 2005). Such committees are set up to

govern the R&D collaboration by contractually defining and enforcing scope of decisions and authority.

Direct oversight serves a control function in an oversight provision. This is because in direct oversight, a single partner unilaterally sets up rules, procedures, and policies to oversee and reward desirable performance. Oversight provisions emphasizing direct oversight triggers formal control processes (Das and Teng, 2001; Fryxell et al., 2002) that serve to standardize the behavior of one partner unilaterally. Such formal control implies aligning incentives of one partner by overseeing their behavior and/or outcomes of the collaboration (Williamson, 1985) by another. Direct oversight emphasizes behaviors in partners that are the opposite of the variation, experimentation, flexibility, and autonomy required of exploratory R&D. Instead, it emphasizes a level of formalization that constrains exploratory R&D in ways that would inhibit innovative performance. Further, this level of oversight does not engender trust (Das and Teng, 2001). However, in exploitative R&D collaborations, direct oversight may provide the necessary formalization that aligns incentives and rewards the successful completion of routine commercialization activities. As such, I propose:

Proposition (P1a): *R&D contracts that establish direct administrative oversight (as opposed to joint administrative oversight) will be positively related to innovative performance in R&D partnerships that are more exploitative in nature.*

On the other hand, joint oversight emphasizes coordination and interfirm collaboration. Establishing joint administrative oversight leads partners to design structural interfaces that reduce information barriers to adaptation by allowing

information sharing and interfirm routines (Joshi and Campbell, 2003). They can also help to achieve coordinated action and promote efficiency *ex post* by facilitating mutual adjustment required for the execution of exploratory R&D activities.

When innovation involves exploratory R&D, partners need to obtain necessary inputs from collaborators, and this knowledge is often sticky and presents difficulties in transfer (Szulanski, 1996). During the process of knowledge sharing, partners may also have to engage in joint problem solving, which requires effective management of the interactions between collaborators, and directing the associated search processes (Nickerson and Zenger, 2004). Joint committees governing the R&D collaboration can serve as useful interfaces that enable partners to overcome the challenges involved in coordinating their activities. The joint nature of the oversight allows partners to communicate shared norms, values and beliefs that emphasize faith in the moral integrity or goodwill of others (Gaertner et al., 1996; Homans, 1962), thus increasing trust between parties (Das and Teng, 2001; Ring and Van de Ven, 1994).

Within the context of exploratory R&D collaborations, joint oversight might facilitate innovative performance for several reasons. First, opposite to formal control emphasizing rules, procedures, and policies, joint control emphasizes shared norms, values, and beliefs (Das and Teng 2001). According to Ouchi (1980: 134), such control can reduce the risk of opportunistic behavior and promote tasks that are "highly unique, completely integrated, or ambiguous." Second, interfirm routines that stress coordination by mutual adjustment are beneficial because this mode of coordination is characterized by excessive information sharing and increased informal communication, essential to come up with innovative solutions (Damanpour, 1991; Aiken and Hage, 1971; Weick and Roberts,

1992; Nonaka and Takeuchi, 1995). Increasing communication flows between partners—against the background of a set of shared norms and values—offers the potential of handling task conflict without risking an escalation of relationship conflict (Faems et al., 2006). In this way, coordination by mutual adjustment might support the type of double-loop learning that would benefit exploratory activities (Argyris and Schon, 1978; Faems et al., 2006).

Doz (1996) observed that, within successful R&D collaborations, partners not only learn each other's competences, but also learn how to cooperate, that is, interact successfully. In other words, firms jointly develop routines that enable interaction and adjustment (Gulati and Singh, 1998, Ring and Van de Ven, 1994). Examples of such interfirm routines are knowledge-sharing routines and joint problem-solving routines (Dyer and Singh, 1998). Devarakonda and Reuer (2018) found that in interfirm collaborations that involve joint administrative duties, problem-solving mechanisms were entailed that enable actors to coordinate functions and work out problems on the fly. As Couchman and Fulop (2001) describe, joint oversight provides an opportunity for socialization across disciplinary and organizational boundaries. It is expected to facilitate the emergence of trust and interfirm routines. Consequently, when such interfirm routines are present, issues of coordination can be addressed not by referring to formalized rules and procedures, but by attending to the process of real-time, interfirm communication. Under such circumstances, coordination by mutual adjustment starts to replace formalized coordination mechanisms (Mintzberg 1979). As such, I propose:

Proposition (P1b): *R&D contracts that establish joint administrative oversight (as opposed to direct administrative oversight) will be positively related to*

innovative performance in R&D partnerships that are more exploratory in nature.

4.1.2 | *Management roles*

The ability of R&D collaborations to produce high-impact innovations often depends not only upon the composition of technical and management human capital, but also on the delegation of duties (Argyres and Mayer, 2007; Ryall and Sampson, 2009). Partners have the ability to use R&D contracts to provide a detailed explication of the roles of partners. By detailing management roles in the collaboration, the contract may serve a safeguarding function by reducing ambiguity about contractual obligations and thereby reducing the scope for opportunistic actions seeking to take advantage of any ambiguity for private gain.

Innovative performance within an R&D collaboration depends upon the production and integration of new knowledge. Understanding how scientific discoveries are translated into useful, commercially successful products requires a close examination of how the partnership invests in technical and management human capital. As the underlying problem to be solved in a partnership becomes more complex, contractual partners seek to reduce this complexity through more explicit description of the partners' roles in the contract. Specifying roles often requires in-depth knowledge of the technology involved in the R&D collaboration and is often created through extensive involvement of the operational team members of the different partners (Couchman and Fulop, 2001). This participatory decision making makes technical personnel, both scientists and engineers, together with management responsible for setting and achieving the objectives of the collaboration. The formalization of the overall objectives is consequently not top-down

implemented, but emerges through a bottom-up process, facilitating trust and the emergence of interfirm routines (Faems et al., 2006).

The contractual specification of management roles provides both a control and coordinating function. This is because the specification of management roles defines the formal roles that managers play in carrying out the tasks of the collaboration. But also, specifying management roles in the contract can lead to greater heterogeneity of knowledge assets between partners, providing interactions that lead to new possibilities, especially when initiating exploratory R&D collaborations. This is achieved through the use of specifying management roles by introducing new individuals to the collaboration. Katz and Allen (1985: 390) stressed that "project newcomers represent a novelty-enhancing condition, challenging and improving the scope of existing methods and accumulated knowledge." In other words, introducing new individuals means the questioning of existing interfirm norms, values and routines and consequently stimulating heterogeneity. Thus, I propose:

Proposition (P2): *R&D contracts that include the specification of management roles will be positively related to innovative performance in R&D collaborations.*

4.2 | Monitoring provision propositions

The specter of opportunism eroding the development of long-term R&D relationships (Barnes et al., 2010) encourages partners to use monitoring mechanisms to align collaborative activities and partners' behaviors toward the achievement of common goals (Kale and Singh, 2007). Establishing collaborative R&D not only necessitates pooling proprietary knowledge resources with the partner, but also delegating responsibilities and relinquishing control over such resources to them (Dimitratos et al., 2009). Some firms

view monitoring provisions of the collaborative contract as a means to coordinate resources between partners. In these cases, contracts are explicitly endowed with process and outcome monitoring provisions that are bilateral in mature, involving both firms.

However, some partner firms are reluctant to relinquish control over their most valuable knowledge in a partnership, given a perceived need to protect this against the counterpart's potential competitive and opportunistic behaviors. In these cases, the more valuable the knowledge initially shared and potentially created in an R&D collaboration, the greater the desire to have control over the partner (Inkpen and Currall, 2004, Zhang and Zhou, 2013). This in turn drives partners to unilaterally manipulate and influence monitoring provisions in the contract in pursuit of their own performance outcomes, even if this undermines overall collaborative development. These firms enact contractual monitoring provisions that represent a unilateral control mechanism, which is defined as "an effort made by one party to measure or meter the performance of another" (Heide et al., 2007, pp. 425–426). As such, unilateral monitoring provisions have been shown to explicitly incorporate auditing provisions that closely monitor the behavior of partners (Lyons and Mehta, 1997). Such provisions may be useful in cases where routine outcomes are easily measured, as in the case of exploitative R&D collaborations. In this context, unilateral provisions spelling out auditing requirements provide the motivation for partner's behavior to adhere strictly to the requirements specified in the contract. As such, I propose:

Proposition (P3a): *R&D contracts that specify unilateral monitoring provisions (auditing provisions) between partners will be positively related to innovative performance in R&D partnerships that are more exploitative in nature.*

I argue that unilateral and bilateral monitoring provisions serve different roles that differentially impact partners' behaviors. While unilateral monitoring serves as a control mechanism that may reliably suppress partner opportunism in cases where routine activities have measurable outcomes (Heide et al., 2007), the use of bilateral monitoring provisions serves a coordinating function. Bilateral monitoring provisions have been shown to explicitly incorporate communication terms (Argyres and Mayer, 2007) and/or meeting requirements (Arino and Ring, 2010) between partners. By incorporating communication terms and meeting provisions into the contract, bilateral monitoring provisions communicate to both parties a range of shared norms. First, it communicates mutuality and solidarity that gives rise to flexibility between partners (Abdi and Aulakh, 2014). Second, it gives rise to information exchange that leads to further increased communication between partners (Kale and Singh, 2009). In this way, bilateral monitoring provisions serve as a means of increasing heterogeneity of knowledge assets between firms, and increasing cooperation among collaborators, factors necessary for the successful competition of exploratory R&D activities. As such, I propose:

> **Proposition (P3b)**: *R&D contracts that specify bilateral monitoring provisions (communication terms and meeting provisions) between partners will be positively related to innovative performance in R&D partnerships that are more exploratory in nature.*

4.3 | Performance milestone propositions

Contracts specify the work to be done from explicit and complete to incomplete phrasing of task execution and output (Schepker et al., 2013). In R&D collaborations, task output is captured in the contract in the form of performance milestones (Robinson and

Stuart, 2007; Ryall and Sampson, 2009). How contracts specify the work to be done can psychologically impact the exchange or ongoing partner relationship (Weber and Mayer, 2011). Contract framing perspective offers one potential mechanism. Framing contract design elements in terms of losses or gains situationally induces a prevention or promotion focus (Roney et al., 1995; Tykocinski et al., 1994) in an exchange, which can be used strategically to activate the desired behaviors and attitudes associated with each of the profiles. Thus, RFT (Higgins, 1998) suggests that contracts can be framed as a loss to induce intense vigilance and monitoring (a prevention frame) or as a gain to incite cooperation and flexibility (a promotion frame), without significantly changing the economic impact of the design element.

Loss-framed contracts play a prevention role because the objective in the exchange is perceived as a minimal goal that must be met, which induces vigilant behavior. The choice to frame a contract design element in a prevention manner also influences the type of details outlined in the agreement. If the parties choose to frame a performance milestone using a prevention frame, RFT suggests that the contract will contain highly detailed specifications, including potential contingencies, because a prevention frame induces detail-oriented (or local) information processing (Förster et al., 2003). Thus, one partner will be vigilant in meeting the detailed specifications in the contract, while the other will be vigilant in unilaterally monitoring the partner. Prevention contracts set expectations for neutral to negative behavior in the exchange since they induce a focus on detecting negative behaviors. In addition, they set expectations of an impersonal, detached, business-like relationship between the exchange partners that often lacks trust. Dyer and Singh (1998) suggest that exchanges governed by trust generate more successful transactions

and exchange relationships than those governed by contracts. Here, the argument is that contracts with extensive detail of performance milestones encourage unilateral monitoring, prevent flexibility, or inhibit joint value creation initiatives. These issues are primarily characteristic of prevention contracts.

A promotion-framed (gain-framed) contract plays an entirely different role than a loss-framed contract. Promotion contracts promote flexible and creative behavior in an exchange. Again, the choice of frame influences the detail used to craft the contract design element. A promotion frame encourages big picture (or global) information processing (Förster et al. 2003), so instead of the detailed specifications typically found in loss-framed performance milestones (e.g., how specific tasks will be performed), gain-framed performance milestones contain detail more focused on aligning overall interests than clarifying how to perform specific tasks. Therefore, if R&D collaborators choose a loss frame, RFT suggests that the performance milestone will typically include detailed specifications, including potential contingencies; however, if the same performance milestone is framed using a gain frame, it is more likely to focus on general milestones or the big picture (i.e., aligning expectations by understanding the other partner's goals and context) instead of detailed specifications regarding how to complete the project or how the tasks will be performed.

I argue that using contract framing to induce a regulatory view that matches the nature of R&D activities in the R&D collaboration (prevention for exploitative R&D requiring vigilance and promotion for exploratory R&D requiring creativity or flexibility) should positively influence innovative performance. Gain-framed performance milestones should lead to innovative performance in the context of exploratory R&D collaborations,

since they engender in partners close, trust-based relationships and creative and flexible global search for solutions. On the other hand, loss-framed performance milestones should lead to innovative performance in the context of exploitative R&D collaborations, since they engender in partners the vigilance to successfully complete routinized activities, explicitly detailed by the contract, requiring only local knowledge to perform. As such, I propose:

Proposition (P4a): *R&D contracts that specify highly detailed, specific performance milestones (as opposed to higher-level, more general performance milestones) will be positively related to innovative performance in R&D partnerships that are more exploitative in nature.*

Proposition (P4b): *R&D contracts that specify higher-level, more general performance milestones (as opposed to highly detailed, specific performance milestones) will be positively related to innovative performance in R&D partnerships that are more exploratory in nature.*

4.4 | Payment and incentive structure propositions

One of the defining features of R&D contracts is the way in which the contract payment structure is designed between partners (Xiao and Xu, 2012). Not only do both parties have opposite preferences for the total size of the payment, but they also have conflicting preferences for how that payment should be structured. For example, a buyer of inventions (licensees) would prefer to pay as little upfront as possible to minimize their risk and the uncertain outcomes they face. Their goal is to delay payments and make them contingent upon the invention's performance through a royalty rate (Gallini and Wright, 1990; Macho-Stadler et al., 2008). Conversely, economic theory predicts that for multiple reasons—such as risk aversion and financial constraints—the suppliers of inventions (the

inventors) will prefer high upfront fixed-fee payments for an invention (Crama, De Reyck, and Degraeve, 2008; Kulatilaka and Lin, 2006).

Payment structured in R&D contracts can be fixed or variable, which are tied to efforts or results (Hypko et al., 2010). Performance incentives involve financially compensating a partner for agreed-upon outcomes (also referred to as pay-for-performance; Caldwell and Howard, 2014; Selviaridis and Spring, 2018). Generally, performance incentives are considered to elicit partner behaviors that are productive; i.e., behaviors that have positive effects, such as promoting performance improvement, cost efficiency and innovation (Randall et al., 2011; Sumo et al., 2016). However, unproductive behaviors, i.e., behaviors having negative effects, resulting from perverse incentives, such as opportunism, may also be at play (Koning and Heinrich, 2013). Overall, the effectiveness of contractual performance incentives, that is, the extent to which they trigger partner responses that have positive effects, largely depends on how the contracts are designed (Selviaridis and Wynstra, 2015; Essig et al., 2016).

Contractual incentives can be designed using a promotion or gain frame that awards partners a bonus in case performance targets are met or even exceeded, or a prevention or loss frame, which imposes a penalty in case performance targets are not met (Weber and Mayer, 2011). Promotion frames are suggested to instigate flexibility, creative behavior and partner cooperation to achieve the specified exchange goals (Weber and Mayer, 2011), while prevention frames are suggested to induce vigilant behavior and arm's length relations.

Under a prevention frame, contractual performance incentives are framed as a loss and parties interpret a performance target as a minimum that must be achieved.

Performance incentives take the form of negative motivation, i.e., the use of penalties in case performance targets are not achieved. RFT suggests that the supplier wishes to avoid not meeting the targets and incurring the penalty, and therefore responds by displaying vigilant behavior during the exchange, aimed solely at meeting the minimum performance. With regard to the relationship, a prevention frame leads the supplier to emphasize negative aspects of the relationship, which triggers the relational response to keep the counterpart at arm's length (Cao and Lumineau, 2015). RFT also suggests that the prevention contract sets, overall, negative *ex ante* expectations. These are based on anticipations for impersonal behaviors during the exchange and transactional relationships focusing mostly on the letter of the contract.

Prevention-framed contractual performance incentives are useful in the context of R&D that is exploitative in nature, where activities are generally performed as if they are routine and one that the partner knows how to conduct. For example, an R&D collaborator brought on to commercialize a pharmaceutical drug in the advanced stages of regulatory approval would benefit from the added vigilance engendered by a prevention-framed performance incentive. It will likely focus the partner's motivation on the avoidance of not meeting the goal, which is to obtain regulatory approval. Prevention-framed incentives would be more appropriate in scenarios such as these, where relationships are perceived as transactional. As such, I propose:

Proposition (P5a): *R&D contracts that frame performance payments as penalties will be positively related to innovative performance in R&D partnerships that are more exploitative in nature.*

In contrast, under a promotion frame, partners view a performance target as a maximum that may be achieved (Weber and Mayer, 2011). Performance incentives take the form of positive motivation, i.e., receiving a bonus in case performance targets are achieved or exceeded. The supplier will actively seek to achieve the objectives, and hence, according to RFT, responses during the exchange will involve the creativity and flexibility needed to achieve an aspirational objective (Weber et al., 2011).

Promotion-framed incentives are more useful in the context of exploratory R&D partnerships, where collaborative relations that lead to greater cooperation and trust benefit the exchange. Promotion-framed incentives also promote creativity, flexibility, broad thinking that lends itself well for exploratory search, greater risk-taking, and building new capabilities with the goal of developing new knowledge. At the relationship level, a promotion frame draws more attention to positive relationship aspects, leading the partner to emphasize cooperation and inducing responses aimed at the development of close, personal, and trusting relationships that promote interfirm communication (Schepker et al., 2013). *Ex ante* expectations set by a promotion frame are, overall, positive. That is, they include positive exchange behaviors that go beyond the letter of the contract, and close, nurturing and interactive relationships that lead to a heterogeneity of knowledge assets. As such, I propose:

Proposition (P5b): *R&D contracts that frame performance payments as bonuses will be positively related to innovative performance in R&D partnerships that are more exploratory in nature.*

4.5 | Duration safeguard propositions

Extendibility and early termination provisions act as contract design elements that mitigate against potential opportunism by allowing partners to alter exchange durations of the R&D collaboration. These two provision types operate differently, yet they offer similar partner protections. Extendibility provisions provide safeguards by allowing one partner to unilaterally continue a contract for a specific period beyond the end date if the counterpart has performed well. Early termination provisions provide safeguards by allowing one to unilaterally terminate the contract before the end date if the counterpart does not meet prespecified conditions or provides unsatisfactory performance.

Extendibility and early termination provisions can be structured to produce identical economic ends, yet these clauses differ significantly from a psychological perspective. An early termination provision leads contracting partners to view a goal as a minimal requirement, but an extendibility provision leads the partners to interpret the goal as an ideal outcome. According to RFT, the dissimilar perspectives produce different motivations, behaviors, and perceptions regarding the parties' exchange and ongoing relationship (Higgins, 1998).

I suggest that aligning the type of R&D with the necessary induced behavior, by matching duration clause framing with the nature of the R&D collaboration, will lead to innovative performance. Since a prevention frame encourages detail-oriented (or local) information processing (Forster and Higgins, 2005), early termination clauses induce exchange partners to focus on completing the first project part rather than all aspects of the entire potential collaboration, and display vigilance in an effort to meet the minimal goal and thereby avoid sins of commission. This framed duration provision would likely suit the characteristics of exploitative R&D better. An early termination clause enhances

performance in a collaboration when vigilance is required (e.g., when adherence to detailed specifications is critical), as is the case with exploitative R&D. As such, I propose:

Proposition (P6a): *R&D contracts that frame contract duration as early terminable will be positively related to innovative performance in R&D partnerships that are more exploitative in nature.*

In contrast, a promotion frame initiates big picture (or global) information processing (Forster and Higgins, 2005), extendibility clauses induce both firms involved to focus on the potential duration of their extended contract and display creative and flexible behavior in an effort to reach this ideal goal while avoiding sins of omission. In conducting exploratory R&D, partners situationally induced in this frame would exhibit creativity and risk taking that would benefit the search for creative solutions to novel questions, thus potentially improving innovative performance in this context, as opposed to exploitative R&D. An extendibility clause therefore enhances performance in a collaboration that requires creativity and flexibility (e.g., when leading-edge technology is being developed). As such, I propose:

Proposition (P6b): *R&D contracts that frame contract duration as extendable will be positively related to innovative performance in R&D partnerships that are more exploratory in nature.*

5 | DISCUSSION

While the literature on interfirm collaborations has found that the design of the contract is a significant factor in explaining transaction outcomes (e.g., its success or failure; Weber, Mayer, and Wu, 2009; Schepker, Oh, Martynov, and Poppo, 2013), the impact of contract design on innovative performance has remained largely unexplored.

This is because scholars have generally viewed the role of contracts as limiting opportunism, mitigating hazards, and preventing misunderstanding between partners (Williamson, 1985; Mayer and Argyres, 2004) and not as promoting or fostering an environment that facilitates innovation. As a result, the focus has not been on how the design of the contract may impact the performance of R&D partnerships, even though contracts specify the nature of the interactions between partners in ways that may enhance or inhibit innovation.

This paper builds on interfirm contracting research by integrating the literatures on innovation and interfirm contracts to develop a framework and a set of propositions for understanding how certain design elements of the contract are likely to influence innovative performance in R&D collaborations. This paper addresses Weber, Mayer, and Wu's (2009) call to complement traditional perspectives in interfirm contracting research with nontraditional perspectives in examining how contact design impacts transaction performance. The choice of collaborative governance mechanisms is frequently addressed in the literature (e.g., Hagedoorn 1993; Sampson 2007). But relatively little attention has been devoted to the performance consequences of such contract design considerations (Weber et al., 2009). By building on research that applies TCE and RBV perspectives to contracts and augmenting them with sociological and psychological perspectives, this paper has identified contract design elements that provide functions of controlling behavior and coordinating resources in addressing the challenges pertaining to exploratory and exploitative R&D collaborations. By focusing on the specification of these focal design elements, this paper has examined how a contract design is likely to play a key role in the success of R&D collaborations with a need for innovative performance. And by developing

a series of propositions, this paper highlights the need to integrate research on innovation with the diverse perspectives on contracts in order to fully understand how contract design influences the potential for collaborators in an R&D transaction to produce an innovative result.

The contract does indeed form a blueprint for an interfirm exchange (Macneil, 1978). But it does more than simply control behavior and coordinate resources across firm boundaries. The contract can be an important element in the emotional response of partners to the transaction and to their exchange partner (Weber and Mayer, 2011; Weber et al., 2011). Research on framing in regulatory focus theory (e.g., Higgins, 1998) can play important roles in complementing the rational governance perspectives of TCE and RBV. It allows for the contract to be designed in such a way that collaborators not only have aligned expectations and the proper incentives to fulfill their obligations in the transaction, but also the ability to foster an environment that maximizes the chances for success by setting the right frames and invoking partner motivation in the most productive way possible to achieve innovative performance. By incorporating research from social psychology, we can conceptualize partner alignment in ways that look more broadly at what is required for a successful transaction and the importance of social factors in driving innovative performance in R&D collaborations. A straightforward transaction like buying commodities requires little attention to social psychology factors (i.e., there is little uncertainty, no need for creativity/innovation, few exchange hazards and typically many alternative suppliers). But transactions involving more complex interaction between firms and in which one firm must do something creative, challenging, or uncertain, as in R&D collaborations, could benefit from considering the role of social psychology in determining

the best way to write contracts that govern the transaction. With this perspective, contract design elements have a useful role in not only controlling behavior or coordinating resources, but also in providing the necessary conditions to ensure successful innovation.

The idea that the design of the contract can play an important role in fostering innovation, not just by creating economic incentives but by helping to create a particular type of environment, is important and calls for additional research to better understand this effect. This paper is not arguing that a well-designed contract is a sufficient condition for a successful R&D collaboration—the parties must still manage the exchange and the individuals involved—but it is an important first step that can set the R&D partnership off on the right foot and increase the chances of innovative performance. Further research is needed to empirically examine the propositions that link contract design and innovative performance of R&D collaborations.

6 | CONCLUSION

Firms increasingly rely on R&D collaborations to develop new technological opportunities. R&D collaboration faces substantial complexity; this poses significant challenges of how to govern the interfirm relationship. Creating something positive and the avoidance of something negative are both important to the management of R&D collaborations, but current research in this area tends to be focused on avoiding a negative rather than creating a positive environment for collaborators. By relying on insights from both the innovation and interfirm collaboration literatures, the purpose of the paper is to improve our understanding of the implications of contract design on innovative performance in R&D collaborations. This paper proposes that contracts can do more than prevent negative events by enacting control provisions; it can also foster the creation of

positive events by specifying provisions in ways that promote coordination and cooperation that lead to innovative performance. But the contract governing any R&D collaboration must be aligned with the type of innovation that is expected to be accomplished. For example, if the transaction is exploitative, an arms-length contract or even simple control provisions may be an adequate contract design choice. However, the challenges for exploratory R&D transactions posed by innovation require more than the simple approach of utilizing control provisions to direct the behavior of partners. It requires contracts that coordinate resources across firm boundaries and motivate partners in ways that achieve a goal that is exploratory in nature. The type of R&D activities carried out, namely exploratory or exploitative R&D, has implications for how firms can design contract elements that lead to innovative performance. By better understanding how contract design is likely to impact the antecedents to innovation, we can better understand how contracts can be designed to ensure successful R&D collaborations.

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TABLE 2.1 Antecedents to Innovation by R&D Type

Innovation Antecedent	Exploratory R&D	Exploitative R&D
Formalization	Low degree	High degree
Flexibility	High degree	Low degree
Autonomy	High degree	Low degree
Knowledge Assets	Heterogeneity is critical	Heterogeneity is beneficial
Communication	Frequent communication is critical	Frequent communication is critical
Cooperation	Greater cooperation is critical	Greater cooperation is beneficial. Lack of cooperation is not detrimental
Trust	Greater trust is critical	Greater trust is beneficial. Lack of trust is not detrimental

TABLE 2.2 Control and coordination specification of contract design elements based on the literature

Contract Design Element	Control	Coordination
Management oversight	Direct oversight	Joint oversight
Monitoring	Unilateral	Bilateral
Management roles	Provides both a control and coordination function	
Performance milestones	Specific and detailed	Higher level and general
Payment structure	Penalties	Bonuses
Duration	Early termination	Extendibility

PAPER 3

CONTRACT DESIGN AND INNOVATIVE PERFORMANCE:

EVIDENCE FROM BIOPHARMACEUTICAL PARTNERSHIPS

ABSTRACT

Firm innovation is important to achieve and maintain competitive advantage. While research conducted within the firm can lead to innovation, firms also rely heavily on interfirm collaborations to develop R&D that can enable successful innovation. R&D partnerships represent one of the most common forms of interfirm collaboration and are especially prevalent in technology-intensive industries such as pharma and biotechnology. Despite the best intentions, R&D partnerships do not always succeed and do not always lead to innovative performance. The design of the contract is a significant factor in explaining these outcomes. But the link between contract design and collaborative innovative performance has remained somewhat unexplored because studies do not focus on how specific contract design elements impact innovative performance directly. Furthermore, they fail to distinguish between exploratory and exploitative R&D. In order to understand innovative performance, it is important to recognize that the level of contractual control and coordination necessary to foster innovation is likely to be different depending on the type of R&D. This study examines whether specific contract design elements, namely the contractual specification of management oversight, monitoring, and management roles, based on their control and coordination distinction, impact collaborative innovative performance in exploratory and exploitative collaborations. I test predictions on a sample of 305 biopharmaceutical partnerships at various stages of research and development and find some evidence that elements of the design of the contract may impact the innovative performance of R&D partnerships. Specifically, I find

support for the link between the contractual specification of direct oversight and innovative performance in exploitative R&D partnerships, the link between bilateral monitoring and innovative performance in exploratory R&D partnerships, and the link between the contractual specification of management roles and innovative performance in R&D partnerships, in general. This study contributes to the literature on both R&D partnerships by improving our understanding of the factors that may lead to innovative performance, and innovation by examining a more robust set of measures for innovative performance than previously operationalized. In doing so, this study posits a role for the specification of contract design elements that provide a control or coordinating role between partners that enhances or inhibits collaborative innovative performance in exploratory and exploitative R&D partnerships.

1 | INTRODUCTION

There is an abundance of literature on R&D partnerships and the factors that impact their success and failure (Mohr and Spekman, 1994; Sampson, 2005). R&D partnerships are frequent, and firms rely on them to maintain their competitive advantage by increasing innovative output (Cassiman and Veugelers, 2006). Yet, many R&D partnerships fail to meet their expectations (Bleeke and Ernst, 1991; Ariño and de la Torre, 1998) because collaborative R&D involves high levels of transactional uncertainty and the exchange of tacit knowledge problems that necessitates control and coordination among partners (Gulati and Singh, 1998; Heiman and Nickerson, 2004; Sampson, 2004, 2005; Mellewigt et al., 2007). As a result of these challenges, conducting research and development across firm boundaries bring to the forefront factors that either enhance or inhibit innovative performance (Galunic and Rodan, 1998; Mitchell and Singh, 1992). The literature on R&D partnerships has found that the design of the contract is a significant factor in explaining the outcome (e.g., success and failure; Ryall and Sampson, 2009) because the contracts used in these partnerships are a central mechanism for governing the interfirm exchange (Schepker, Oh, Martynov, and Poppo, 2014). Thus, to understand why R&D partnerships fail or succeed it is important to examine the design of the contract.

The high failure rate of R&D partnerships means that careful contract design is key. Despite substantial scholarly interest in the role of contract design in R&D partnerships, few studies have directly analyzed the mechanisms and conditions relevant to how the elements of the design of the contract influence innovative performance. Furthermore, prior studies usually consider R&D collaborations yet fail to distinguish between the types of R&D activities within the innovation process (Martinez-Noya and Narula, 2018). Yet, the

multidisciplinary and increasingly complex nature of the innovation process has induced firms to disintegrate their own R&D processes into exploratory and exploitative types (Koza and Lewin, 1998), and even partner with other firms on the different aspects of the R&D value chain. Ignoring the potential variance that exists across R&D partnerships initiated under different motivations can mask the influence that contract design elements have on innovative performance. As a consequence, I argue that a more subtle understanding of the control and coordination functions that contractual elements provide in the R&D partnership context and its relationship to the realization of innovative performance necessitates a more fine-grained analysis. I accomplish this by analyzing different types of R&D partnerships and different specifications of contract design elements with a focus on innovative performance effects at the transaction level of analysis.

This paper seeks to develop and test a framework to better understand how the elements of the design of the contract may impact the performance of R&D partnerships. It does so by identifying control and coordination provisions of contracts that are highly pertinent to understanding collaborative innovative performance. This study examines control and coordination provisions from the transaction cost economics (TCE) and resource-based view (RBV) perspectives. Based on this literature, the elements of contract design that may impact partnership success or failure include provisions that specify management oversight, monitoring, and management roles. These contract design elements, based on their functional distinction, can enhance or inhibit innovation by providing varying degrees of formalization, flexibility, autonomy, heterogeneity of knowledge sources, communication protocols, trust, and cooperation in the R&D partnership context.

I propose that the contractual specification of management oversight, monitoring, and management roles, both separately and together, are likely to lead to innovative performance. I test these predictions on a sample of 305 biopharmaceutical partnerships at various stages of R&D. Specifically, I find support for the link between the contractual specification of direct oversight and innovative performance in exploitative R&D partnerships, the link between bilateral monitoring and innovative performance in exploratory R&D partnerships, and the link between the contractual specification of management roles and innovative performance in R&D partnerships, in general.

This paper contributes to the literature on R&D partnerships by improving our understanding of the factors that may lead to innovative performance (Sampson, 2007; Keil et al., 2008; Satta et al., 2016). By investigating elements of the design of the contract, I contribute to our understanding of how contracts can both control and coordinate partners in ways that lead to innovative performance. I do this by distinguishing the type of R&D carried out in the partnership, exploratory versus exploitative. Prior studies have generally not systematically distinguished between partnerships at different foci of the R&D value chain and are thus at risk of aggregation bias. By distinguishing the types of R&D, this study more clearly examines the elements of the design of the contract that are likely to lead to success in innovation performance in exploratory and exploitative R&D.

Finally, this paper contributes to the literature on innovation by examining a more robust set of measures for innovative performance than previously operationalized. Studies in the innovation literature have highlighted several limitations of measuring innovative performance in the biopharmaceutical industry (e.g., Lanthier et al., 2013; Hagedoorn and Cloodt, 2003; DiMasi, 2000). The research and development process in the

biopharmaceutical industry is a long process that sees most drugs fail to obtain FDA regulatory approval (DiMasi, 2000). Yet, the traditional measures of innovative performance by focusing on this end point, do not provide an adequate representation of innovation in this industry (Adams et al., 2006). There is no intermediary innovative output measure in the case that partnerships fail to produce an approved drug. Therefore, this study addresses this limitation by examining a more robust set of measures for innovative performance that capture the knowledge gained along different aspects of the R&D process.

Overall, this study focuses on examining how contract elements can foster innovative performance. This sheds light on how specific elements of the contract can promote innovation and how this is likely to be different in exploratory and exploitative R&D partnerships.

2 | THEORY AND HYPOTHESES

R&D partnerships allow for many benefits, including spreading R&D costs and pooling different but complementary knowledge (Doz and Williamson, 2002; Rothaermel and Deeds, 2004; Leiponen and Helfat, 2010). Despite these advantages, R&D partnerships face major challenges. Prior literature, relying on insights from both TCE and RBV, suggests the likely emergence of two problems in R&D partnerships: the risk of partners behaving opportunistically and the difficulty of achieving coordinated action. To address the potential problems of opportunistic behavior and coordination within interfirm collaborations, numerous scholars emphasize the relevance of contract design elements that emphasize management oversight, monitoring, and the delegation of duties (e.g., Parkhe, 1993; Pisano, 1990; Schepker et al., 2014). But the level of control instituted into

these provisions may create problems of rigidity that would hamper innovation outcomes, depending on the R&D context, by limiting coordination processes that lead to positive collaboration between partners.

Collaborative R&D presents many managerial challenges in their effective design and management. This is because R&D partnerships tend to require the exchange of specific knowledge that is difficult to codify and is better transferred through close interaction (Cantwell and Santangelo, 1999). Provisions for safeguards, controls, and monitoring exist in most R&D contracts in order to set the right scope of interaction between partners (Faems et al., 2008). Because of the tacit nature of knowledge and complex problem-solving required of such collaborations and in order to forestall disagreements (Heiman and Nickerson, 2004), R&D contracts specifically require coordination mechanisms (Lumineau and Malhotra, 2011) or provisions that explicitly specify information-sharing, communication terms, management roles, auditing requirements, and disclosure (Ryall and Sampson, 2009). Additionally, clauses often specify, with varying clarity, the duties undertaken by each partner and the coordination of interface protocols between them. Such clauses can be thought of in terms of seeking to enhance the efficiencies that the partnership can bring. As the essence of many R&D partnerships is the distribution of roles and tasks that require coordinated action between the partners, these are often specified *ex ante*. Specifying contracts to establish, for example, high bandwidth communication channels among partners that allow for higher intensity of communication and interaction are expected to help partners develop a better understanding of each other's cultures and management systems, thus enhancing coordination. But such levels of relationship-specific investments, especially those that are

of an intangible nature, may act as a "double-edged sword" as they may give rise to contracting hazards (Martínez-Noya et al., 2013). This dilemma implies that although maintaining relationships that provide flexibility and autonomy and foster knowledge sharing are beneficial, they may exacerbate other behaviors that serve to limit innovative outcomes.

So, a key question in designing a collaborative R&D contract is to determine the degree of control and coordination that the partners want to have with each other to limit the risk of opportunistic behaviors while fostering innovation. However, the innovation literature suggests that R&D is not uniform. Scholars have identified two types of innovation along the research and development value chain: exploratory and exploitative R&D (see Gilsing and Nooteboom, 2006; Jansen et al., 2006; Andriopoulos and Lewis, 2009). In order to understand innovative performance, it is important to recognize that the level of contractual control and coordination necessary to foster innovation is likely to be different depending on the type of R&D.

From the generation of new ideas through the launch of a new technologies and products, the exploration and exploitation of knowledge is a core function of R&D. During the early stages of the R&D process, firms are prospecting for new wealth-creating opportunities in a given area. Exploratory R&D involves conducting activities such as improvisation and experimentation. The hoped-for outcome for collaborators in the exploration process is the embodiment of new knowledge learned through exploratory research into a prototype product that can be extended into the testing and development process or the codification of new knowledge through patenting. Once potentially valuable knowledge and skills have been acquired through exploration, the process then turns to

exploitative R&D activities. Exploitative activities are those which are generally performed as if they are routine, activities that an organization generally knows how to conduct, and activities that the organization can properly conduct by using present knowledge (March, 1991). Thus, successful exploitative R&D often enables a firm to commercialize the knowledge gained through exploratory research and development.

It is important to make the distinction between exploratory and exploitative R&D because they differ in terms of the factors that are likely to lead to innovative performance by type of R&D. The higher need for novelty in exploratory R&D requires partners to focus on how they can coordinate to maximize their joint creative potential. Conversely, mechanistic workflows in such predefined tasks as manufacturing, regulatory approval, marketing, and distribution, require deliberate control structures in order to realize innovative performance in exploitative R&D. This is because an emphasis on control versus coordination of the contract differentially impacts the antecedents of innovative performance, such as the heterogeneity of knowledge assets, and levels of communication, formalization, flexibility, autonomy, trust, and cooperation between collaborators.

The following sections examine how specific contract design elements may lead to innovative performance by impacting the antecedents to collaborative innovative performance. In the first section, I examine management oversight of R&D partnerships and how the specification of direct oversight provides control between partners that impacts innovative performance in exploitative R&D partnerships. Then, I examine how the specification of joint oversight provides coordination between partners that impacts innovative performance in exploratory R&D partnerships. In the second section, I examine monitoring provisions of R&D partnerships and how the specification of unilateral

monitoring provides control between partners that impacts innovative performance in exploitative R&D partnerships. Then, I examine how the specification of bilateral monitoring provides coordination between partners that impacts innovative performance in exploratory R&D partnerships. Third, I examine the specification of management roles and how it provides both control and coordination between partners in ways that impact innovative performance in R&D partnerships, in general. Finally, I compare two states of contracts and examine their impact on innovative performance. Specifically, I compare whether contracts that include the specification of (1) direct oversight, unilateral monitoring, and management roles, together, are more positively associated with innovative performance in exploitative R&D partnerships than contracts that include the specification of (2) joint oversight, bilateral monitoring, and no management roles. Then, I compare whether contracts that include the specification of (1) joint oversight, bilateral monitoring, and management roles are more positively associated with innovative performance in exploratory R&D partnerships than contracts that include the specification of (2) direct oversight, unilateral monitoring, and no management roles.

2.1 | Management Oversight of R&D Partnerships

Firms in R&D partnerships can employ provisions in contracts to support the management oversight of a collaborative R&D relationship. Partners can *ex ante* allocate the authority to one of the partners to make all decisions in the event of a contingency (e.g., Arruñada, Garicano, and Vázquez, 2001; Lerner and Merges, 1998), called direct oversight, or allow both partners to be involved in decision making (Palay, 1984), called joint oversight. Such structural interfaces often occur as dedicated joint committees, which are commonly observed in research collaborations in industries including chemicals,

pharmaceuticals, electronics, and airlines (e.g., Deck and Strom, 2002; de Man, Roijakkers, and de Graauw, 2010; Laroia and Krishnan, 2005). In these provisions, partners allocate decision rights, and sometimes include reporting and auditing requirements (Lerner and Merges, 1998; Reuer and Ariño, 2007) that are vested in an administrative apparatus that extends beyond procedural control (e.g., Mayer and Argyres, 2004) to expand the adaptive limits of bilateral contracts. Partners can delegate the specific authority of overseeing and coordinating the activities of the collaboration to a single partner or to a joint administrative structure that is often presumed to be available only to equity-based collaborations. In joint oversight of R&D collaborations, partners can establish jointly staffed oversight committees that control the activities of the collaboration and contractually stipulate the design, functions and performance of these board-like structures (Reuer and Devarakonda, 2016; Smith, 2005). Such committees are set up to govern the R&D collaboration by contractually defining and enforcing scope of decisions and authority.

Direct oversight serves a control function in an oversight provision. This is because in direct oversight, a single partner unilaterally sets up rules, procedures, and policies to oversee and reward desirable performance. Oversight provisions emphasizing direct oversight triggers formal control processes (Das and Teng, 2001; Fryxell et al., 2002) that serve to standardize the behavior of one partner unilaterally. Such formal control implies aligning incentives of one partner by overseeing their behavior and/or outcomes of the collaboration by another (Williamson, 1985). Direct oversight emphasizes behaviors in partners that are the opposite of the variation, experimentation, flexibility, and autonomy required of exploratory R&D. Instead, direct oversight emphasizes a level of formalization

that constrains exploratory R&D in ways that would inhibit innovative performance. Further, this level of oversight does not engender trust (Das and Teng, 2001). However, in exploitative R&D collaborations, direct oversight may provide the necessary formalization that aligns incentives and rewards the successful completion of routine commercialization activities. As such, I propose the following:

Hypothesis (H1a) *R&D contracts that establish direct administrative oversight are positively associated with innovative performance in exploitative R&D partnerships.*

On the other hand, joint oversight emphasizes coordination and interfirm collaboration. Establishing joint administrative oversight leads partners to design structural interfaces that reduce information barriers to adaptation by allowing information sharing and interfirm routines (Joshi and Campbell, 2003). They can also help to achieve coordinated action and promote efficiency *ex post* by facilitating mutual adjustment (Schepker et al., 2014), required features for the execution of novel and complex R&D activities (Kim and Parke, 2009).

When innovation involves exploratory R&D, partners need to obtain necessary inputs from collaborators, and this knowledge is often sticky and presents difficulties in transfer (Szulanski, 1996). During the process of knowledge sharing, partners may also have to engage in joint problem solving, which requires effective management of the interactions between collaborators, and directing the associated search processes (Nickerson and Zenger, 2004). Joint oversight committees governing the R&D collaboration can serve as useful interfaces that enable partners to overcome the challenges involved in coordinating their activities. The joint nature of the oversight allows partners to

communicate shared norms, values and beliefs that emphasize faith in the moral integrity or goodwill of others (Gaertner et al., 1996; Homans, 1962), thus increasing trust between parties (Das and Teng, 2001; Ring and Van de Ven, 1994).

Within the context of exploratory R&D collaborations, joint oversight might facilitate innovative performance for several reasons. First, opposite to formal control emphasizing rules, procedures, and policies, joint control emphasizes the communication of shared norms, values, and beliefs (Das and Teng 2001). According to Ouchi (1980: 134), joint control can reduce the risk of opportunistic behavior and promote tasks that are "highly unique, completely integrated, or ambiguous." Second, interfirm routines that stress coordination by mutual adjustment are beneficial because this mode of coordination is characterized by excessive information sharing and increased informal communication, essential elements to finding innovative solutions (Damanpour, 1991; Aiken and Hage, 1971; Weick and Roberts, 1992; Nonaka and Takeuchi, 1995). Increasing communication flows between partners—against the background of a set of shared norms and values—offers the potential of handling task conflict without risking an escalation of relationship conflict (Faems et al., 2006). In this way, coordination by mutual adjustment might support the type of double-loop learning that would benefit exploratory activities (Argyris and Schon, 1978; Faems et al., 2006).

Doz (1996) observed that, within successful R&D collaborations, partners not only learn each other's competences, but also learn how to cooperate, that is, interact successfully. In other words, firms jointly develop routines that enable interaction and adjustment (Gulati and Singh, 1998, Ring and Van de Ven, 1994). Examples of such interfirm routines are knowledge-sharing routines and joint problem-solving routines

(Dyer and Singh, 1998). Devarakonda and Reuer (2018) found that in interfirm collaborations that involve joint administrative duties, problem-solving mechanisms were entailed that enable actors to coordinate functions and work out problems on the fly. As Couchman and Fulop (2001) describe, joint oversight provides an opportunity for socialization across disciplinary and organizational boundaries. It is expected to facilitate the emergence of trust and interfirm routines. Consequently, when such interfirm routines are present, issues of coordination can be addressed not by referring to formalized rules and procedures, but by attending to the process of real-time, interfirm communication. Under such circumstances, coordination by mutual adjustment starts to replace formalized coordination mechanisms (Mintzberg 1979). As such, I propose the following:

Hypothesis (H1b) *R&D contracts that establish joint administrative oversight are positively associated with innovative performance in exploratory R&D partnerships.*

2.2 | Monitoring of R&D Partnerships

The specter of opportunism eroding the development of long-term R&D relationships (Barnes et al., 2010) encourages partners to use monitoring mechanisms to align collaborative activities and partners' behaviors toward the achievement of common goals (Kale and Singh, 2007). Establishing collaborative R&D not only necessitates pooling proprietary knowledge resources with the partner, but also delegating responsibilities and relinquishing control over such resources to them (Dimitratos et al., 2009). Some firms view monitoring provisions of the collaborative contract as a means to coordinate resources between partners. In these cases, contracts are explicitly endowed with process and outcome monitoring provisions that are bilateral in mature, involving both firms.

However, some partner firms are reluctant to relinquish control over their most valuable knowledge in a partnership, given a perceived need to protect this against the counterpart's potential competitive and opportunistic behaviors (Inkpen and Currall, 2004). In these cases, the more valuable the knowledge initially shared and potentially created in an R&D collaboration, the greater the desire to have control over the partner (Zhang and Zhou, 2013). This in turn drives partners to unilaterally manipulate and influence monitoring provisions in the contract in pursuit of their own performance outcomes, even if this undermines overall collaborative development. These firms enact contractual monitoring provisions that represent a unilateral control mechanism, which is defined as "an effort made by one party to measure or meter the performance of another" (Heide et al., 2007, pp. 425–426). As such, unilateral monitoring provisions have been shown to explicitly incorporate auditing provisions that allows one partner to closely monitor the behavior of the other (Lyons and Mehta, 1997). Such provisions may be useful in cases where routine outcomes are easily measured, as in the case of exploitative R&D collaborations. In this context, unilateral provisions spelling out auditing requirements provide the motivation for partner's behavior to adhere strictly to the requirements specified in the contract. As such, I propose the following:

Hypothesis (H2a) *R&D contracts that specify unilateral monitoring are positively associated with innovative performance in exploitative R&D partnerships.*

I argue that unilateral and bilateral monitoring provisions serve different roles that differentially impact partners' behaviors. While unilateral monitoring serves as a control mechanism that may reliably suppress partner opportunism in cases where routine activities have measurable outcomes (Heide et al., 2007), the use of bilateral monitoring

provisions serves a coordinating function. Bilateral monitoring provisions have been shown to explicitly incorporate communication terms (Argyres and Mayer, 2007) and/or meeting requirements (Ariño and Ring, 2010) between partners. Provisions that mandate bilateral monitoring of processes employed in interfirm collaborations appear to increase communication of task-specific activities, which can facilitate greater collaboration (e.g., effective coordination; Faems et al., 2008). By incorporating communication terms and meeting provisions into the contract, bilateral monitoring provisions communicate to both parties a range of shared norms. First, it communicates mutuality and solidarity that gives rise to flexibility between partners (Abdi and Aulakh, 2014). Second, it gives rise to information exchange that leads to further increased communication between partners (Kale and Singh, 2009). In this way, bilateral monitoring provisions serve as a means of increasing heterogeneity of knowledge assets between firms, and increasing cooperation among collaborators, factors necessary for the successful competition of exploratory R&D activities. As such, I propose the following:

Hypothesis (H2b) *R&D contracts that specify bilateral monitoring are positively associated with innovative performance in exploratory R&D partnerships.*

2.3 | Management Roles in R&D Partnerships

The ability of R&D collaborations to produce high-impact innovations often depends not only upon the composition of technical and management human capital, but also on the delegation of duties (Argyres and Mayer, 2007; Ryall and Sampson, 2009). Partners have the ability to use R&D contracts to provide a detailed explication of the roles of partners. By detailing management roles in the collaboration, this provision may serve both a control and coordinating function. It serves a control function by acting as a safeguard, by reducing

ambiguity about contractual obligations and thereby reducing the scope for opportunistic actions seeking to take advantage of any ambiguity for private gain. It also serves a coordinating function by delineating roles in ways that ensures that the diversity of activities carried out are coordinated among the staff in the collaboration.

Innovative performance within an R&D collaboration, especially in the context of exploratory R&D activities, depends upon the production and integration of new knowledge. Understanding how scientific discoveries are translated into useful, commercially successful products requires a close examination of how the partnership invests in technical and management human capital. As the underlying problem to be solved in a partnership becomes more complex, contractual partners seek to reduce this complexity through more explicit description of the partners' roles in the contract. Specifying roles often requires in-depth knowledge of the technology involved in the R&D collaboration and is often created through extensive involvement of the operational team members of the different partners (Couchman and Fulop, 2001). This participatory decision making at the activity-level makes technical personnel (scientists and engineers) together with management responsible for setting and achieving the objectives of the collaboration. The formalization of the overall objectives is consequently not top-down implemented, but emerges through a bottom-up process, facilitating trust and interfirm routines to emerge (Faems et al., 2006).

By specifying management roles in the contract, heterogeneity of knowledge assets between partners consequently increases, providing new possibilities to initiate both exploratory and exploitative R&D collaborations. This is achieved through the use of specifying management roles by introducing new individuals to the collaboration. Katz and

Allen (1985: 390) stressed that "project newcomers represent a novelty-enhancing condition, challenging and improving the scope of existing methods and accumulated knowledge." In other words, specifying different individuals to fulfill different roles stimulates heterogeneity of knowledge assets that should impact innovative performance. Thus, I propose the following:

Hypothesis (H3) *R&D contracts that include the specification of management roles are positively associated with innovative performance in R&D partnerships.*

2.4 | Comparing Two Contract States in Exploitative and Exploratory R&D Partnerships

In the preceding hypotheses, I propose that the contractual specification of management oversight, monitoring, and management roles, separately, is likely to lead to innovative performance in R&D partnerships. In order to address the need for a more subtle understanding of contract design within the collaborative R&D context and its relationship to innovative performance, I compare two contract states that specify provisions in ways that match the type of R&D partnership. Here, I propose that the specification of the above contract provisions, together, are also likely to lead to innovative performance, depending on the type of R&D partnership. Therefore, I propose:

Hypothesis (H4a) *R&D contracts that include the specification of (1) direct oversight, unilateral monitoring, and management roles are more positively associated with innovative performance in exploitative R&D partnerships than contracts that include the specification of (2) joint oversight, bilateral monitoring, and no management roles.*

Hypothesis (H4b) *R&D contracts that include the specification of (1) joint oversight, bilateral monitoring, and management roles are more positively associated with innovative performance in exploratory R&D partnerships than contracts that include the specification of (2) direct oversight, unilateral monitoring, and no management roles.*

3 | SAMPLE AND METHODS

3.1 | Sample and Data

To study the influence of R&D contract design on innovative performance, I examine R&D partnerships in the biopharmaceuticals industry. This industry provides an appropriate setting for my analysis for several reasons. First, the biopharmaceuticals industry is a highly R&D-driven business. It is characterized by advances in science and technology and a high level of interactions among many technological fields (Lenoir and Herron, 2009), where numerous knowledge stocks and innovative activities can be observed. Second, partnership activity in this industry has been very extensive and has attracted considerable research. Collaborative R&D agreements between firms are burgeoning in this industry because the complexities of technologies urge organizations to cooperate with others and thus, numerous inter-organizational R&D partnerships can be observed. Third, R&D transactions in this industry can be categorized as exploratory (or upstream) or exploitative (or downstream) transactions (Hoang and Rothaermel, 2005; 2010), enabling me to test which specifications of contract design elements aligned with the types of R&D will lead to innovative performance. Fourth, this industry allows for the comparison of R&D contracts in which partnerships share similar goals, namely the successful completion of drug development. Finally, innovative performance can be

conceptualized and measured in many ways in this industry, such as the number of products generated from an R&D partnership (Rothaermel and Deeds, 2004), FDA approval (Hoang and Rothaermel, 2005), the time to regulatory advancement through stages (Shah, 2004; Roin, 2013), the number of drug indications (DiMasi et al., 2016), the number of target-based actions (Lanthier et al., 2013), and the number of technologies incorporated into the products in development (Plenge, 2016).

The data to test the hypotheses come from Clarivate Analytics' Cortellis (formerly Recombinant Capital), a consulting firm specializing in services to the life sciences industry. Cortellis collates data on partnerships from various public sources, including Securities and Exchange Commission (SEC) filings, industry trade conferences, scientific meetings, and press releases, and analyzes the corresponding R&D contracts to create a data set at the transaction level, and covers all major partnerships from 1981 to present in the worldwide biopharmaceutical industry. An analysis found the Cortellis database to be representative in its coverage of biopharmaceutical partnerships (Schilling, 2009). Several studies in management, finance, and economics have used partnership data from this database to conduct a variety of fine-grained analyses of R&D contracts (e.g., Adegbesan and Higgins, 2011; Lerner, Shane, and Tsai, 2003; Reuer and Devarakonda, 2016; Robinson and Stuart, 2007). I enriched the R&D partnership data from Cortellis with firm financial information from Compustat and I/B/E/S.

3.1.1 | *Sample Construction*

I focus on R&D partnerships formed during the 1989 to 2011 timeframe because the beginning of this period marks substantial growth in partnerships in the biopharmaceuticals industry (Roijakkers and Hagedoorn, 2006). This industry saw

exponential rise in R&D partnerships from 1989 until its peak in 2001 (Robinson and Stuart, 2007). Prior studies that have used this data set have used a similar time period (Robinson and Stuart, 2007; Reuer and Devarakonda, 2016). The middle 80% of the R&D partnerships in Cortellis was between 1.5 and 9 years in duration. Therefore, I use 2011 as the final year of the time period in order to give partnerships the time necessary to complete. I include non-equity partnerships that are classified as research, development, co-development, co-promotion, collaboration, commercialization, or development licensing agreements, and consider that individual partnerships can involve more than one deal type, as well as potentially involving foreign partners. I include partnerships that have either been completed or terminated, so that the outcome is known, and have an unredacted contract available for analysis, so that contract design elements may be coded. The sample only includes partnerships that offer worldwide rights. I do this in order to eliminate any country-specific contractual specifications from the sample and the need of having to compare contracts specific to one country with a contract specific to another. Finally, the sample only includes partnerships involving pharmaceutical or biotechnology firms and excludes partnerships involving academic or government institutions in order to eliminate the idiosyncrasies of government and academic contracting, since their contracting space is different than private firms (Goldfarb, 2008).

The final sample consists of 305 R&D partnerships. For every R&D partnership in the sample, Cortellis designates the partner that is the principal source of R&D services or the technology as the principal firm, and the other partner is denoted as the client firm. The sample involves 352 unique firms total: 218 unique principal firms and 134 unique client firms. Of the 218 unique principal firms, approximately 40% are biotechnology firms and

60% are pharmaceutical firms. Of the 134 unique client firms, 20% are biotechnology firms and 80% are pharmaceutical firms. Additional descriptive information on the sample appears in Table 3.1.

3.1.2 | *Sample Coding into Types of R&D Partnerships*

Characterizing partnerships as exploratory R&D is highly consistent with the biopharmaceutical drug discovery and early-stage development process. Similarly, exploitative R&D partnerships map well onto activities that occur in later stages of the value chain that tap a firm's existing knowledge including clinical testing, regulatory affairs, distribution, and marketing and sales. R&D partnerships in the sample are coded as either exploratory or exploitative R&D partnerships. Exploratory R&D partnerships focus on upstream activities of the R&D value chain (Rothaermel and Deeds, 2004), including basic research and drug discovery. Exploratory R&D partnerships are coded as those that start prior to Phase I clinical trials (discovery and preclinical phases). Exploitative R&D partnerships focus on downstream activities of the R&D value chain (Rothaermel and Deeds, 2004), including formulation adjustments, drug manufacturing, marketing and distribution, and regulatory advancement (Aitken, 2016). Exploitative R&D partnerships are coded as those R&D collaborations that start at Phase I clinical trials or later (Phase II or Phase III), involving the downstream activities of clinical trials, FDA-phased regulatory process, or commercialization—marketing and sales. The sample consists of 142 exploratory and 163 exploitative R&D partnerships.

3.2 | Measures

3.2.1 | *Dependent Variables*

The strategic significance of innovative performance in R&D partnerships is ultimately its impact on the competitive standing of the partner firms, or of its role in determining factors such as the long-term survival, sales, profitability, and market share of the partners (Henderson and Cockburn, 1994). Unfortunately, the use of financial measures to explore the innovative performance of biopharmaceutical firms is not optimal because it is fraught with difficulty (DiMasi, 2000). Scholars have argued that this difficulty is due to both the lag-time between the commencement of an R&D program and a drug reaching the market and the fact that so few products in development actually make it that far (Schmid and Smith, 2005). This is because on average, it takes about 12 years to take a promising biopharmaceutical drug from the laboratory to the market (DiMasi et al., 1991) and the economic returns to new drugs are highly skewed. As a result, the major pharmaceutical firms have diversified drug portfolios, but a few "blockbuster" drugs account for most of their financial performance (Grabowski and Vernon, 1990).[3] To address this, prior studies have assessed innovative performance by capturing aspects of a firm's regulatory performance, such as measuring the number of products entered into the regulatory process (Rothaermel and Deeds, 2004) or whether or not regulatory approval was ultimately gained (Hoang and Rothaermel, 2010).

But some scholars have argued that these measures also miss some important facets of innovation in the biopharmaceutical industry (Adams, Bessant, and Phelps, 2006), and that these measures focus only on the measurement of innovation inputs and outputs and ignore the R&D process in-between (Cordero, 1990). FDA approval comes at the end of a

[3] A blockbuster drug is a compound that, at maturity, generates annual revenues of or in excess of one billion US dollars (Drews, 2003).

very long process, one that sees more than 90% of drugs that enter the process fail for one reason or another (Batta, Kalra, and Khirasaria, 2020). Thus, measuring innovation based solely on regulatory performance has considerable limitations (Cockburn, 2007; Munos, 2009). Measuring innovative performance using FDA approval alone, for example, could miss the innovative value of unapproved drugs (Caprino and Russo, 2006), such as a breakthrough in an underlying technology or disease treatment from an investigational drug that ultimately failed to gain FDA approval. In order to capture the full life cycle of innovation and important differences in the novel contribution of a drug, additional measures are needed (Deshpande, Hood, Leach, and Guthrie, 2019), especially ones that capture the intrinsic properties of products that emerge during R&D (Caprino and Russo, 2006; Lanthier et al., 2013). Therefore, I use the products in development that emerge during R&D by including three alternative measures: number of drug indications, number of target-based actions, and number of technologies utilized. I define these alternative measures below.

In total, I utilize a series of measures of innovative performance in R&D partnerships. I utilize two traditional measures of innovative performance based on prior research: the number of products in development (Rothaermel and Deeds, 2004) and FDA approval (Hoang and Rothaermel, 2005). I include a third measure to capture the speed at which drugs move through the regulatory process, the time to regulatory advancement, because innovation speed has been positively correlated with product quality (Hauser and Zettelmeyer, 1997) and has been used as a means to measure R&D performance (Chiesa and Masella, 1994). Finally, I use three alternative measures of innovative performance that capture the innovative value of drugs that emerge during the R&D process whether or

not they ultimately gain FDA approval: the number of indications, number of target-based actions, and number of technologies.

Products in development

I operationalize a firm's products in development as a count variable of the partnership's biopharmaceutical products in development that have successfully entered FDA-phased clinical trials but have not yet reached the market for pharmaceuticals. This measure only counts those products formally tested in the FDA regulatory process as a result of the R&D transaction.

Several studies in the management literature have confirmed that there are significant and persistent differences across biotechnology and pharmaceutical firms in their ability to conduct research to develop new products (e.g., Henderson and Cockburn, 1994; Rothaermel and Deeds, 2004). Similar to these studies, this measure captures the number of products generated from the R&D partnership, whether or not they eventually gain regulatory approval. The mean number of products in development in the sampled R&D partnerships was approximately 1. The maximum number of products in development in the sampled R&D partnerships is 4 and the minimum is 0.

FDA Approval

FDA approval is a binary variable, with a 1 indicating the partnership resulted in an FDA-approved, marketable new drug, and a 0 indicating a failure to gain FDA approval. FDA approval is an important milestone for biopharmaceutical firms and is a common goal for most R&D partnerships in this industry. Of the 305 R&D partnerships in the sample, 67, or 22%, result in an FDA-approved, marketable new drug, while 238, or 78%, fail to gain FDA approval.

Time to Regulatory Advancement

The dependent variable, time to regulatory advancement, incorporates information on the average time it takes for a product in development of an R&D partnership to move to the next phase of the FDA approval process. Measured in days per regulatory stage, this continuous variable is calculated by dividing the overall duration, in days, of the R&D partnership by the number of FDA regulatory stages completed.

A shorter number of days is better when it comes to innovative performance because an important driver in the pharmaceutical industry is the speed of regulatory advancement (Shah, 2004). Firms secure very significant returns in the early life of a successful drug, before any competition from similar drugs. The time it takes to gain regulatory approval is important because the competition-free life of pharmaceuticals has shortened, typically from 5 years in 1990 to 1–2 years in 2000 (Butler, 2002). As pharmaceutical inventions' time to gain regulatory approval increases, those inventions become less profitable (Roin, 2013). Time to regulatory advancement is a more fine-tuned measure of innovative performance than FDA approval, since it captures the stages of success, in terms of the FDA approval process, for those products in development that may not have ultimately gained FDA approval. Further, using innovation speed has been positively correlated with product quality (Hauser and Zettelmeyer, 1997) and has been used as a means to measure R&D performance (Chiesa and Masella, 1994) in this industry. In the sampled R&D partnerships, the average time to regulatory advancement is more than 17 months, with a maximum time of 8.5 years.

Number of Indications

The number of indications is measured by the extent to which a product in development might effectively treat disease(s). An indication refers to the use of that drug for treating a particular disease. For example, diabetes is an indication for insulin. A drug can have more than one indication, which means that there is more than one disease for which it is being tested or used. The FDA strictly classifies indications for drugs in the United States. This count variable captures the number of drug indications for which the product in development is being tested in the FDA regulatory process.

Prior studies have argued that the greater number of indications for a drug, the greater its commercial and/or medical value (Schmid and Smith, 2005; Cowen, 2004). This is because repositioning a drug for alternative indications requires the identification and use of known drugs that can treat diseases other than those for which they were originally designed and is an increasingly attractive mode of therapeutic discovery (Ekins et al., 2011). This strategy has the potential of being an efficient and innovative technique for drug development since it increases its potential marketability (Ashburn and Thor, 2004). For these reasons, I use the number of indications as an intrinsic property of the products in development that emerge during R&D as an alternative measure of innovative performance. There are 893 possible FDA classified drug indications in the Cortellis database. The R&D partnerships in the sample have a mean number of indications of approximately 3, a median of 2, and a range of 0 to 34 indications. In cases where sampled R&D partnerships result in no products under development, the number of indications would also be 0.

Number of Target-based Actions

Drugs produce their therapeutic effects by modulating specific biological targets. A target is usually a single gene, gene product or molecular mechanism of action that has been identified on the basis of genetic analysis or biological observations (Knowles and Gromo, 2003). This count variable captures the number of biological target-based actions for which the product in development is being tested in the FDA regulatory process.

Multi-target drugs have attracted considerable attention as potential therapeutic solutions to diseases of complex etiology (Talevi et al., 2012; Koeberle and Werz, 2014). It is generally accepted that multi-target drugs are more sophisticated (i.e., require greater technological advancement) and have advantages in the treatment of complex diseases and health conditions linked to drug resistance issues (Rask-Andersen *et al*., 2011). The complexity of the current incurable pathologies has demonstrated that single-target drugs are inadequate to achieve a therapeutic effect (Bolognesi, 2013). Further, it has been shown that molecules hitting more than one target may possess a safer profile compared to single-target ones (Bolognesi and Cavalli, 2016). It is for these reason that drugs with a greater number of target-based actions are viewed as more complex and innovative and of higher quality (Ramsay et al., 2018). For these reasons, I use the number of target-based actions as an intrinsic property of the products in development that emerge during R&D as an alternative measure of innovative performance. There are 4,944 target-based actions in the Cortellis database. For this measure, the mean is approximately 1 and the range is 0 to 9.

Number of Technologies

A number of studies have attempted to capture technological sophistication and "advancedness" of a pharmaceutical firm's products as a measure of its technological

innovation (e.g., Roberts and Hauptman, 1986; Hauptman and Roberts, 1985). In response, some scholars are beginning to use alternative measures of pharmaceutical innovation, such as looking at the underlying technologies of approved drugs (Lanthier et al., 2013). The progression of complex diseases, especially in cancer, is necessitating the use of multi-technology drugs that can provide a multi-pronged approach for combating disease (Workman et al., 2013). In the presence of ever-increasing complexity of disease, firms face the challenge of having to constantly develop new technological products by developing novel technologies and recombining multiple technologies in a single product (Kim and Lee, 2017). There are 498 possible FDA-classified biopharmaceutical technologies in the Cortellis database. The sampled R&D partnerships incorporate, on average, 3 technologies into their products in development, with a range of 0 to 10 FDA-classified technologies.

3.2.2 | *Independent Variables*

Oversight

The independent variable, oversight, is an indicator for whether the R&D contract specifies direct or joint oversight for the R&D partnership. Oversight is 1 when the contract establishes direct oversight, and 0 otherwise (when it establishes joint oversight). In 114 of the sampled R&D partnerships, contracts specify direct oversight of the partnership, while in 191 partnerships, contracts specify joint oversight of the partnership.

Monitoring

The independent variable, monitoring, is an indicator for whether the R&D contract specifies unilateral or bilateral monitoring for the R&D partnership. Monitoring is 1 when the contract establishes unilateral monitoring, and 0 otherwise (when it establishes bilateral monitoring). In 210 of the sampled R&D partnerships, contracts specify unilateral

monitoring of the partnership, while in 95 partnerships, contracts specify bilateral monitoring of the partnership.

Management Roles

The independent variable, management roles, is an indicator for whether the R&D contract specifies management roles for the R&D partnership. Management roles is 1 when the contract specifies management roles, and 0 otherwise. In 96 of the sampled R&D partnerships, contracts specify management roles the partnership, while in 209 partnerships, contracts do not.

3.2.3 | *Control Variables*

In order to control for transaction- and partner firm-level factors that may influence innovative performance, I include a number of variables based on past research (Henderson and Cockburn, 1994; Hoang and Rothaermel, 2005; Robinson and Stuart, 2007; Reuer and Devarakonda, 2016). I include a series of controls for attributes of both the principal and client firms entering into the R&D partnership, as well as for transaction characteristics. The data for the control variables were obtained and calculated from databases such as Compustat, Thomson Reuters, and I/B/E/S.

Transaction Characteristics

Contract length

I account for the complexity of the contract governing the R&D partnership. An elaborate contract between partners that incorporates adequate provisions, such as various safeguards and contingency plans, can mitigate *ex pos*t hazards. I therefore add a control for contract length, measured as the kilobyte (KB) size of the contract (in

thousands) provided by Cortellis (Robinson and Stuart, 2007). The mean contract length is 1,402 KB and has a range of 110 KB to 7,100 KB.

Incentive payment

Partners can also mitigate certain exchange hazards through suitable incentive structures. Consistent with the idea of modeling incentives as output-contingent payments (Bolton and Dewatripont, 2005; Reuer and Devarakonda, 2016), I include incentive payments, measured as total milestone payments as a percent of total deal size or value. Milestone payments are payments to one partner firm in a series of lump sums, each paid upon the achieving a milestone or a contractually defined stage of progress. The mean incentive payment is 67% and has a range of 0% to 100%.

Deal size

I control for the size (or value) of the partnership. Larger collaborations are more likely to require more oversight, monitoring and coordination of roles by the partners, just as larger organizations require formal mechanisms for decision ratification in the interfirm context (Fama and Jensen, 1983; Lehn, Patro, and Zhao, 2009). The greater the number of researchers deployed on joint collaborations and the greater the need to track their progress to make contingent resource allocations, the greater the informational requirements of such partnerships. Therefore, I measure deal size as the maximum possible payments (in hundreds of millions of dollars) contracted upon for the life of the collaborative agreement (Robinson and Stuart, 2007; Reuer and Devarakonda, 2016). The mean deal size is $149 million and has a range of $0 to $1.9 billion.

Contract duration

I control for the specifics of the contract concerned with the timing of the expected length of the R&D partnership in thousands of days (Robinson and Stuart, 2007). The mean contract duration is approximately 4.5 years and has a range of 9 months to nearly 23 years.

Patent protection

I note whether the activities of the sampled R&D partnership are protected under a U.S. and/or European patent, coded 1 when a patent existed and 0 otherwise, since a patent-protected R&D collaboration is viewed as potentially more valuable and thus attracts more resources and managerial attention (Hoang and Rothaermel, 2005). Of the 305 R&D partnerships in the sample, 122, or 40%, are protected under a patent, while 183, or 60%, are not.

Cross-border deal

I distinguish R&D partnerships involving partners from different countries from domestic partnerships by including an indicator variable, coded 1 when the headquarters of partner firms are located in different countries and 0 otherwise (Gulati, 1995; Reuer and Devarakonda, 2016). Of the 305 R&D partnerships in the sample, 141, or 46%, are cross-border deals, while 164, or 54%, are domestic partnerships.

Biotech-biotech deal

I differentiate deals between two biotechnology firms versus a biotechnology firm and pharmaceutical firm (or two pharmaceutical firms) by including an indicator variable, biotech-biotech deal in order to control for other potential sources of unobserved effects from prior studies (Lerner et al., 2003; Reuer and Devarakonda, 2016). This dummy variable is coded 1 when both the principal and client firms are biotechnology companies

and 0 otherwise (when one or both partner firms are pharmaceutical companies). Of the 305 R&D partnerships in the sample, 171, or 56%, involve partner firms that are both biotechnology companies, while 134, or 54%, are not.

Year (of deal initiation) dummies

I controlled for the year in which a sampled R&D partnership was initiated. The median year of initiation for sampled R&D partnerships is 1999 and the mode is 1997.

Agreement type dummies

I control for the type of contract governing the focal R&D partnerships. Cortellis categorizes the R&D contracts into 7 broad categories of agreements: drug commercialization license, drug development license, early research/development, drug screening/evaluation, patent license, technology delivery/formulation, and technology target validation. These constitute dummy variables, since there is no order to the categories.

Partner Firm Characteristics

Firm prior partnerships

At the partner firm-level, I control for the prior partnership experience of both partners, since firms might learn to manage R&D collaborations better with experience and might require less governance mechanisms for their partnerships (e.g., Anand and Khanna, 2000; Colombo, 2003; Hagedoorn et al., 2009). Specifically, I measure prior partnership experience of both principal and client firms as the number of previous partnerships in which the partners engaged in the 5 years preceding initiation of the focal R&D partnership (Hoang and Rothaermel, 2005). The mean number of principal firm prior partnerships was approximately 3, while the mean number of client firm prior partnerships was

approximately 7, both with a range of 0 to 18 prior partnerships in the 5 years preceding the focal R&D partnership.

Principal firm size

I measure principal firm size using the natural logarithm of total assets in the year preceding the initiation of the focal R&D partnership.

Client firm size

I measure client firm size using the natural logarithm of the number of employees in the year preceding the initiation of the focal R&D partnership.

Firm performance

To assess whether principal or client firm performance influences innovative performance, I control for firm performance in terms of return on equity (ROE) in the year preceding the initiation of the focal R&D partnership.

R&D intensity

I use a firm's R&D expenditures per sales in the year preceding the initiation of the focal R&D partnership as a proxy for a firm's R&D inputs to the innovation process. Higher levels of R&D intensity lead to greater stocks of knowledge and hence to more new products and technologies (Cohen and Levinthal, 1990).

Firm slack

Slack reserves of both principal and client firms are not directly helpful in the development of innovations, but they may affect decisions to continue or discontinue R&D collaborations and lengthen the time that firms will take to introduce new technologies. Greater levels of slack make it easier to continue R&D partnerships and increase R&D

intensity (Greve, 2003). I measure firm slack as the ratio of a firm's current assets to current liabilities in the year preceding the initiation of the focal R&D partnership.

3.3 | Model Specification

I propose a model of contract design elements that leads to innovative performance in exploitative and exploratory R&D partnerships using six dependent variables: products in development, FDA approval, time to regulatory advancement, number of indications, number of target-based actions, and number of technologies. The dependent variable *products in development* is a count variable and because most sampled R&D partnerships resulted in 0 generated products (n = 143), I apply a censored regression model estimating how specific contract design elements affect the number of products in development in both exploitative and exploratory partnerships. The dependent variable *FDA approval* is binary, and thus I apply a logistic regression model estimating how specific contract design elements affect the probability of FDA approval in both exploitative and exploratory R&D partnerships. The dependent variable *time to regulatory advancement* is over-dispersed, and thus I apply a negative binomial regression model estimating how specific contract design elements affect the time to regulatory advancement in both exploitative and exploratory R&D partnerships. The dependent variable *number of indications* is a count variable and because most sampled R&D partnerships result in products in development with 1 drug indication tested (n = 142), I apply a censored regression model estimating how specific contract design elements affect the number of indications in both exploitative and exploratory R&D partnerships. The dependent variable *number of target-based actions* is a count variable and because most collaborations result in products with either 0 target-based actions (n = 142) or a single target-based action (n = 102) with a maximum number

of 9 target-based actions, I apply a censored regression model estimating how specific contract design elements affect the number of target-based actions in both exploitative and exploratory R&D partnerships. Finally, the dependent variable *number of technologies* is a count variable and approximately follows a normal curve, I apply a regression model estimating how specific contract design elements affect the number of technologies in both exploitative and exploratory R&D partnerships.

I represent the two contract states tested in Hypothesis (H4a) by testing two values of a single composite variable, *c*, that is comprised of the 3 indicator variables measuring the contractual specifications of oversight, monitoring, and management roles. The variable $c = 1$ denotes the contractual specification of joint oversight, bilateral monitoring, and no management roles, while the variable $c = 8$ denotes the contractual specification of direct oversight, unilateral monitoring, and management roles. I estimate models that include the interaction term of these two contract states with exploitative R&D partnerships for each of the six dependent variables measuring innovative performance.

Finally, I represent the two contract states tested in Hypothesis (H4b) by testing two values of a single composite variable, *d*, that is comprised of the 3 indicator variables measuring the contractual specifications of oversight, monitoring, and management roles. The variable $d = 1$ denotes the contractual specification of direct oversight, unilateral monitoring, and no management roles, while the variable $d = 8$ denotes the contractual specification of joint oversight, bilateral monitoring, and management roles. I estimate models that include the interaction term of these two contract states with exploratory R&D partnerships for each of the six dependent variables measuring innovative performance.

4 | RESULTS

The sample data set has 305 R&D partnerships initiated by 352 unique partner pharmaceutical or biotechnology firms over the 1989-2011 time period. Table 3.1 depicts the descriptive statistics and bivariate correlation matrix for the variables in the models. The regression results for the models are shown in Tables 3.2-3.21, organized by hypothesis. Models for Hypothesis (H1) are shown for the six dependent variables measuring innovative performance in Tables 3.2-3.7. Models for Hypothesis (H2) are shown for the six dependent variables measuring innovative performance in Tables 3.8-3.13. Models for Hypothesis (H3) are shown for the six dependent variables measuring innovative performance in Tables 3.14-3.19. Models for Hypothesis (H4a) are shown for the six dependent variables measuring innovative performance in Table 3.20. And finally, models for Hypothesis (H4b) are shown for the six dependent variables measuring innovative performance in Table 3.21.

Model 1 in Tables 3.2-3.7 is the control model for each of the six dependent variables measuring innovative performance.[4] Models 2- 5 in Tables 3.2-3.7 test the hypotheses. All of the models in Tables 3.2-3.7 are significant. Incentive payment is significant and negatively related to the products in development (Table 3.2), FDA approval (Table 3.3), number of indications (Table 3.5). This indicates that incentives in the form of milestone payments, on average, fail to generate innovative performance. A client firm's slack is significant and positively related to the number of target-based actions (Table 3.6). Partnerships involving biotechnology partner firms is significant and positively related to FDA approval (Table 3.3) and the number of indications (Table 3.5). R&D intensity of both

[4] Model 1, the control model, is repeated for the six dependent variables measuring innovative performance for Hypothesis (H2a) and Hypothesis (H2b) in Tables 3.8-3.13, and for Hypothesis (H3) in Tables 3.14-3.19.

the principal and client firms are significant and positively related to FDA approval (Table 3.3). Contract duration is significant and positively related to the time to regulatory advancement (Table 3.4). Cross-border deals is significant and positively related to the time to regulatory advancement (Table 3.4). Deal size is significant and positively related to the number of indications (Table 3.5) and target-based actions (Table 3.6). The principal firm's performance is significant and negatively related to the time to regulatory advancement (Table 3.4) and the number of indications (Table 3.5).

For Hypothesis (H1a) and as shown in Model 2 in Tables 3.2-3.7, the coefficient of exploitative R&D partnerships is significant and positively related to FDA approval (Table 3.3, $\beta = 1.551$, $p < 0.001$), the time to regulatory advancement (Table 3.4, $\beta = 0.569$, $p < 0.001$), the number of indications (Table 3.5, $\beta = 1.500$, $p < 0.001$) and number of technologies (Table 3.7, $\beta = 0.372$, $p < 0.10$), but not significant for products in development (Table 3.2) and number of target-based actions (Table 3.6). The coefficient of direct oversight is significant and positively related to FDA approval (Table 3.3, $\beta = 1.505$, $p < 0.001$) and negatively related to the time to regulatory advancement (Table 3.4, $\beta = -0.280$, $p < 0.01$). Note that the coefficient for direct oversight is negative for the time to regulatory advancement.[5] The coefficient of direct oversight is not significant for products in development (Table 3.2), the number of indications (Table 3.5), number of target-based actions (Table 3.6) and number of technologies (Table 3.7).

For Hypothesis (H1a), Model 3 in Tables 3.2-3.7 is the full model. The coefficient of the interaction term is significant and positive for products in development (Table 3.2, $\beta =$

[5] A negative coefficient related to this dependent variable, time to regulatory advancement, implies greater innovative speed and, thus, greater innovative performance.

0.713, $p < 0.05$), FDA approval (Table 3.3, $\beta = 3.806$, $p < 0.01$), time to regulatory advancement (Table 3.4, $\beta = -0.593$, $p < 0.001$), and not significant for number of indications (Table 3.5), number of target-based actions (Table 3.6), and number of technologies (Table 3.7). Additionally, as shown in Model 3, the main effect of exploitative R&D partnerships is significant and positive for the time to regulatory advancement (Table 3.4, $\beta = 0.763$, $p < 0.001$) and number of indications (Table 3.5, $\beta = 1.148$, $p < 0.05$), but not significant for products in development (Table 3.2), FDA approval (Table 3.3), the number of target-based actions (Table 3.6), and number of technologies (Table 3.7). The main effect of direct oversight is not significant for any of the dependent variables measuring innovative performance in Model 3.

Because Model 3 exhibits intrinsic nonlinearity of limited dependent variables (Ai and Norton, 2003; Hoetker, 2007; Wiersema and Bowen, 2009), I conducted additional analysis to assess the average marginal effect (AME) of direct oversight on innovative performance at the mean of all other variables in exploitative R&D partnerships.[6] Figure 3.1 shows the AME of direct oversight on FDA approval and the predicted time to regulatory advancement in exploitative R&D partnerships. I find that the AME of direct oversight in exploitative R&D partnerships is significant and positive for the probability of FDA approval (AME = 0.402, $p < 0.001$) and negative for the predicted time to regulatory advancement (AME = -321.6, $p < 0.001$). Though the AME of direct oversight is in the

[6] Two consequences of intrinsic nonlinearity of the dependent variables are that the explanatory variable's marginal effect does not equal the variable's model coefficient and that this marginal effect varies with the value of all model variables. Therefore, to infer the true nature of the relationship between the explanatory variable and the dependent variables in these models. I assess the AME for the focal contract design element in either exploitative R&D partnerships (H1a, H2a, H4a), exploratory R&D partnerships (H1b, H2b, H4b), or both types of R&D partnerships (H3). I then report and graphically depict, in the associated figures, those values of AME that are significant against the predicted values of the six dependent outcomes of innovative performance.

predicted direction for products in development, number of indications, number of target-based actions, and number of technologies, they are not significant. Hypothesis (H1a) predicts that contracts that establish direct oversight are positively associated with innovative performance in exploitative R&D partnerships. In terms of the actual impact that direct oversight has on innovative performance in exploitative partnerships, I find that including a direct oversight provision in the exploitative R&D contract is associated with a 40% greater probability of FDA approval and a decrease in the time to regulatory advancement of approximately 10 months on average. Thus, exploitative R&D partnerships that contractually specify direct oversight are more likely to lead to innovative performance as measured by the probability of FDA approval or the time to regulatory advancement. Direct oversight in the contract design for exploitative R&D partnerships is not significantly related to the other measures of innovative performance, such as products in development, and the number of indications, number of target-based actions, and number of technologies. Based on the results, Hypothesis (H1a) is partially supported.

For Hypothesis (H1b), and as shown in Model 4 in Tables 3.2-3.7, the coefficient of exploratory R&D partnerships is significant and negatively related to FDA approval (Table 3.3, $\beta = -1.551$, $p < 0.001$), the time to regulatory advancement (Table 3.4, $\beta = -0.569$, $p < 0.001$), the number of indications (Table 3.5, $\beta = -1.500$, $p < 0.001$), and number of technologies (Table 3.7, $\beta = -0.372$, $p < 0.10$), but not significant for products in development (Table 3.2) and the number of target-based actions (Table 3.6). The coefficient of direct oversight is significant and negatively related to FDA approval (Table 3.3, $\beta = -1.505$, $p < 0.001$) and positively related to the time to regulatory advancement (Table 3.4, $\beta = 0.280$, $p < 0.01$). The coefficient of direct oversight is not significant for

products in development (Table 3.2), the number of indications (Table 3.5), number of target-based actions (Table 3.6), and number of technologies (Table 3.7).

For Hypothesis (H1b), Model 5 in Tables 3.2-3.7 is the full model. The coefficient of the interaction term is significant and positive for products in development (Table 3.2, $\beta = 0.713$, $p < 0.05$) and FDA approval (Table 3.3, $\beta = 3.806$, $p < 0.01$), and negative for time to regulatory advancement (Table 3.4, $\beta = -0.593$, $p < 0.001$). The coefficient of the interaction term is not significant for the number of indications (Table 3.5) and number of target-based actions (Table 3.6), and number of technologies (Table 3.7). Additionally, as shown in Model 5, the main effect of exploratory R&D partnerships is significant and negative for products in development (Table 3.2, $\beta = -0.608$, $p < 0.05$), FDA approval (Table 3.3, $\beta = -3.976$, $p < 0.001$), and number of indications (Table 3.5, $\beta = -2.071$, $p < 0.05$), but not significant for the time to regulatory advancement (Table 3.4) and number of target-based actions (Table 3.6), and number of technologies (Table 3.7). The main effect of joint oversight is significant and negative for FDA approval (Table 3.3, $\beta = -2.642$, $p < 0.001$), but not significant for products in development (Table 3.2), time to regulatory advancement (Table 3.4), number of indications (Table 3.5), and number of target-based actions (Table 3.6), and number of technologies (Table 3.7).

Hypothesis (H1b) predicts that contracts that establish joint oversight are positively associated with innovative performance in exploratory R&D partnerships. Joint oversight in the contract design for exploratory R&D partnerships is not significantly related to the measures of innovative performance. Based on the results, Hypothesis (H1b) is not supported.

Model 1 in Tables 3.8-3.13 is the control model for each of the six dependent variables measuring innovative performance. Models 2- 5 in Tables 3.8-3.13 test the hypotheses. All of the models in Table 3.8-13 are significant. For Hypothesis (H2a) and as shown in Model 2 in Tables 3.8-3.13, the coefficient of exploitative R&D partnerships is significant and positively related to FDA approval (Table 3.9, $\beta = 1.589$, $p < 0.001$), the time to regulatory advancement (Table 3.10, $\beta = 0.583$, $p < 0.001$), the number of indications (Table 3.11, $\beta = 1.498$, $p < 0.001$), and number of technologies (Table 3.13, $\beta = 0.371$, $p < 0.10$), but not significant for products in development (Table 3.8) and number of target-based actions (Table 3.12). The coefficient of unilateral monitoring is not significant for any of the six dependent variables measuring innovative performance in Model 2.

For Hypothesis (H2a), Model 3 in Tables 3.8-3.13 is the full model. The coefficient of the interaction term is significant and positive for FDA approval (Table 3.9, $\beta = 2.562$, $p < 0.01$) and number of indications (Table 3.11, $\beta = 2.103$, $p < 0.05$), but are not significant for products in development (Table 3.8), time to regulatory advancement (Table 3.10), number of target-based actions (Table 3.12) and number of technologies (Table 3.13). Additionally, as shown in Model 3, the main effect of exploitative R&D partnerships is significant and positive for the time to regulatory advancement (Table 3.10, $\beta = 0.556$, $p < 0.001$), but not significant for products in development (Table 3.8), FDA approval (Table 3.9), number of indications (Table 3.11), number of target-based actions (Table 3.12), and number of technologies (Table 3.13). The main effect of unilateral monitoring is significant and negative for FDA approval (Table 3.9, ($\beta = -2.379$, $p < 0.01$) and number of indications (Table 3.11, $\beta = -1.381$, $p < 0.05$), but not significant for products in development (Table

3.8), time to regulatory advancement (Table 3.10), number of indications (Table 3.11), number of target-based actions (Table 3.12), and number of technologies (Table 3.13).

Hypothesis (H2a) predicts that contracts that specify unilateral monitoring are positively associated with innovative performance in exploitative R&D partnerships. Unilateral monitoring in the contract design for exploitative R&D partnerships is not significantly related to the measures of innovative performance. Based on the results, Hypothesis (H2a) is not supported.

For Hypothesis (H2b) and as shown in Model 4 in Tables 3.8-3.13, the coefficient of exploratory R&D partnerships is significant and negatively related to FDA approval (Table 3.9, $\beta = 1.589$, $p < 0.001$), the time to regulatory advancement (Table 3.10, $\beta = -0.583$, $p < 0.001$), the number of indications (Table 3.11, $\beta = -1.498$, $p < 0.001$), and number of technologies (Table 3.13, $\beta = -0.371$, $p < 0.10$), but not significant for products in development (Table 3.8) and number of target-based actions (Table 3.12). The coefficient of bilateral monitoring is not significant for any of the six dependent variables measuring innovative performance in Model 4.

For Hypothesis (H2b), Model 5 in Tables 3.8-3.13 is the full model. The coefficient of the interaction term is significant and positive for FDA approval (Table 3.9, $\beta = 2.562$, $p < 0.01$) and number of indications (Table 3.11, $\beta = 2.103$, $p < 0.05$), but are not significant for products in development (Table 3.8), time to regulatory advancement (Table 3.10), number of target-based actions (Table 3.12) and number of technologies (Table 3.13). Additionally, as shown in Model 5, the main effect of exploratory R&D partnerships is significant and negative for FDA approval (Table 3.9, $\beta = -2.718$, $p < 0.001$), time to regulatory advancement (Table 3.10, $\beta = -0.592$, $p < 0.001$), number of indications (Table

3.11, β = -2.083, $p < 0.001$), and number of technologies (Table 3.13, β = -0.400, $p < 0.10$), but not significant for products in development (Table 3.8) and number of target-based actions (Table 3.12). The main effect of bilateral monitoring is not significant for any of the six dependent variables measuring innovative performance in Model 5.

For Model 5, I conducted additional analysis to assess the AME of bilateral monitoring on innovative performance at the mean of all other variables in exploratory R&D partnerships. Figure 3.2 shows the AME of bilateral monitoring on the probability of FDA approval and the predicted number of indications in exploitative R&D partnerships. I find that the AME of bilateral monitoring in exploratory R&D partnerships is significant and positive for both the probability of FDA approval (AME = 0.225, $p < 0.01$) and number of indications (AME = 1.381, $p < 0.05$). Though the AME of bilateral monitoring is in the predicted direction for products in development, time to regulatory advancement, number of target-based actions, and number of technologies, they are not significant. Hypothesis (H2b) predicts that contracts that establish bilateral monitoring are positively associated with innovative performance in exploratory R&D partnerships. In terms of the actual impact that bilateral monitoring has on innovative performance in exploratory partnerships, I find that including a bilateral monitoring provision in the exploratory R&D contract is associated with a 22.5% greater probability of FDA approval and an increase by more than one in the number of drug indications on average. Thus, exploratory R&D partnerships that contractually specify bilateral monitoring are more likely to lead to innovative performance as measured by the probability of FDA approval or the number of indications. Bilateral monitoring in the contract design for exploratory R&D partnerships is not significantly related to the other measures of innovative performance, such as products

in development, time to regulatory advancement, number of target-based actions and technologies. Based on the results, Hypothesis (H2b) is partially supported.

Model 1 in Tables 3.14-3.19 is the control model for each of the six dependent variables measuring innovative performance. Model 2 in Tables 3.14-3.19 test Hypothesis (H3). All of the models in Table 3.14-19 are significant. As shown in Model 2 in Tables 3.14-3.19, the coefficient of management roles is significant and negatively related to the time to regulatory approval (Table 3.16, $\beta = -0.302$, $p < 0.01$) and number of indications (Table 3.17, $\beta = -0.782$, $p < 0.10$). Note that while the sign of the coefficient of management roles is in the predicted direction for the time to regulatory advancement, the sign is not in the predicted direction for the number of indications. The coefficient is not significant for products in development (Table 3.14), FDA approval (Table 3.15), number of target-based actions (Table 3.18) and number of technologies (Table 3.19).

I conducted additional analysis to assess the AME of management roles on innovative performance at the mean of all other variables in R&D partnerships. Figure 3.3 shows the AME of management roles on the predicted time to regulatory advancement. I find that the AME of management roles in R&D partnerships is significant and negative for the time to regulatory advancement (AME = -158.12, $p < 0.01$). AME of management roles are in the predicted direction for the products in development and number of technologies, but are not significant. The AME of management roles is neither in the predicted direction nor significant for FDA approval, number of indications, number of target-based actions, and number of technologies. Hypothesis (H3) predicts that contracts that specify management roles are positively associated with innovative performance in R&D partnerships. In terms of the actual impact that management roles have on innovative

performance in R&D partnerships, I find that including a provision for management roles in the R&D contract is associated with a decrease in the time to regulatory stage advancement of approximately 5 months on average. Thus, R&D partnerships that contractually specify management roles are more likely to lead to innovative performance as measured by the time to regulatory advancement. Management roles in the contract design for R&D partnerships is not significantly related to the other measures of innovative performance, such as products in development, FDA approval, number of target-based actions, number of indications, and number of technologies. Based on the results, Hypothesis (H3) is partially supported.

For Hypothesis (H4a), the models in Table 3.20 show the effect of two contract states (when $c = 1$ and $c = 8$) on the six dependent variables measuring innovative performance in exploitative R&D partnerships. The coefficient of the interaction of the composite variable in contract state $c = 1$ with exploitative R&D partnerships is significant and positive for the time to regulatory advancement ($\beta = 0.281$, $p < 0.10$). The coefficient of this interaction term is not significant for products in development, FDA approval, number of indications, number of target-based actions, and number of technologies. The coefficient of the interaction of the composite variable in contract state $c = 8$ with exploitative R&D partnerships is significant and positive for the products in development ($\beta = 1.595$, $p < 0.01$), FDA approval ($\beta = 1.532$, $p < 0.10$), number of indications ($\beta = 2.518$, $p < 0.05$), target-based actions ($\beta = 1.855$, $p < 0.01$), and technologies ($\beta = 1.583$, $p < 0.01$), and negative for the time to regulatory advancement ($\beta = -0.662$, $p < 0.05$). That is, this coefficient is significant and in the predicted direction for all six dependent variables measuring innovative performance.

I assess the AME of moving from one contract state (where composite variable $c = 1$) to the other (where composite variable $c = 8$) in exploitative R&D partnerships. Figure 3.4 shows the AME of such a move on the predicted products in development, probability of FDA approval, time to regulatory advancement, number of target-based actions, and number of technologies. I find that the AME between these two contract states in exploitative R&D partnerships is significant and in the predicted direction for products in development (AME = 1.031, $p < 0.001$), probability of FDA approval (AME = 0.198, $p < 0.05$), time to regulatory advancement (AME = -260.3, $p < 0.01$), number of target-based actions (AME = 0.879, $p < 0.05$), and number of technologies (AME = 0.942, $p < 0.01$). AME is in the predicted direction for the number of indications but is not significant. Hypothesis (H4a) predicts that contracts that include the specification of (1) direct oversight, unilateral monitoring, and management roles are more positively associated with innovative performance in exploitative R&D partnerships than contracts that include the specification of (2) joint oversight, bilateral monitoring, and no management roles. In terms of the actual impact that moving from one contract state ($c = 1$) to the other ($c = 8$) has on innovative performance in exploitative R&D partnerships, I find that this move is associated with, on average, an increase by about one in the number of products in development, number of target-based actions, and number of technologies, a nearly 20% greater probability of FDA approval, and a decrease by more than 8 months in the time to regulatory advancement. Thus, exploitative R&D partnerships that "flip" their contract states to specify direct oversight, unilateral monitoring, and management roles are more likely to lead to innovative performance as measured by the products in development, FDA approval, time to regulatory advancement, number of target-based actions, or number of

technologies. This move from one contract state to the other in exploitative R&D partnerships is not significantly related to innovative performance as measured by the number of indications. Based on the results, Hypothesis (H4a) is partially supported.

For Hypothesis (H4b), the models in Table 3.21 show the effect of two contract states (when $d = 1$ and $d = 8$) on the six dependent variables measuring innovative performance in exploratory R&D partnerships. The coefficient of the interaction of the composite variable in state $d = 1$ with exploratory R&D partnerships is significant and negative for FDA approval ($\beta = -2.617$, $p < 0.10$), time to regulatory advancement ($\beta = -0.328$, $p < 0.05$), number of indications ($\beta = -1.202$, $p < 0.05$), and number of technologies ($\beta = -0.551$, $p < 0.05$). The coefficient of this interaction term is not significant for products in development and the number of target-based actions. The coefficient of the interaction of the composite variable in state $d = 8$ with exploratory R&D partnerships is significant and negative for the time to regulatory advancement ($\beta = -0.660$, $p < 0.001$). The coefficient of this interaction term is not significant for products in development, FDA approval, number of indications, number of target-based actions, and number of technologies.

I assess the AME of moving from one contract state (where composite variable $d = 1$) to the other (where composite variable $d = 8$) in exploratory R&D partnerships. Figure 3.5 shows the AME of such a move from one contract state to the other on the predicted probability of FDA approval. I find that the AME between these two contract states in exploratory R&D partnerships is significant and in the predicted direction for the probability of FDA approval (AME = 0.198, $p < 0.05$). AME is in the predicted direction for the products in development and the time to regulatory advancement, but are not significant. The AME is neither in the predicted directions nor significant for the number of

indications, number of target-based actions, and number of technologies. Hypothesis (H4b) predicts that contracts that include the specification of (1) joint oversight, bilateral monitoring, and management roles are more positively associated with innovative performance in exploratory R&D partnerships than contracts that include the specification of (2) direct oversight, unilateral monitoring, and no management roles. In terms of the actual impact that moving from one contract state (d = 1) to the other (d = 8) has on innovative performance in exploratory R&D partnerships, I find that this move is associated with, on average, an increase by 14% in the probability of FDA approval. Thus, exploratory R&D partnerships that "flip" their contract states to specify joint oversight, bilateral monitoring, and management roles are more likely to lead to innovative performance as measured by the probability of FDA approval. This move from one contract state to the other in exploratory R&D partnerships is not significantly related to innovative performance as measured by the products in development, time to regulatory advancement, the number of indications, number of target-based actions, or number of technologies. Based on the results, Hypothesis (H4b) is partially supported.

A summary in Table 3.22 shows the hypotheses for which I find support. For Hypothesis (H1a), exploitative R&D partnerships that contractually specify direct oversight are more likely to lead to innovative performance as measured by the probability of FDA approval or the time to regulatory advancement, but is not significantly related to the products in development, the number of indications, number of target-based actions, and number of technologies. For Hypothesis (H1b), joint oversight in the contract design for exploratory R&D partnerships is not significantly related to any of the six measures of innovative performance. For Hypothesis (H2a), unilateral monitoring in the contract design

for exploitative R&D partnerships is not significantly related to the measures of innovative performance. For Hypothesis (H2b), exploratory R&D partnerships that contractually specify bilateral monitoring are more likely to lead to innovative performance as measured by the probability of FDA approval or the number of indications, but is not significantly related to products in development, time to regulatory advancement, number of target-based actions, and number of technologies. For Hypothesis (H3), R&D partnerships that contractually specify management roles are more likely to lead to innovative performance as measured by the time to regulatory advancement, but is not significantly related to the products in development, FDA approval, number of target-based actions, number of indications, and number of technologies. For Hypothesis (H4a), exploitative R&D partnerships that "flip" their contract states to specify direct oversight, unilateral monitoring, and management roles are more likely to lead to innovative performance as measured by the products in development, FDA approval, time to regulatory advancement, number of target-based actions, or number of technologies, but is not significantly related to innovative performance as measured by the number of indications. And finally, for Hypothesis (H4b), exploratory R&D partnerships that "flip" their contract states to specify joint oversight, bilateral monitoring, and management roles are more likely to lead to innovative performance as measured by the probability of FDA approval, but is not significantly related to innovative performance as measured by the products in development, time to regulatory advancement, the number of indications, number of target-based actions, or number of technologies.

5 | DISCUSSION

This paper seeks to develop and test a framework to better understand how elements of the design of the contract may impact the innovative performance of R&D partnerships. It does so by identifying control and coordination provisions of contracts that are highly pertinent to understanding collaborative innovative performance. Specifically, this study examines control and coordination provisions from the TCE and RBV perspectives. It does so in a way that recognizes that R&D is not uniform, and that the type of R&D partnership matters when designing contract elements to support collaborative innovation outcomes. Based on the literature, the elements of contract design that may impact partnership success or failure include provisions that specify management oversight, monitoring, and management roles.

Firms in R&D partnerships can employ provisions in contracts to support the management oversight of a collaborative R&D relationship. Partners can *ex ante* allocate the authority to one of the partners to make all decisions in the event of a contingency (e.g., Arruñada et al., 2001; Lerner and Merges, 1998), called direct oversight. I find support for the link between the contractual specification of direct oversight and innovative performance in exploitative R&D partnerships as measured by regulatory approval and time to regulatory advancement. Direct oversight may provide the necessary formalization that aligns incentives and rewards the successful completion of routine commercialization activities required of exploitative R&D partnerships.

The specter of opportunism eroding the development of long-term R&D relationships (Barnes et al., 2010) encourages partners to use monitoring mechanisms to align collaborative activities and partners' behaviors toward the achievement of common goals (Kale and Singh, 2007). I find support that contractual provisions that mandate

bilateral monitoring of processes employed in exploratory R&D partnerships may increase communication of task-specific activities, which can facilitate greater collaboration (e.g., effective coordination; Faems et al., 2008). Bilateral monitoring provisions may serve as a means of increasing heterogeneity of knowledge assets between firms, facilitating information exchange, and increasing cooperation among collaborators, factors necessary for the success of exploratory R&D activities.

The ability of R&D collaborations to produce high-impact innovations often depends not only upon the composition of technical and management human capital, but also on the delegation of duties (Argyres and Mayer, 2007). I find some support for the link between the contractual specification of management roles in R&D contracts and innovative performance as measured by the time to regulatory advancement. By detailing management roles in the collaboration, this provision may serve both a control and coordinating function: by reducing ambiguity about contractual obligations and thereby reducing the scope for opportunistic actions seeking to take advantage of any ambiguity for private gain and by delineating roles in ways that ensures that the diversity of activities carried out are coordinated among the partners in the collaboration.

Finally, in addition to the findings that contract design elements—separately—impact innovative performance I find support that contract design elements—together—when aligned with the proper R&D context lead to superior innovative performance. The specification of direct oversight, unilateral monitoring and management roles, together, is more positively associated with innovative performance in exploitative R&D partnerships than contracts specifying joint oversight, bilateral monitoring, and no management roles. Likewise, the specification of joint oversight, bilateral monitoring, and management roles,

together, is more positively associated with innovative performance in exploratory R&D partnerships than contracts specifying direct oversight, unilateral monitoring and no management roles.

This paper contributes to the literature on R&D partnerships by improving our understanding of the factors that may lead to innovative performance (Sampson, 2007; Keil et al., 2008; Satta et al., 2016). By investigating elements of the design of the contract, I contribute to our understanding of how contracts can both control and coordinate partners in ways that foster collaborative innovation and lead to innovative performance. Collaborative innovation results from a contracting environment that promotes coordination through cooperative knowledge exchange, while simultaneously limiting opportunism and misunderstandings between partners. Both coordination and control are important to the management of R&D collaborations. However, as evident by the TCE literature, contracting partners tend to be more focused on control mechanisms that limit opportunism than on creating a positive environment for collaborators (Williamson, 1975, 1985; Sampson, 2004). Scholars have argued that in attempting to mitigate threats from opportunistic behavior, formal contracts that emphasize control mechanisms actually serve to foster distrust and bring about the very actions they are designed to prevent (e.g., Dyer and Singh, 1998; Ghoshal and Moran, 1996; Malhotra and Murnighan, 2002; Ring and Van de Ven, 1994). In contrasts, this paper, by distinguishing by R&D type, shows that control mechanisms may foster a positive environment that positively impacts innovative performance. Thus, identifying contract design elements that may lead to an environment that fosters innovation, while avoiding opportunism or misunderstandings, is an important research issue that this study addresses.

This study also contributes to the R&D partnerships literature by distinguishing the type of R&D carried out when examining the link between contract design and innovative performance. With few notable exceptions (e.g., Gilsing and Nooteboom, 2006; Jansen et al., 2006; Rothaermel and Deeds, 2004), prior studies have generally not systematically distinguished between partnerships at different foci of the R&D value chain and are thus at risk of aggregation bias. Ignoring the potential variance that exists across R&D partnerships initiated under different motivations can lead to spurious results and/or mask the impact that contract design has on innovative performance. Therefore, I leverage Koza and Lewin's (1998) typology of partnership activity to examine external exploratory and exploitative R&D partnerships on subsequent innovative performance. In doing so, this study provides a more subtle understanding of the control and coordination functions that contractual elements provide in the R&D partnership context and its relationship to the realization of innovative performance.

Finally, this paper contributes to the literature on innovation by examining a more robust set of measures for innovative performance than previously operationalized. Studies in the innovation literature have highlighted several limitations of measuring innovative performance in the biopharmaceutical industry (e.g., Lanthier et al., 2013; Hagedoorn and Cloodt, 2003; DiMasi, 2000). The research and development process in the biopharmaceutical industry is a long process that sees most drugs fail to obtain FDA regulatory approval (DiMasi, 2000). Yet, the traditional measures of innovative performance in this industry have either been a count variable of the number of drugs approved or an indicator variable for FDA approval (Rothaermel and Deeds, 2004; Hoang and Rothaermel, 2009). As output measures of a long process, these measures fail to give

an adequate picture of innovation in this industry (Adams et al., 2006) since knowledge is gained and innovation occurs even without regulatory approval. Collaborations in the biopharmaceutical industry lead to the development of a product that is based on either underlying technologies, mechanisms of action, target binding sites, disease indications, or therapeutic areas that have innovative value whether or not the drug is ultimately approved (Lanthier et al., 2013). For some partners that focus on, say, a core technology platform in an R&D collaboration, there may not be approved products for a long time, yet there are still significant R&D expenditures to develop the underlying technology. Therefore, this study addresses this limitation by examining a more robust set of measures for innovative performance that capture the knowledge gained along different aspects of the product development or R&D process. By using additional measures, such as the speed of regulatory advancement, number of indications, number of target-based actions, and number of technologies, I am able to provide a more holistic assessment of innovative performance in the biopharmaceutical industry.

5.1 | Limitations and future research

This study provides some evidence that R&D contract design can affect innovative performance in R&D partnerships. For future research, it will be interesting to complement traditional perspectives in interfirm contracting research with nontraditional perspectives in examining how contact design impacts innovative performance. By building on research that applies TCE and RBV perspectives to contracts and augmenting them with sociological and psychological perspectives, researchers can investigate additional contract roles. For example, contract framing has been proposed to offer one potential mechanism to psychologically impact the exchange or ongoing partner relationship (Weber and Mayer,

2011). One way that scholars have examined contract framing is by using a theory from cognitive and social psychology: regulatory focus theory (Weber and Mayer, 2011), which differentiates between framing contractual provisions as gains/non-gains (promotion frame) or loss/non-loss (prevention frame; Higgins, 1997, 1998). Using regulatory focus theory to specify contract provisions might enable us to understand why certain contract frames may lead to positive transaction outcomes and relationships while others may negatively impact the focal exchange and ongoing relationship in ways that differentially affect innovative performance.

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TABLE 3.1 Descriptive statistics and correlation

Variable	Mean	SD	1	2	3	4	5	6	7	8	9
1. Products in development	0.80	0.88									
2. FDA approval	0.22	0.41	0.24***								
3. Time to regulatory advancement	515.71	488.25	-0.01	-0.05							
4. Number of indications	2.74	3.42	-0.09	0.10	0.08						
5. Number of target-based actions	0.87	1.20	0.06	0.01	0.11	0.29***					
6. Number of technologies	2.54	1.43	0.15*	0.12	0.18*	0.17*	0.18*				
7. Exploitative R&D	0.53	0.50	0.10	0.27***	0.27***	0.05	-0.02	0.07			
8. Oversight	0.37	0.48	0.02	0.23**	-0.12	-0.08	-0.12	-0.16*	-0.06		
9. Monitoring	0.69	0.46	-0.07	-0.08	-0.01	-0.06	-0.19**	-0.06	-0.10	0.28***	
10. Management roles	0.31	0.47	0.17*	0.03	-0.18**	-0.12	0.08	0.03	-0.01	-0.23***	-0.30***
11. Contract length	1.40	0.98	0.11	0.12	0.09	-0.02	0.10	0.03	0.20**	-0.39***	-0.35***
12. Incentive payment	0.67	0.25	0.00	-0.05	-0.14	-0.168*	-0.02	-0.21**	0.08	-0.03	-0.01
13. Deal size	1.49	2.53	0.28***	0.12	0.04	-0.02	0.21**	-0.06	0.24***	-0.15*	-0.29***
14. Contract duration	1.69	1.36	-0.06	0.00	0.60***	0.06	0.07	0.04	-0.10	0.05	-0.02
15. Patent protection	0.40	0.49	-0.20**	0.03	0.00	-0.01	-0.12	0.06	-0.06	0.09	0.14
16. Cross-border deal	0.46	0.50	-0.05	-0.01	0.16*	0.03	-0.04	0.06	-0.02	-0.10	0.00
17. Biotech-biotech deal	0.56	0.50	0.00	0.16*	0.04	-0.02	-0.04	-0.01	0.01	-0.01	0.02
18. Principal firm prior partnerships	2.74	2.65	0.04	-0.05	-0.03	0.03	-0.02	-0.01	-0.11	0.10	0.01
19. Principal firm size	2.98	9.60	0.07	0.05	-0.08	-0.05	-0.03	0.00	0.04	0.11	-0.10
20. Principal firm performance	-1.03	11.46	0.12	0.05	-0.09	0.04	-0.07	-0.03	0.03	0.07	-0.09
21. Principal firm R&D intensity	5.54	19.99	0.03	0.13	-0.04	0.00	-0.03	0.05	0.03	0.06	0.07
22. Principal firm slack	8.19	10.81	0.19**	0.00	0.00	0.07	0.05	0.01	0.01	-0.09	0.05
23. Client firm prior partnerships	6.86	5.94	0.03	0.00	0.11	0.04	0.07	-0.03	0.05	-0.17*	-0.06
24.Client firm size	0.39	0.39	0.01	0.01	0.10	0.06	0.01	-0.03	0.08	-0.08	-0.04
25. Client firm performance	-1.96	12.13	0.04	-0.07	0.11	0.06	0.07	0.02	-0.01	-0.12	0.01
26. Client firm R&D intensity	0.87	3.35	0.04	0.05	-0.03	0.01	-0.08	0.04	0.01	0.16*	0.14
27. Client firm slack	1.74	3.25	0.04	-0.07	-0.05	0.07	0.11	0.06	-0.09	-0.04	0.04

Note: n=305 R&D collaborations. Year and Agreement type dummies are omitted. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

TABLE 3.1 (Continued)

Variable	10	11	12	13	14	15	16	17	18
11. Contract length	0.36***								
12. Incentive payment	0.10	0.15*							
13. Deal size	0.33***	0.46***	0.23**						
14. Contract duration	-0.12	-0.02	-0.27***	-0.08					
15. Patent protection	-0.14	-0.21**	-0.10	-0.26***	0.07				
16. Cross-border deal	-0.02	0.08	0.03	0.00	0.15*	0.00			
17. Biotech-biotech deal	-0.09	0.12	0.10	-0.01	0.09	-0.09	0.05		
18. Principal firm prior partnerships	-0.04	-0.17*	-0.21**	-0.16*	-0.01	0.05	-0.13	-0.02	
19. Principal firm size	0.08	0.00	0.00	-0.05	-0.08	0.00	-0.10	0.01	0.50***
20. Principal firm performance	0.06	0.02	-0.06	0.03	0.06	-0.14*	-0.10	-0.01	0.00
21. Principal firm R&D intensity	-0.05	-0.03	0.01	-0.02	-0.01	0.11	-0.11	0.01	-0.01
22. Principal firm slack	-0.08	0.08	-0.04	0.06	0.01	-0.14	-0.01	0.02	-0.15*
23. Client firm prior partnerships	0.10	0.09	0.05	0.23***	0.10	0.05	0.07	0.00	-0.12
24.Client firm size	0.07	0.06	0.02	0.32***	0.08	0.02	0.14	0.04	-0.12
25. Client firm performance	0.00	0.16*	-0.03	0.07	0.12	0.11	0.05	-0.02	-0.13
26. Client firm R&D intensity	-0.13	-0.12	0.05	-0.10	-0.03	0.07	-0.12	-0.02	0.00
27. Client firm slack	0.00	-0.09	0.03	-0.11	0.04	-0.03	-0.08	-0.11	0.09

Note: n=305 R&D collaborations. Year and Agreement type dummies are omitted. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

TABLE 3.1 (Continued)

Variable	19	20	21	22	23	24	25	26
20. Principal firm performance	0.03							
21. Principal firm R&D intensity	-0.06	-0.07						
22. Principal firm slack	-0.15*	0.05	0.11					
23. Client firm prior partnerships	-0.07	-0.09	0.05	-0.11				
24.Client firm size	-0.10	-0.19**	-0.03	-0.09	0.49***			
25. Client firm performance	-0.29***	-0.02	0.02	-0.01	0.22**	0.20**		
26. Client firm R&D intensity	-0.03	0.02	0.08	0.20**	-0.22**	-0.25***	0.03	
27. Client firm slack	-0.05	0.04	0.00	0.17*	-0.24***	-0.29***	0.07	0.41***

Note: n=305 R&D collaborations. Year and Agreement type dummies are omitted. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

T A B L E 3.2 Censored regression results for the products in development

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Direct oversight		0.070	-0.341		
		(0.181)	(0.271)		
Joint oversight				-0.070	-0.373
				(0.181)	(0.233)
Exploitative R&D		0.163	-0.105		
		(0.183)	(0.223)		
Exploratory R&D				-0.163	-0.608*
				(0.183)	(0.286)
Direct oversight x Exploitative R&D			0.713*		
			(0.350)		
Joint oversight x Exploratory R&D					0.713*
					(0.350)
Contract length	-0.021	-0.009	-0.014	-0.009	-0.014
	(0.093)	(0.099)	(0.098)	(0.099)	(0.098)
Incentive payment	-0.815*	-0.790*	-0.864*	-0.790*	-0.864*
	(0.363)	(0.366)	(0.366)	(0.366)	(0.366)
Deal Size	-0.011	-0.015	-0.005	-0.015	-0.005
	(0.042)	(0.043)	(0.043)	(0.043)	(0.043)
Contract duration	0.028	0.028	0.025	0.028	0.025
	(0.067)	(0.067)	(0.067)	(0.067)	(0.067)
Patent protection	-0.216	-0.217	-0.209	-0.217	-0.209
	(0.187)	(0.187)	(0.186)	(0.187)	(0.186)
Cross-border deal	0.028	0.031	0.039	0.031	0.039
	(0.165)	(0.165)	(0.164)	(0.165)	(0.164)
Biotech-biotech deal	-0.142	-0.138	-0.150	-0.138	-0.150
	(0.167)	(0.167)	(0.165)	(0.167)	(0.165)
Principal num of prior partnerships	0.040	0.041	0.041	0.041	0.041
	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)
Principal firm size	-0.018†	-0.018†	-0.018†	-0.018†	-0.018†
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Principal firm performance	0.023	0.023	0.024	0.023	0.024
	(0.022)	(0.022)	(0.024)	(0.022)	(0.024)
Principal R&D intensity	0.001	0.001	0.000	0.001	0.000
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Principal slack	-0.002	-0.002	-0.001	-0.002	-0.001
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Client num of prior partnerships	0.022	0.024	0.023	0.024	0.023
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Client firm size	-0.009	-0.021	-0.024	-0.021	-0.024
	(0.259)	(0.260)	(0.257)	(0.260)	(0.257)
Client firm performance	0.007	0.007	0.009	0.007	0.009
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Client R&D intensity	0.036	0.032	0.031	0.032	0.031
	(0.026)	(0.027)	(0.026)	(0.027)	(0.026)
Client slack	0.028	0.030	0.035	0.030	0.035
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Constant	-0.460	-0.583	-0.300	-0.351	-0.033
	(1.039)	(1.060)	(1.054)	(1.046)	(1.043)
χ^2	146.30***	147.24***	151.41***	147.24***	151.41***
Log likelihood	-331.4	-331.0	-328.9	-331.0	-328.9
Pseudo R^2	.18	.18	.19	.18	.19

Note: n=305 R&D collaborations. Year and Agreement type dummies included. *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

T A B L E 3.3 Logistic regression results for probability of FDA approval

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Direct oversight		1.505***	-1.164		
		(0.436)	(1.097)		
Joint oversight				-1.505***	-2.642***
				(0.436)	(0.621)
Exploitative R&D		1.551***	0.170		
		(0.475)	(0.559)		
Exploratory R&D				-1.551***	-3.976***
				(0.475)	(1.161)
Direct oversight x Exploitative R&D			3.806**		
			(1.280)		
Joint oversight x Exploratory R&D					3.806**
					(1.280)
Contract length	0.161	0.380	0.387	0.380	0.387
	(0.217)	(0.272)	(0.257)	(0.272)	(0.257)
Incentive payment	-1.926*	-1.838*	-2.672**	-1.838*	-2.672**
	(0.850)	(0.924)	(0.938)	(0.924)	(0.938)
Deal Size	0.112	0.107	0.146	0.107	0.146
	(0.086)	(0.094)	(0.089)	(0.094)	(0.089)
Contract duration	-0.095	-0.186	-0.190	-0.186	-0.190
	(0.170)	(0.175)	(0.163)	(0.175)	(0.163)
Patent protection	0.177	0.213	0.333	0.213	0.333
	(0.370)	(0.387)	(0.417)	(0.387)	(0.417)
Cross-border deal	-0.367	-0.242	-0.159	-0.242	-0.159
	(0.372)	(0.361)	(0.352)	(0.361)	(0.352)
Biotech-biotech deal	1.132**	1.505**	1.453**	1.505**	1.453**
	(0.439)	(0.528)	(0.548)	(0.528)	(0.548)
Principal num of prior partnerships	-0.165†	-0.156	-0.137	-0.156	-0.137
	(0.094)	(0.096)	(0.098)	(0.096)	(0.098)
Principal firm size	0.005	0.014	0.014	0.014	0.014
	(0.022)	(0.022)	(0.021)	(0.022)	(0.021)
Principal firm performance	0.011	0.007	0.012	0.007	0.012
	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)
Principal R&D intensity	0.012*	0.011	0.010	0.011	0.010
	(0.005)	(0.007)	(0.007)	(0.007)	(0.007)
Principal slack	-0.011	-0.005	0.002	-0.005	0.002
	(0.015)	(0.018)	(0.018)	(0.018)	(0.018)
Client num of prior partnerships	-0.018	0.010	-0.001	0.010	-0.001
	(0.036)	(0.040)	(0.044)	(0.040)	(0.044)
Client firm size	0.244	0.142	0.242	0.142	0.242
	(0.580)	(0.671)	(0.635)	(0.671)	(0.635)
Client firm performance	-0.035	-0.037	-0.021	-0.037	-0.021
	(0.021)	(0.032)	(0.029)	(0.032)	(0.029)
Client R&D intensity	0.100*	0.067	0.061	0.067	0.061
	(0.050)	(0.056)	(0.054)	(0.056)	(0.054)
Client slack	0.029	0.070	0.088	0.070	0.088
	(0.050)	(0.054)	(0.055)	(0.054)	(0.055)
Constant	1.506	-0.318	0.745	2.738	3.557
	(1.881)	(2.299)	(2.353)	(2.210)	(2.290)
χ^2	58.39†	88.86***	93.90***	88.86***	93.90***
Log likelihood	-117.9	-105.2	-98.1	-105.2	-98.1
Pseudo R^2	.23	.32	.36	0.32	.36

Note: n=280 R&D collaborations. Year and Agreement type dummies included. Robust *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

T A B L E 3.4 Negative binomial regression results for the time to regulatory advancement

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Direct oversight		-0.280**	0.047		
		(0.091)	(0.132)		
Joint oversight				0.280**	0.547
				(0.091)	(0.116)
Exploitative R&D		0.569***	0.763***		
		(0.087)	(0.100)		
Exploratory R&D				-0.569***	-0.169
				(0.087)	(0.145)
Direct oversight x Exploitative R&D			-0.593***		
			(0.174)		
Joint oversight x Exploratory R&D					-0.593***
					(0.174)
Contract length	0.037	-0.041	-0.033	-0.041	-0.033
	(0058)	(0.054)	(0.052)	(0.054)	(0.052)
Incentive payment	-0.272	-0.084	-0.012	-0.084	-0.012
	(0.208)	(0.186)	(0.180)	(0.186)	(0.180)
Deal Size	0.011	-0.008	-0.018	-0.008	-0.018
	(0.026)	(0.022)	(0.022)	(0.022)	(0.022)
Contract duration	0.463***	0.484***	0.482***	0.484***	0.482
	(0.044)	(0.040)	(0.038)	(0.040)	(0.038)
Patent protection	0.145	0.126	0.098	0.126	0.098
	(0.105)	(0.092)	(0.090)	(0.092)	(0.090)
Cross-border deal	0.226*	0.176*	0.174*	0.176*	0.174
	(0.089)	(0.079)	(0.078)	(0.079)	(0.078)
Biotech-biotech deal	-0.124	-0.142†	-0.125†	-0.142†	-0.125
	(0.090)	(0.080)	(0.078)	(0.080)	(0.078)
Principal num of prior partnerships	0.019	0.010	0.011	0.010	0.011
	(0.018)	(0.016)	(0.016)	(0.016)	(0.016)
Principal firm size	-0.006	-0.003	-0.003	-0.003	-0.003
	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
Principal firm performance	-0.005†	-0.006*	-0.007**	-0.006*	-0.007
	(0003)	(0.003)	(0.003)	(0.003)	(0.003)
Principal R&D intensity	-0.002	-0.003†	-0.002	-0.003†	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Principal slack	-0.003	-0.004	-0.004	-0.004	-0.004
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Client num of prior partnerships	0.000	0.001	0.002	0.001	0.002
	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
Client firm size	0.080	-0.075	-0.038	-0.075	-0.038
	(0.141)	(0.126)	(0.124)	(0.126)	(0.124)
Client firm performance	-0.001	0.004	0.002	0.004	0.002
	(0.007)	(0.007)	(0.006)	(0.007)	(0.006)
Client R&D intensity	0.027	0.020	0.026†	0.020	0.026
	(0.017)	(0.014)	(0.014)	(0.014)	(0.014)
Client slack	-0.017	-0.022*	-0.026*	-0.022*	-0.026
	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)
Constant	3.791***	3.789***	3.803***	4.078***	4.019***
	(0.535)	(0.480)	(0.467)	(0.478)	(0.464)
χ^2	204.93***	147.24***	265.38***	253.95***	265.38***
Log likelihood	-1339.3	-1314.8	-1309.1	-1314.8	-1309.1
Pseudo R^2	.07	.09	.09	.09	.09

Note: n=200 R&D collaborations. Year and Agreement type dummies included. Robust *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

TABLE 3.5 Censored regression results for the number of indications

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Direct oversight		-0.151	-0.638		
		(0.424)	(0.601)		
Joint oversight				0.151	-0.285
				(0.424)	(0.570)
Exploitative R&D		1.500***	1.148*		
		(0.424)	(0.524)		
Exploratory R&D				-1.500***	-2.071**
				(0.424)	(0.656)
Direct oversight x Exploitative R&D			0.923		
			(0.809)		
Joint oversight x Exploratory R&D					0.923
					(0.809)
Contract length	0.288	0.226	0.220	0.226	0.220
	(0.233)	(0.241)	(0.241)	(0.241)	(0.241)
Incentive payment	-2.032*	-1.682*	-1.780*	-1.682*	-1.780*
	(0.863)	(0.852)	(0.854)	(0.852)	(0.854)
Deal Size	0.247*	0.203†	0.217*	0.203†	0.217*
	(0.110)	(0.109)	(0.109)	(0.109)	(0.109)
Contract duration	-0.220	-0.196	-0.198	-0.196	-0.198
	(0.159)	(0.156)	(0.156)	(0.156)	(0.156)
Patent protection	-0.500	-0.516	-0.507	-0.516	-0.507
	(0.435)	(0.426)	(0.425)	(0.426)	(0.425)
Cross-border deal	-0.170	-0.136	-0.139	-0.136	-0.139
	(0.396)	(0.389)	(0.388)	(0.389)	(0.388)
Biotech-biotech deal	0.949*	0.967*	0.942*	0.967*	0.942*
	(0.395)	(0.388)	(0.387)	(0.388)	(0.387)
Principal num of prior partnerships	-0.106	-0.091	-0.094	-0.091	-0.094
	(0.088)	(0.086)	(0.086)	(0.086)	(0.086)
Principal firm size	0.010	0.012	0.013	0.012	0.013
	(0.026)	(0.025)	(0.025)	(0.025)	(0.025)
Principal firm performance	0.003	0.001	0.001	0.001	0.001
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Principal R&D intensity	-0.003	-0.004	-0.005	-0.004	-0.005
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Principal slack	0.020	0.020	0.022	0.020	0.022
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Client num of prior partnerships	-0.037	-0.029	-0.032	-0.029	-0.032
	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)
Client firm size	0.138	-0.007	-0.008	-0.007	-0.008
	(0.607)	(0.596)	(0.594)	(0.596)	(0.594)
Client firm performance	0.023	0.023	0.027	0.023	0.027
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Client R&D intensity	0.059	0.041	0.038	0.041	0.038
	(0.063)	(0.062)	(0.062)	(0.062)	(0.062)
Client slack	0.079	0.089	0.096	0.089	0.096
	(0.066)	(0.065)	(0.065)	(0.065)	(0.065)
Constant	5.704*	5.327*	5.686*	6.675**	7.118**
	(2.272)	(2.282)	(2.299)	(2.242)	(2.270)
χ^2	79.23**	91.55**	92.84**	91.55**	92.84**
Log likelihood	-758.9	-752.8	-752.1	-752.8	-752.1
Pseudo R^2	.05	.06	.06	.06	.06

Note: n=305 R&D collaborations. Year and Agreement type dummies included. *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

T A B L E 3.6 Censored regression results for the number of target-based actions

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Direct oversight		-0.153	-0.418		
		(0.264)	(0.391)		
Joint oversight				0.153	-0.041
				(0.264)	(0.336)
Exploitative R&D		0.368	0.204		
		(0.255)	(0.310)		
Exploratory R&D				-0.368	-0.663
				(0.255)	(0.409)
Direct oversight x Exploitative R&D			0.459		
			(0.498)		
Joint oversight x Exploratory R&D					0.459
					(0.498)
Contract length	0.198	0.160	0.158	0.160	0.158
	(0.131)	(0.138)	(0.138)	(0.138)	(0.138)
Incentive payment	0.187	0.306	0.266	0.306	0.266
	(0.525)	(0.529)	(0.530)	(0.529)	(0.530)
Deal Size	0.112†	0.101†	0.105†	0.101†	0.105†
	(0.061)	(0.061)	(0.061)	(0.061)	(0.061)
Contract duration	0.123	0.134	0.136	0.134	0.136
	(0.101)	(0.101)	(0.101)	(0.101)	(0.101)
Patent protection	-0.275	-0.284	-0.277	-0.284	-0.277
	(0.264)	(0.263)	(0.263)	(0.263)	(0.263)
Cross-border deal	0.037	0.037	0.032	0.037	0.032
	(0.237)	(0.237)	(0.237)	(0.237)	(0.237)
Biotech-biotech deal	0.069	0.065	0.049	0.065	0.049
	(0.233)	(0.233)	(0.233)	(0.233)	(0.233)
Principal num of prior partnerships	0.001	0.006	0.006	0.006	0.006
	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)
Principal firm size	-0.012	-0.012	-0.011	-0.012	-0.011
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Principal firm performance	-0.017*	-0.018*	-0.017*	-0.018*	-0.017*
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Principal R&D intensity	-0.006	-0.006	-0.006	-0.006	-0.006
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Principal slack	-0.001	-0.001	0.000	-0.001	0.000
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Client num of prior partnerships	0.021	0.020	0.019	0.020	0.019
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
Client firm size	-0.454	-0.478	-0.483	-0.478	-0.483
	(0.364)	(0.362)	(0.361)	(0.362)	(0.361)
Client firm performance	0.013	0.014	0.015	0.014	0.015
	(0.017)	(0.016)	(0.016)	(0.016)	(0.016)
Client R&D intensity	-0.093	-0.099	-0.099	-0.099	-0.099
	(0.059)	(0.061)	(0.061)	(0.061)	(0.061)
Client slack	0.101**	0.101**	0.102**	0.101**	0.102**
	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)
Constant	-0.997	-1.003	-0.862	0.788	-0.618
	(1.325)	(1.355)	(1.366)	(1.330)	(1.345)
χ^2	104.20***	106.58***	107.43***	106.58***	107.43***
Log likelihood	-392.3	-391.1	-390.7	-391.1	-390.7
Pseudo R^2	.12	.12	.12	.12	.12

Note: n=305 R&D collaborations. Year and Agreement type dummies included. *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

T A B L E 3.7 Regression results for the number of technologies

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Direct oversight		-0.106	-0.297		
		(0.194)	(0.275)		
Joint oversight				0.106	-0.066
				(0.194)	(0.261)
Exploitative R&D		0.372†	0.232		
		(0.194)	(0.240)		
Exploratory R&D				-0.372†	-0.596*
				(0.194)	(0.299)
Direct oversight x Exploitative R&D			0.363		
			(0.370)		
Joint oversight x Exploratory R&D					0.363
					(0.370)
Contract length	0.116	0.089	0.086	0.089	0.086
	(0.105)	(0.111)	(0.111)	(0.111)	(0.111)
Incentive payment	-1.280***	-1.188**	-1.226**	-1.188**	-1.226**
	(0.388)	(0.390)	(0.392)	(0.390)	(0.392)
Deal Size	0.041	0.029	0.034	0.029	0.034
	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
Contract duration	0.033	0.040	0.039	0.040	0.039
	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)
Patent protection	0.091	0.086	0.089	0.086	0.089
	(0.195)	(0.194)	(0.194)	(0.194)	(0.194)
Cross-border deal	0.296†	0.301†	0.299†	0.301†	0.299†
	(0.178)	(0.178)	(0.178)	(0.178)	(0.178)
Biotech-biotech deal	0.127	0.128	0.119	0.128	0.119
	(0.177)	(0.177)	(0.177)	(0.177)	(0.177)
Principal num of prior partnerships	-0.027	-0.023	-0.024	-0.023	-0.024
	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)
Principal firm size	0.001	0.001	0.002	0.001	0.002
	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)
Principal firm performance	-0.003	-0.003	-0.003	-0.003	-0.003
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Principal R&D intensity	0.003	0.003	0.002	0.003	0.002
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Principal slack	-0.001	-0.001	-0.001	-0.001	-0.001
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Client num of prior partnerships	-0.013	-0.012	-0.012	-0.012	-0.012
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Client firm size	-0.065	-0.102	-0.103	-0.102	-0.103
	(0.272)	(0.272)	(0.272)	(0.272)	(0.272)
Client firm performance	0.009	0.010	0.011	0.010	0.011
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Client R&D intensity	0.000	-0.003	-0.004	-0.003	-0.004
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Client slack	0.051†	0.052†	0.055†	0.052†	0.055†
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
Constant	2.299*	2.285*	2.428*	2.551*	2.727**
	(1.024)	(1.046)	(1.057)	(1.028)	(1.044)
F	1.39†	1.42*	1.41*	1.42*	1.41*
R^2	.22	.24	.24	.24	.24

Note: n=305 R&D collaborations. Year and Agreement type dummies included. Robust *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

FIGURE 3.1 Average marginal effect of direct oversight on innovative performance in exploitative R&D partnerships.

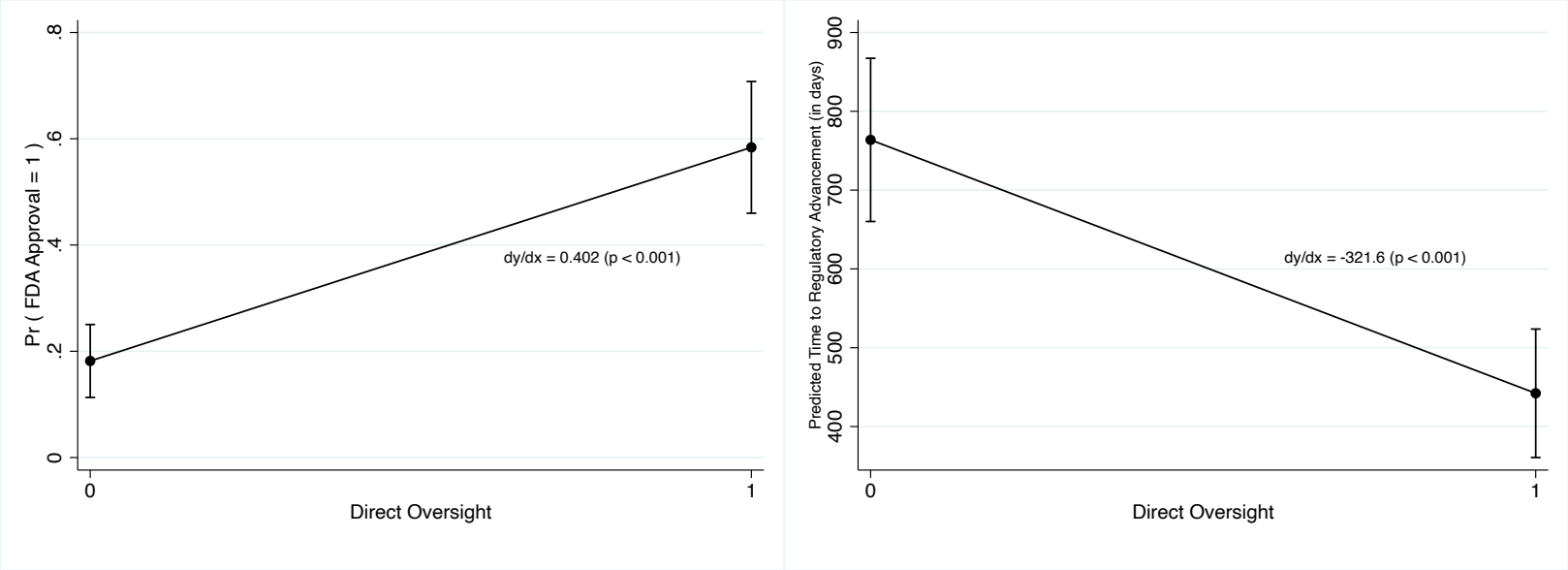


TABLE 3.8 Censored regression results for the products in development

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Unilateral monitoring		0.211	-0.057		
		(0.186)	(0.292)		
Bilateral monitoring				-0.211	-0.378
				(0.186)	(0.233)
Exploitative R&D		0.160	-0.152		
		(0.183)	(0.320)		
Exploratory R&D				-0.160	-0.284
				(0.183)	(0.210)
Unilateral monitoring x Exploitative R&D			0.435		
			(0.369)		
Bilateral monitoring x Exploratory R&D					0.435
					(0.369)
Contract length	-0.021	-0.003	0.008	-0.003	0.008
	(0.093)	(0.094)	(0.094)	(0.094)	(0.094)
Incentive payment	-0.815*	-0.847*	-0.834*	-0.847*	-0.834*
	(0.363)	(0.370)	(0.368)	(0.370)	(0.368)
Deal Size	-0.011	-0.008	0.002	-0.008	0.002
	(0.042)	(0.043)	(0.044)	(0.043)	(0.044)
Contract duration	0.028	0.032	0.035	0.032	0.035
	(0.067)	(0.067)	(0.067)	(0.067)	(0.067)
Patent protection	-0.216	-0.223	-0.216	-0.223	-0.216
	(0.187)	(0.187)	(0.186)	(0.187)	(0.186)
Cross-border deal	0.028	0.023	0.003	0.023	0.003
	(0.165)	(0.165)	(0.165)	(0.165)	(0.165)
Biotech-biotech deal	-0.142	-0.148	-0.160	-0.148	-0.160
	(0.167)	(0.166)	(0.166)	(0.166)	(0.166)
Principal num of prior partnerships	0.040	0.040	0.036	0.040	0.036
	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)
Principal firm size	-0.018†	-0.016	-0.015	-0.016	-0.015
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Principal firm performance	0.023	0.025	0.024	0.025	0.024
	(0.022)	(0.024)	(0.021)	(0.024)	(0.021)
Principal R&D intensity	0.001	0.001	0.000	0.001	0.000
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Principal slack	-0.002	-0.003	-0.002	-0.003	-0.002
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Client num of prior partnerships	0.022	0.023	0.023	0.023	0.023
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Client firm size	-0.009	-0.022	-0.023	-0.022	-0.023
	(0.259)	(0.259)	(0.258)	(0.259)	(0.258)
Client firm performance	0.007	0.007	0.007	0.007	0.007
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Client R&D intensity	0.036	0.031	0.030	0.031	0.030
	(0.026)	(0.027)	(0.027)	(0.027)	(0.027)
Client slack	0.028	0.030	0.029	0.030	0.029
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Constant	-0.460	-0.767	-0.492	-0.395	-0.266
	(1.039)	(1.061)	(1.079)	(1.043)	(1.042)
χ^2	146.30***	148.39***	149.78***	148.39***	149.78***
Log likelihood	-331.4	-330.4	-329.7	-330.4	-329.7
Pseudo R^2	.18	.18	.19	.18	.19

Note: n=305 R&D collaborations. Year and Agreement type dummies included. *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

TABLE 3.9 Logistic regression results for probability of FDA approval

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Unilateral monitoring		-0.454	-2.379**		
		(0.476)	(0.809)		
Bilateral monitoring				0.454	-0.183
				(0.476)	(0.508)
Exploitative R&D		1.589***	0.157		
		(0.463)	(0.651)		
Exploratory R&D				-1.589***	-2.718***
				(0.463)	(0.677)
Unilateral monitoring x Exploitative R&D			2.562**		
			(0.858)		
Bilateral monitoring x Exploratory R&D					2.562**
					(0.858)
Contract length	0.161	0.114	0.165	0.114	0.165
	(0.217)	(0.267)	(0.271)	(0.267)	(0.271)
Incentive payment	-1.926*	-1.528†	-1.546†	-1.528†	-1.546†
	(0.850)	(0.879)	(0.877)	(0.879)	(0.877)
Deal Size	0.112	0.066	0.115	0.066	0.115
	(0.086)	(0.095)	(0.095)	(0.095)	(0.095)
Contract duration	-0.095	-0.136	-0.169	-0.136	-0.169
	(0.170)	(0.168)	(0.185)	(0.168)	(0.185)
Patent protection	0.177	0.180	0.178	0.180	0.178
	(0.370)	(0.396)	(0.406)	(0.396)	(0.406)
Cross-border deal	-0.367	-0.319	-0.307	-0.319	-0.307
	(0.372)	(0.376)	(0.369)	(0.376)	(0.369)
Biotech-biotech deal	1.132**	1.273*	1.237*	1.273*	1.237*
	(0.439)	(0.503)	(0.506)	(0.503)	(0.506)
Principal num of prior partnerships	-0.165†	-0.126	-0.131	-0.126	-0.131
	(0.094)	(0.085)	(0.088)	(0.085)	(0.088)
Principal firm size	0.005	0.006	0.012	0.006	0.012
	(0.022)	(0.021)	(0.021)	(0.021)	(0.021)
Principal firm performance	0.011	0.006	0.006	0.006	0.006
	(0.008)	(0.009)	(0.011)	(0.009)	(0.011)
Principal R&D intensity	0.012*	0.012*	0.011†	0.012*	0.011†
	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
Principal slack	-0.011	-0.006	0.001	-0.006	0.001
	(0.015)	(0.016)	(0.017)	(0.016)	(0.017)
Client num of prior partnerships	-0.018	-0.004	0.000	-0.004	0.000
	(0.036)	(0.040)	(0.039)	(0.040)	(0.039)
Client firm size	0.244	0.069	0.080	0.069	0.080
	(0.580)	(0.649)	(0.588)	(0.649)	(0.588)
Client firm performance	-0.035	-0.034	-0.032	-0.034	-0.032
	(0.021)	(0.022)	(0.020)	(0.022)	(0.020)
Client R&D intensity	0.100*	0.083†	0.089†	0.083†	0.089†
	(0.050)	(0.048)	(0.049)	(0.048)	(0.049)
Client slack	0.029	0.036	0.035	0.036	0.035
	(0.050)	(0.049)	(0.048)	(0.049)	(0.048)
Constant	1.506	1.733	3.747	2.868	4.086
	(1.881)	(2.186)	(2.894)	(2.066)	(2.765)
χ^2	58.39†	97.12***	106.25***	97.12***	106.25***
Log likelihood	-117.9	-110.7	-106.6	-110.7	-106.6
Pseudo R^2	.23	.28	.31	.28	.31

Note: n=280 R&D collaborations. Year and Agreement type dummies included. Robust *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

T A B L E 3.10 Negative binomial regression results for the time to regulatory advancement

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Unilateral monitoring		0.121	0.106		
		(0.087)	(0.139)		
Bilateral monitoring				-0.121	-0.131
				(0.087)	(0.113)
Exploitative R&D		0.583***	0.566***		
		(0.087)	(0.148)		
Exploratory R&D				-0.583***	-0.592***
				(0.087)	(0.106)
Unilateral monitoring x Exploitative R&D			0.025		
			(0.180)		
Bilateral monitoring x Exploratory R&D					0.025
					(0.180)
Contract length	0.037	0.036	0.036	0.036	0.036
	(0058)	(0.036)	(0.054)	(0.036)	(0.054)
Incentive payment	-0.272	-0.127	-0.127	-0.127	-0.127
	(0.208)	(0.189)	(0.189)	(0.189)	(0.189)
Deal Size	0.011	-0.001	0.000	-0.001	0.000
	(0.026)	(0.023)	(0.024)	(0.023)	(0.024)
Contract duration	0.463***	0.470***	0.470***	0.470***	0.470***
	(0.044)	(0.040)	(0.040)	(0.040)	(0.040)
Patent protection	0.145	0.118	0.117	0.118	0.117
	(0.105)	(0.094)	(0.095)	(0.094)	(0.095)
Cross-border deal	0.226*	0.184*	0.183*	0.184*	0.183*
	(0.089)	(0.081)	(0.081)	(0.081)	(0.081)
Biotech-biotech deal	-0.124	-0.129	-0.130	-0.129	-0.130
	(0.090)	(0.081)	(0.082)	(0.081)	(0.082)
Principal num of prior partnerships	0.019	0.011	0.011	0.011	0.011
	(0.018)	(0.016)	(0.016)	(0.016)	(0.016)
Principal firm size	-0.006	-0.003	-0.003	-0.003	-0.003
	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
Principal firm performance	-0.005†	-0.007**	-0.007**	-0.007**	-0.007**
	(0003)	(0.003)	(0.003)	(0.003)	(0.003)
Principal R&D intensity	-0.002	-0.003*	-0.003*	-0.003*	-0.003*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Principal slack	-0.003	-0.003	-0.003	-0.003	-0.003
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Client num of prior partnerships	0.000	0.003	0.003	0.003	0.003
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Client firm size	0.080	-0.049	-0.051	-0.049	-0.051
	(0.141)	(0.128)	(0.128)	(0.128)	(0.128)
Client firm performance	-0.001	0.004	0.004	0.004	0.004
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Client R&D intensity	0.027	0.013	0.013	0.013	0.013
	(0.017)	(0.014)	(0.014)	(0.014)	(0.014)
Client slack	-0.017	-0.016	-0.016	-0.016	-0.016
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Constant	3.791***	3.414***	3.429***	4.118***	4.127***
	(0.535)	(0.496)	(0.508)	(0.485)	(0.489)
χ^2	204.93***	246.81***	246.83***	246.81***	246.83***
Log likelihood	-1339.3	-1318.4	-1318.4	-1318.4	-1318.4
Pseudo R^2	.07	.09	.09	.09	.09

Note: n=200 R&D collaborations. Year and Agreement type dummies included. Robust *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

TABLE 3.11 Censored regression results for the number of indications

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Unilateral monitoring		-0.176	-1.381*		
		(0.435)	(0.643)		
Bilateral monitoring				0.176	-0.723
				(0.435)	(0.559)
Exploitative R&D		1.498***	-0.021		
		(0.424)	(0.734)		
Exploratory R&D				-1.498***	-2.083***
				(0.424)	(0.479)
Unilateral monitoring x Exploitative R&D			2.103*		
			(0.834)		
Bilateral monitoring x Exploratory R&D					2.103*
					(0.834)
Contract length	0.288	0.238	0.284	0.238	0.284
	(0.233)	(0.232)	(0.230)	(0.232)	(0.230)
Incentive payment	-2.032*	-1.640†	-1.572†	-1.640†	-1.572†
	(0.863)	(0.862)	(0.853)	(0.862)	(0.853)
Deal Size	0.247*	0.199†	0.254*	0.199†	0.254*
	(0.110)	(0.109)	(0.110)	(0.109)	(0.110)
Contract duration	-0.220	-0.200	-0.180	-0.200	-0.180
	(0.159)	(0.156)	(0.155)	(0.156)	(0.155)
Patent protection	-0.500	-0.506	-0.469	-0.506	-0.469
	(0.435)	(0.426)	(0.422)	(0.426)	(0.422)
Cross-border deal	-0.170	-0.119	-0.167	-0.119	-0.167
	(0.396)	(0.388)	(0.384)	(0.388)	(0.384)
Biotech-biotech deal	0.949*	0.981*	0.918*	0.981*	0.918*
	(0.395)	(0.387)	(0.384)	(0.387)	(0.384)
Principal num of prior partnerships	-0.106	-0.091	-0.107	-0.091	-0.107
	(0.088)	(0.086)	(0.085)	(0.086)	(0.085)
Principal firm size	0.010	0.011	0.018	0.011	0.018
	(0.026)	(0.025)	(0.025)	(0.025)	(0.025)
Principal firm performance	0.003	0.000	-0.001	0.000	-0.001
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Principal R&D intensity	-0.003	-0.004	-0.006	-0.004	-0.006
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Principal slack	0.020	0.021	0.027	0.021	0.027
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Client num of prior partnerships	-0.037	-0.028	-0.030	-0.028	-0.030
	(0.038)	(0.038)	(0.037)	(0.038)	(0.037)
Client firm size	0.138	-0.001	0.023	-0.001	0.023
	(0.607)	(0.595)	(0.589)	(0.595)	(0.589)
Client firm performance	0.023	0.023	0.025	0.023	0.025
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Client R&D intensity	0.059	0.041	0.041	0.041	0.041
	(0.063)	(0.062)	(0.061)	(0.062)	(0.061)
Client slack	0.079	0.089	0.080	0.089	0.080
	(0.066)	(0.065)	(0.064)	(0.065)	(0.064)
Constant	5.704*	5.384*	6.495 **	6.707**	7.197***
	(2.272)	(2.302)	(2.319)	(2.245)	(2.229)
χ^2	79.23**	91.58**	97.87***	91.58**	97.87***
Log likelihood	-758.9	-752.7	-749.6	-752.7	-749.6
Pseudo R^2	.05	.06	.06	.06	.06

Note: n=305 R&D collaborations. Year and Agreement type dummies included. *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

TABLE 3.12 Censored regression results for the number of target-based actions

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Unilateral monitoring		-0.252	-0.363		
		(0.254)	(0.391)		
Bilateral monitoring				0.252	0.178
				(0.254)	(0.323)
Exploitative R&D		0.365	0.235		
		(0.254)	(0.433)		
Exploratory R&D				-0.365	-0.420
				(0.254)	(0.294)
Unilateral monitoring x Exploitative R&D			0.185		
			(0.498)		
Bilateral monitoring x Exploratory R&D					0.185
					(0.498)
Contract length	0.198	0.165	0.169	0.165	0.169
	(0.131)	(0.133)	(0.133)	(0.133)	(0.133)
Incentive payment	0.187	0.382	0.383	0.382	0.383
	(0.525)	(0.535)	(0.534)	(0.535)	(0.534)
Deal Size	0.112†	0.095	0.100	0.095	0.100
	(0.061)	(0.061)	(0.062)	(0.061)	(0.062)
Contract duration	0.123	0.125	0.128	0.125	0.128
	(0.101)	(0.100)	(0.100)	(0.100)	(0.100)
Patent protection	-0.275	-0.269	-0.265	-0.269	-0.265
	(0.264)	(0.262)	(0.262)	(0.262)	(0.262)
Cross-border deal	0.037	0.055	0.048	0.055	0.048
	(0.237)	(0.236)	(0.236)	(0.236)	(0.236)
Biotech-biotech deal	0.069	0.091	0.085	0.091	0.085
	(0.233)	(0.232)	(0.232)	(0.232)	(0.232)
Principal num of prior partnerships	0.001	0.008	0.006	0.008	0.006
	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)
Principal firm size	-0.012	-0.014	-0.013	-0.014	-0.013
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Principal firm performance	-0.017*	-0.018*	-0.019*	-0.018*	-0.019*
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Principal R&D intensity	-0.006	-0.005	-0.006	-0.005	-0.006
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Principal slack	-0.001	0.000	0.000	0.000	0.000
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Client num of prior partnerships	0.021	0.021	0.021	0.021	0.021
	(0.023)	(0.022)	(0.022)	(0.022)	(0.022)
Client firm size	-0.454	-0.480	-0.481	-0.480	-0.481
	(0.364)	(0.361)	(0.361)	(0.361)	(0.361)
Client firm performance	0.013	0.014	0.013	0.014	0.013
	(0.017)	(0.016)	(0.016)	(0.016)	(0.016)
Client R&D intensity	-0.093	-0.098	-0.098	-0.098	-0.098
	(0.059)	(0.061)	(0.061)	(0.061)	(0.061)
Client slack	0.101**	0.101**	0.100**	0.101**	0.100**
	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)
Constant	-0.997	-0.821	-0.721	-0.708	-0.664
	(1.325)	(1.367)	(1.392)	(1.329)	(1.335)
χ^2	104.20***	107.22***	107.36***	107.22***	107.36***
Log likelihood	-392.3	-390.8	-390.7	-390.8	-390.7
Pseudo R^2	.12	.12	.12	.12	.12

Note: n=305 R&D collaborations. Year and Agreement type dummies included. *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

TABLE 3.13 Regression results for the number of technologies

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Unilateral monitoring		-0.175	-0.235		
		(0.199)	(0.297)		
Bilateral monitoring				0.175	0.130
				(0.199)	(0.259)
Exploitative R&D		0.371†	0.295		
		(0.194)	(0.340)		
Exploratory R&D				-0.371†	-0.400†
				(0.194)	(0.221)
Unilateral monitoring x Exploitative R&D			0.105		
			(0.386)		
Bilateral monitoring x Exploratory R&D					0.105
					(0.386)
Contract length	0.116	0.092	0.094	0.092	0.094
	(0.105)	(0.106)	(0.107)	(0.106)	(0.107)
Incentive payment	-1.280***	-1.141**	-1.138**	-1.141**	-1.138**
	(0.388)	(0.394)	(0.395)	(0.394)	(0.395)
Deal Size	0.041	0.024	0.027	0.024	0.027
	(0.050)	(0.050)	(0.051)	(0.050)	(0.051)
Contract duration	0.033	0.037	0.038	0.037	0.038
	(0.072)	(0.071)	(0.072)	(0.071)	(0.072)
Patent protection	0.091	0.096	0.098	0.096	0.098
	(0.195)	(0.195)	(0.195)	(0.195)	(0.195)
Cross-border deal	0.296†	0.314†	0.312†	0.314†	0.312†
	(0.178)	(0.177)	(0.178)	(0.177)	(0.178)
Biotech-biotech deal	0.127	0.139	0.136	0.139	0.136
	(0.177)	(0.177)	(0.177)	(0.177)	(0.177)
Principal num of prior partnerships	-0.027	-0.023	-0.023	-0.023	-0.023
	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)
Principal firm size	0.001	0.000	0.001	0.000	0.001
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Principal firm performance	-0.003	-0.004	-0.004	-0.004	-0.004
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Principal R&D intensity	0.003	0.003	0.003	0.003	0.003
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Principal slack	-0.001	0.000	0.000	0.000	0.000
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Client num of prior partnerships	-0.013	-0.011	-0.011	-0.011	-0.011
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Client firm size	-0.065	-0.099	-0.098	-0.099	-0.098
	(0.272)	(0.271)	(0.272)	(0.271)	(0.272)
Client firm performance	0.009	0.009	0.010	0.009	0.010
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Client R&D intensity	0.000	-0.002	-0.002	-0.002	-0.002
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Client slack	0.051†	0.052†	0.051†	0.052†	0.051†
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
Constant	2.299*	2.393*	2.449*	2.590*	2.615*
	(1.024)	(1.054)	(1.076)	(1.029)	(1.035)
F	1.39†	1.43*	1.40*	1.43*	1.40*
R^2	.22	.24	.24	.24	.24

Note: n=305 R&D collaborations. Year and Agreement type dummies included. Robust *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

FIGURE 3.2 Average marginal effect of bilateral monitoring on innovative performance in exploratory R&D partnerships.

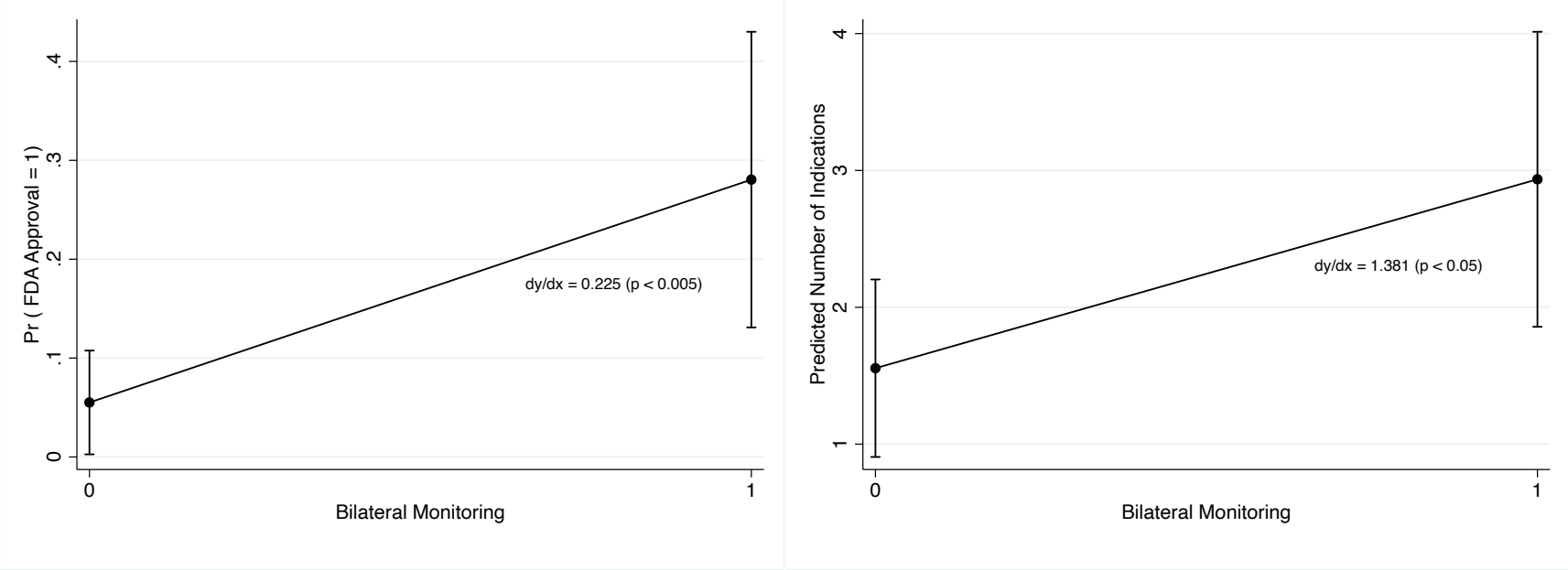


TABLE 3.14 Censored regression results for the products in development

Variables	Model 1	Model 2
Management roles		0.204
		(0.192)
Contract length	-0.021	-0.050
	(0.093)	(0.097)
Incentive payment	-0.815*	-0.803*
	(0.363)	(0.362)
Deal Size	-0.011	-0.019
	(0.042)	(0.043)
Contract duration	0.028	0.032
	(0.067)	(0.067)
Patent protection	-0.216	-0.204
	(0.187)	(0.187)
Cross-border deal	0.028	0.031
	(0.165)	(0.164)
Biotech-biotech deal	-0.142	-0.124
	(0.167)	(0.167)
Principal num of prior partnerships	0.040	0.042
	(0.036)	(0.036)
Principal firm size	-0.018†	-0.019†
	(0.011)	(0.011)
Principal firm performance	0.023	0.023
	(0.022)	(0.023)
Principal R&D intensity	0.001	0.001
	(0.004)	(0.004)
Principal slack	-0.002	-0.002
	(0.007)	(0.007)
Client num of prior partnerships	0.022	0.021
	(0.016)	(0.016)
Client firm size	-0.009	0.009
	(0.259)	(0.258)
Client firm performance	0.007	0.007
	(0.012)	(0.012)
Client R&D intensity	0.036	0.036
	(0.026)	(0.026)
Client slack	0.028	0.027
	(0.026)	(0.026)
Constant	-0.460	-0.505
	(1.039)	(1.034)
χ^2	146.30***	147.42***
Log likelihood	-331.4	-330.9
Pseudo R^2	.18	.18

Note: n=305 R&D collaborations. Year and Agreement type dummies included. *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol.
†p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

TABLE 3.15 Logistic regression results for probability of FDA approval

Variables	Model 1	Model 2
Management roles		-0.199
		(0.379)
Contract length	0.161	0.181
	(0.217)	(0.216)
Incentive payment	-1.926*	-1.930*
	(0.850)	(0.852)
Deal Size	0.112	0.119
	(0.086)	(0.087)
Contract duration	-0.095	-0.097
	(0.170)	(0.170)
Patent protection	0.177	0.158
	(0.370)	(0.371)
Cross-border deal	-0.367	-0.375
	(0.372)	(0.372)
Biotech-biotech deal	1.132**	1.117*
	(0.439)	(0.442)
Principal num of prior partnerships	-0.165†	-0.164†
	(0.094)	(0.094)
Principal firm size	0.005	0.005
	(0.022)	(0.022)
Principal firm performance	0.011	0.011
	(0.008)	(0.008)
Principal R&D intensity	0.012*	0.012*
	(0.005)	(0.005)
Principal slack	-0.011	-0.013
	(0.015)	(0.015)
Client num of prior partnerships	-0.018	-0.016
	(0.036)	(0.037)
Client firm size	0.244	0.235
	(0.580)	(0.582)
Client firm performance	-0.035	-0.035
	(0.021)	(0.022)
Client R&D intensity	0.100*	0.100*
	(0.050)	(0.051)
Client slack	0.029	0.031
	(0.050)	(0.050)
Constant	1.506	1.508
	(1.881)	(1.890)
χ^2	58.39†	58.77†
Log likelihood	-117.9	-117.8
Pseudo R^2	.23	.24

Note: n=280 R&D collaborations. Year and Agreement type dummies included. Robust *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

T A B L E 3.16 Negative binomial regression results for the time to regulatory advancement

Variables	Model 1	Model 2
Management roles		-0.302**
		(0.101)
Contract length	0.037	0.085
	(0058)	(0.060)
Incentive payment	-0.272	-0.218
	(0.208)	(0.206)
Deal Size	0.011	0.023
	(0.026)	(0.026)
Contract duration	0.463***	0.458
	(0.044)	(0.043)
Patent protection	0.145	0.122
	(0.105)	(0.103)
Cross-border deal	0.226*	0.197
	(0.089)	(0.088)
Biotech-biotech deal	-0.124	-0.163
	(0.090)	(0.088)
Principal num of prior partnerships	0.019	0.014
	(0.018)	(0.018)
Principal firm size	-0.006	-0.005
	(0.007)	(0.006)
Principal firm performance	-0.005†	-0.005
	(0003)	(0.003)
Principal R&D intensity	-0.002	-0.002
	(0.002)	(0.002)
Principal slack	-0.003	-0.004
	(0.004)	(0.004)
Client num of prior partnerships	0.000	0.001
	(0.008)	(0.008)
Client firm size	0.080	0.087
	(0.141)	(0.137)
Client firm performance	-0.001	-0.002
	(0.007)	(0.007)
Client R&D intensity	0.027	0.024
	(0.017)	(0.016)
Client slack	-0.017	-0.015
	(0.012)	(0.012)
Constant	3.791***	3.845
	(0.535)	(0.524)
χ^2	204.93***	213.46***
Log likelihood	-1339.3	-1335.1
Pseudo R^2	.07	.07

Note: n=200 R&D collaborations. Year and Agreement type dummies included. Robust *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

T A B L E 3.17 Censored regression results for the number of indications

Variables	Model 1	Model 2
Management roles		-0.782†
		(0.451)
Contract length	0.288	0.389
	(0.233)	(0.239)
Incentive payment	-2.032*	-2.024*
	(0.863)	(0.859)
Deal Size	0.247*	0.275*
	(0.110)	(0.111)
Contract duration	-0.220	-0.228
	(0.159)	(0.159)
Patent protection	-0.500	-0.549
	(0.435)	(0.433)
Cross-border deal	-0.170	-0.196
	(0.396)	(0.394)
Biotech-biotech deal	0.949*	0.909*
	(0.395)	(0.394)
Principal num of prior partnerships	-0.106	-0.110
	(0.088)	(0.087)
Principal firm size	0.010	0.011
	(0.026)	(0.026)
Principal firm performance	0.003	0.004
	(0.016)	(0.016)
Principal R&D intensity	-0.003	-0.005
	(0.009)	(0.009)
Principal slack	0.020	0.017
	(0.018)	(0.018)
Client num of prior partnerships	-0.037	-0.033
	(0.038)	(0.038)
Client firm size	0.138	0.111
	(0.607)	(0.604)
Client firm performance	0.023	0.024
	(0.026)	(0.026)
Client R&D intensity	0.059	0.059
	(0.063)	(0.063)
Client slack	0.079	0.080
	(0.066)	(0.065)
Constant	5.704*	5.864**
	(2.272)	(2.263)
χ^2	79.23**	82.22**
Log likelihood	-758.9	-757.4
Pseudo R^2	.05	.05

Note: n=305 R&D collaborations. Year and Agreement type dummies included. *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol.
†p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

TABLE 3.18 Censored regression results for the number of target-based actions

Variables	Model 1	Model 2
Management roles		0.000
		(0.270)
Contract length	0.198	0.198
	(0.131)	(0.135)
Incentive payment	0.187	0.187
	(0.525)	(0.525)
Deal Size	0.112†	0.112†
	(0.061)	(0.061)
Contract duration	0.123	0.123
	(0.101)	(0.101)
Patent protection	-0.275	-0.275
	(0.264)	(0.264)
Cross-border deal	0.037	0.037
	(0.237)	(0.238)
Biotech-biotech deal	0.069	0.069
	(0.233)	(0.233)
Principal num of prior partnerships	0.001	0.001
	(0.052)	(0.052)
Principal firm size	-0.012	-0.012
	(0.015)	(0.015)
Principal firm performance	-0.017*	-0.017*
	(0.009)	(0.009)
Principal R&D intensity	-0.006	-0.006
	(0.007)	(0.007)
Principal slack	-0.001	-0.001
	(0.011)	(0.011)
Client num of prior partnerships	0.021	0.021
	(0.023)	(0.023)
Client firm size	-0.454	-0.454
	(0.364)	(0.364)
Client firm performance	0.013	0.013
	(0.017)	(0.017)
Client R&D intensity	-0.093	-0.093
	(0.059)	(0.059)
Client slack	0.101**	0.101**
	(0.038)	(0.038)
Constant	-0.997	-0.997
	(1.325)	(1.327)
χ^2	104.20***	104.20***
Log likelihood	-392.3	-392.3
Pseudo R^2	.12	.12

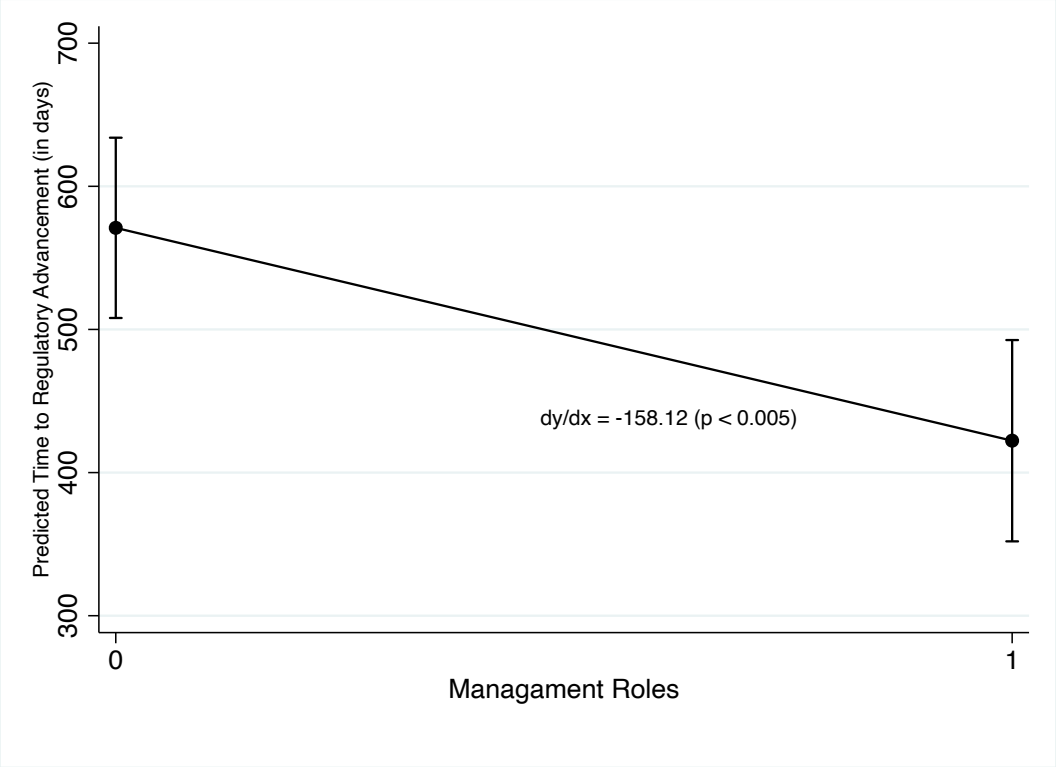
Note: n=305 R&D collaborations. Year and Agreement type dummies included. *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol.
†p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

TABLE 3.19 Regression results for the number of technologies

Variables	Model 1	Model 2
Management roles		0.187
		(0.203)
Contract length	0.116	0.092
	(0.105)	(0.108)
Incentive payment	-1.280***	-1.282***
	(0.388)	(0.389)
Deal Size	0.041	0.034
	(0.050)	(0.050)
Contract duration	0.033	0.035
	(0.072)	(0.072)
Patent protection	0.091	0.104
	(0.195)	(0.196)
Cross-border deal	0.296†	0.302†
	(0.178)	(0.178)
Biotech-biotech deal	0.127	0.136
	(0.177)	(0.178)
Principal num of prior partnerships	-0.027	-0.026
	(0.039)	(0.039)
Principal firm size	0.001	0.001
	(0.012)	(0.012)
Principal firm performance	-0.003	-0.003
	(0.007)	(0.007)
Principal R&D intensity	0.003	0.003
	(0.004)	(0.004)
Principal slack	-0.001	0.000
	(0.008)	(0.008)
Client num of prior partnerships	-0.013	-0.014
	(0.017)	(0.017)
Client firm size	-0.065	-0.061
	(0.272)	(0.272)
Client firm performance	0.009	0.009
	(0.012)	(0.012)
Client R&D intensity	0.000	0.000
	(0.028)	(0.028)
Client slack	0.051†	0.051†
	(0.030)	(0.030)
Constant	2.299*	2.259*
	(1.024)	(1.025)
F	1.39†	1.38†
R^2	.22	.23

Note: n=305 R&D collaborations. Year and Agreement type dummies included. Robust *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

FIGURE 3.3 Average marginal effect of management roles on innovative performance in R&D partnerships.

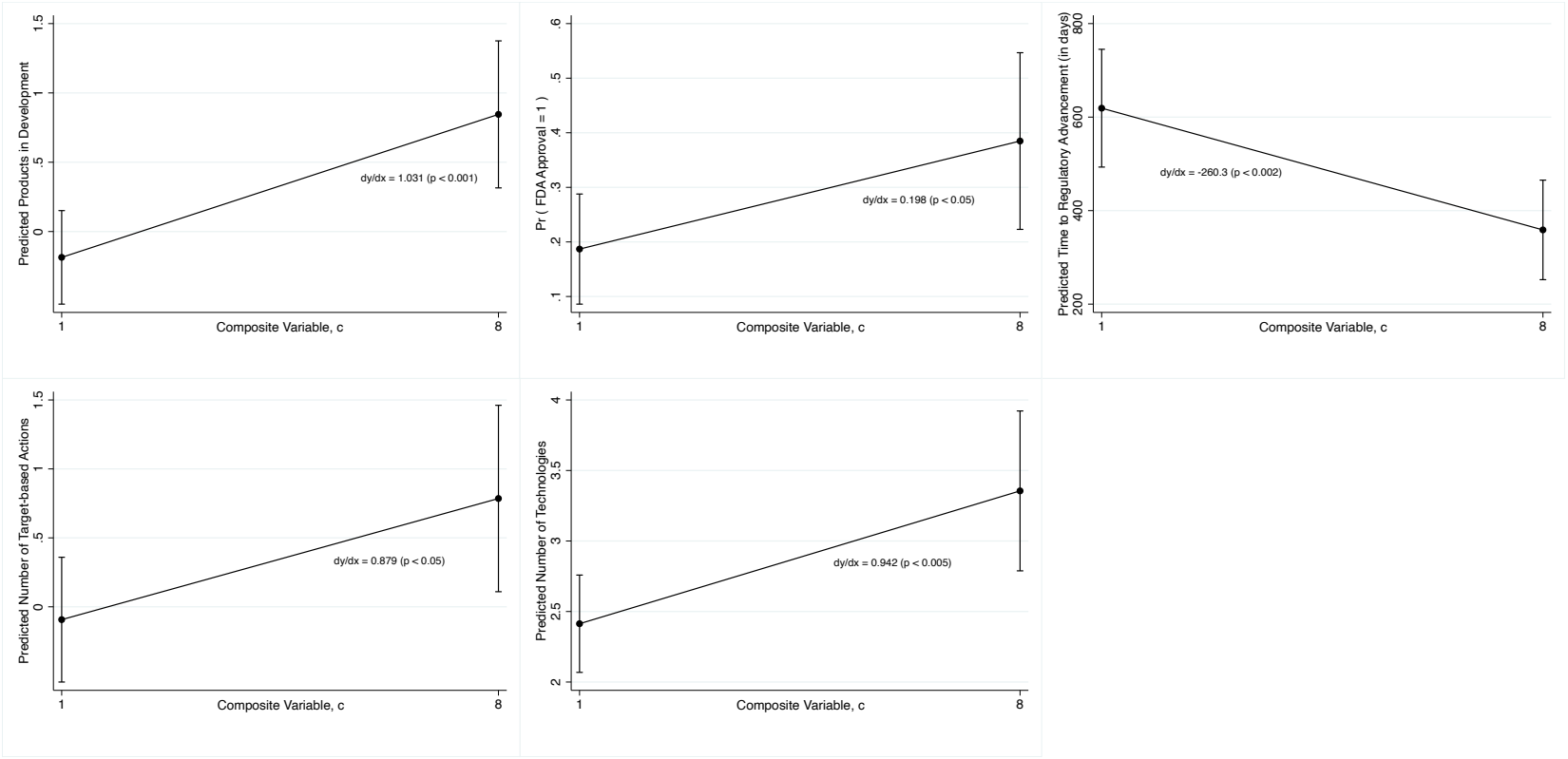


T A B L E 3.20 Results of "dual states" of composite variable, *c*, in exploitative R&D collaborations

Dependent Variable	**Products in Dev.**	**FDA Approval**	**Time to Reg. Adv.**	**Number of Ind.**	**Number of Targets**	**Number of Tech.**
Function	Censored regression	Logistic regression	Negative binomial regression	Censored regression	Censored regression	Regression
1.c x 1.Exploitative R&D	-0.334	-0.669	0.281†	0.454	0.212	-0.179
	(0.313)	(0.755)	(0.158)	(0.759)	(0.431)	(0.340)
8.c x 1.Exploitative R&D	1.595**	1.532†	-0.662*	2.518*	1.855**	1.583**
	(0.507)	(0.888)	(0.327)	(1.220)	(0.661)	(0.546)
Contract length	0.021	0.192	0.027	0.319	0.225†	0.143
	(0.091)	(0.218)	(0.057)	(0.232)	(0.130)	(0.104)
Incentive payment	-0.899*	-2.050*	-0.210	-2.113*	0.089	-1.362***
	(0.353)	(0.855)	(0.206)	(0.860)	(0.521)	(0.385)
Deal Size	-0.017	0.108	0.008	0.239*	0.107†	0.035
	(0.041)	(0.091)	(0.025)	(0.110)	(0.060)	(0.049)
Contract duration	0.038	-0.079	0.457***	-0.213	0.134	0.040
	(0.065)	(0.172)	(0.044)	(0.158)	(0.100)	(0.071)
Patent protection	-0.139	0.211	0.161	-0.480	-0.245	0.124
	(0.183)	(0.366)	(0.104)	(0.433)	(0.262)	(0.193)
Cross-border deal	0.039	-0.332	0.201*	-0.082	0.102	0.328†
	(0.160)	(0.379)	(0.088)	(0.396)	(0.237)	(0.177)
Biotech-biotech deal	-0.127	1.190**	-0.140	0.914*	0.037	0.122
	(0.161)	(0.431)	(0.088)	(0.394)	(0.231)	(0.175)
Principal num of prior partnerships	0.046	-0.149	0.019	-0.091	0.014	-0.020
	(0.035)	(0.092)	(0.018)	(0.087)	(0.052)	(0.039)
Principal firm size	-0.015	0.008	-0.005	0.014	-0.009	0.003
	(0.010)	(0.024)	(0.006)	(0.026)	(0.015)	(0.011)
Principal firm performance	0.021	0.011	-0.006†	0.002	-0.018*	-0.003
	(0.018)	(0.008)	(0.003)	(0.016)	(0.009)	(0.007)
Principal R&D intensity	0.001	0.012*	-0.002	-0.003	-0.006	0.003
	(0.004)	(0.005)	(0.002)	(0.009)	(0.007)	(0.004)
Principal slack	-0.001	-0.010	-0.003	0.020	-0.001	0.000
	(0.007)	(0.015)	(0.004)	(0.018)	(0.010)	(0.008)
Client num of prior partnerships	0.020	-0.018	0.000	-0.031	0.025	-0.011
	(0.015)	(0.036)	(0.008)	(0.038)	(0.022)	(0.017)
Client firm size	0.070	0.389	0.085	0.065	-0.493	-0.038
	(0.255)	(0.585)	(0.142)	(0.615)	(0.368)	(0.274)
Client firm performance	0.006	-0.037†	-0.001	0.021	0.012	0.007
	(0.012)	(0.022)	(0.007)	(0.026)	(0.016)	(0.012)
Client R&D intensity	0.038	0.108*	0.028†	0.067	-0.083	0.004
	(0.025)	(0.053)	(0.016)	(0.063)	(0.058)	(0.028)
Client slack	0.030	0.032	-0.017	0.079	0.100**	0.053†
	(0.025)	(0.050)	(0.012)	(0.065)	(0.038)	(0.029)
Constant	-0.907	0.957	4.094***	5.204*	-1.463	1.945†
	(1.018)	(1.883)	(0.546)	(2.272)	(1.330)	(1.017)
N	305	280	200	305	305	305
Test Statistic (χ^2, F)	157.35***	63.53*	211.91***	83.68**	112.20***	1.54*
Log likelihood	-325.9	-116.1	-1335.8	-756.7	-388.3	
Model Fit (Pseudo R^2, R^2)	.19	.25	.07	.05	.13	.25

Note: Composite variable, *c*, where *c* = 1 (Direct oversight = 0; Unilateral monitoring = 0; Management roles = 0) and *c* = 8 (Direct oversight = 1; Unilateral monitoring = 1; Management roles = 1). Year and Agreement type dummies included. Robust *SE* are reported in parentheses. †p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

FIGURE 3.4 Average marginal effect of two states of composite variable, *c*, on innovative performance in exploitative R&D partnerships.



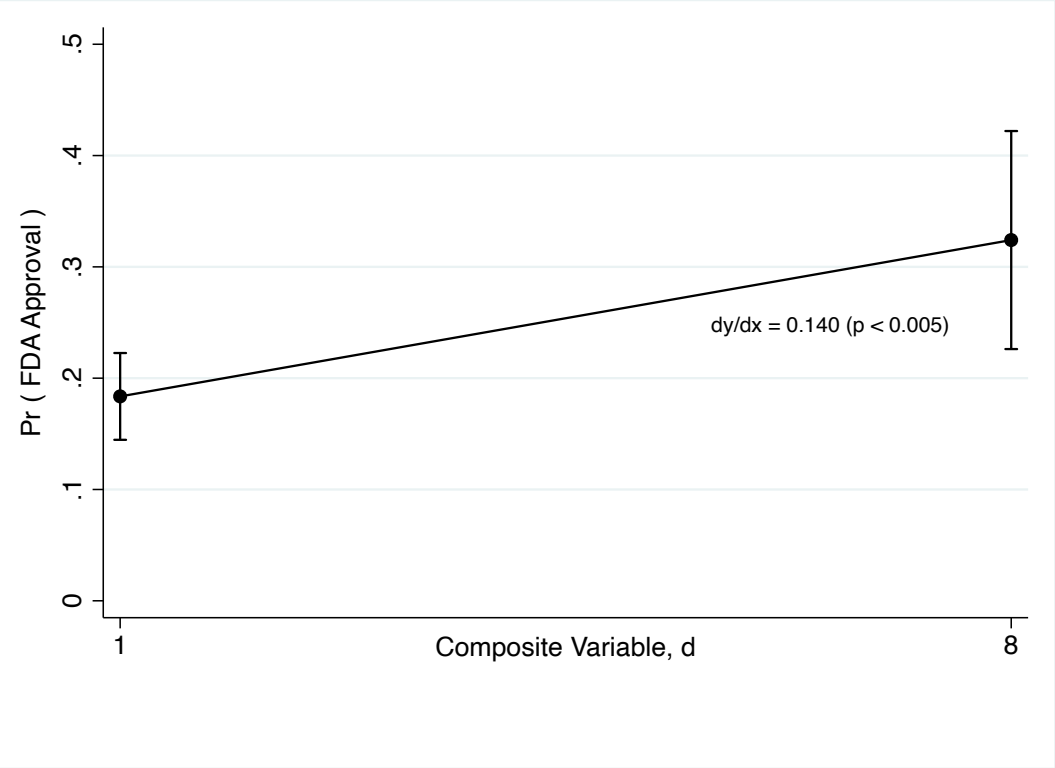
Note: *c* =1 (direct oversight =0, unilateral monitoring =0, management roles =0).
c = 8 (direct oversight =1, unilateral monitoring =1, management roles =1).

T A B L E 3.21 Results of "dual states" of composite variable, *d*, in exploratory R&D collaborations

Dependent Variable	**Products in Dev.**	**FDA Approval**	**Time to Reg. Adv.**	**Number of Ind.**	**Number of Targets**	**Number of Tech.**
Function	Censored regression	Logistic regression	Negative binomial regression	Censored regression	Censored regression	Regression
1.d x 1.Exploratory R&D	-0.317	-2.617†	-0.328*	-1.202*	-0.434	-0.551*
	(0.264)	(1.17)	(0.146)	(0.594)	(0.382)	(0.267)
8.d x 1.Exploratory R&D	0.324	1.039	-0.660***	-1.378	-0.536	-0.678
	(0.391)	(0.695)	(0.195)	(0.979)	(0.580)	(0.438)
Contract length	-0.041	0.087	0.015	0.178	0.163	0.066
	(0.095)	(0.236)	(0.059)	(0.236)	(0.134)	(0.107)
Incentive payment	-0.798*	-2.077*	-0.212	-1.915*	0.248	-1.225**
	(0.362)	(0.861)	(0.203)	(0.857)	(0.526)	(0.386)
Deal Size	-0.008	0.125	0.006	0.241*	0.107†	0.037
	(0.042)	(0.085)	(0.025)	(0.110)	(0.061)	(0.049)
Contract duration	0.029	-0.081	0.468***	-0.231	0.123	0.027
	(0.067)	(0.169)	(0.043)	(0.158)	(0.100)	(0.071)
Patent protection	-0.202	0.254	0.138	-0.509	-0.277	0.085
	(0.187)	(0.402)	(0.101)	(0.432)	(0.263)	(0.194)
Cross-border deal	0.009	-0.404	0.205*	-0.146	0.037	0.309†
	(0.165)	(0.377)	(0.087)	(0.393)	(0.238)	(0.177)
Biotech-biotech deal	-0.147	0.992*	-0.118	0.926*	0.059	0.118
	(0.166)	(0.446)	(0.087)	(0.392)	(0.233)	(0.176)
Principal num of prior partnerships	0.038	-0.159†	0.017	-0.105	0.002	-0.026
	(0.036)	(0.092)	(0.018)	(0.087)	(0.052)	(0.039)
Principal firm size	-0.017	0.011	-0.007	0.011	-0.012	0.001
	(0.011)	(0.022)	(0.006)	(0.026)	(0.015)	(0.011)
Principal firm performance	0.023	0.012	-0.004	0.005	-0.017†	-0.002
	(0.022)	(0.008)	(0.003)	(0.016)	(0.009)	(0.007)
Principal R&D intensity	0.001	0.011	-0.003†	-0.005	-0.006	0.002
	(0.004)	(0.005)	(0.002)	(0.009)	(0.007)	(0.004)
Principal slack	-0.002	-0.006	-0.005	0.016	-0.002	-0.003
	(0.007)	(0014.)	(0.004)	(0.018)	(0.011)	(0.008)
Client num of prior partnerships	0.021	-0.021	0.000	-0.042	0.019	-0.015
	(0.016)	(0.038)	(0.008)	(0.038)	(0.022)	(0.017)
Client firm size	-0.032	0.107	0.062	0.148	-0.438	-0.055
	(0.258)	(0.553)	(0.138)	(0.603)	(0.364)	(0.271)
Client firm performance	0.008	-0.023	-0.002	0.022	0.013	0.009
	(0.012)	(0.019)	(0.007)	(0.026)	(0.017)	(0.012)
Client R&D intensity	0.037	0.103*	0.022	0.050	-0.095	-0.004
	(0.026)	(0.051)	(0.016)	(0.063)	(0.060)	(0.028)
Client slack	0.028	0.031	-0.016	0.093	0.104**	0.057†
	(0.026)	(0.050)	(0.012)	(0.065)	(0.038)	(0.029)
Constant	2.729	0.957	3.806 ***	6.442**	-0.820	2.636*
	(2.122)	(1.883)	(0.521)	(2.286)	(1.339)	(1.032)
N	305	280	200	305	305	305
Test Statistic (χ^2, F)	69.23***	63.53*	218.37***	84.73**	106.22***	1.47*
Log likelihood	-330.3	-112.7	-1332.6	-756.2	-391.3	
Model Fit (Pseudo R^2, R^2)	.18	.27	.08	.05	.12	.24

Note: Composite variable, *d*, where *d* = 1 (Joint oversight = 0; Bilateral monitoring = 0; Management roles = 0) and *d* = 8 (Joint oversight = 1; Bilateral monitoring = 1; Management roles = 1). Year and Agreement type dummies included. Robust *SE* are reported in parentheses. Two-tailed *p*-values indicated by symbol.
†p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001.

FIGURE 3.5 Average marginal effect of two states of composite variable, *d*, on innovative performance in exploratory R&D partnerships.



Note: *d* =1 (joint oversight =0, bilateral monitoring =0, management roles =0).
d =8 (joint oversight =1, bilateral monitoring =1, management roles =1).

T A B L E 3.22 Summary table of significant AME findings of contract design elements

		Dependent Variable	Products in Dev.	FDA Approval	Time to Reg. Adv.	Number of Ind.	Number of Targets	Number of Tech.
Hypothesis	**IV – Contract Design Element**	**R&D Type**						
H1a	Direct oversight	Exploitative		Yes	Yes			
H1b	Joint oversight	Exploratory						
H2a	Unilateral monitoring	Exploitative						
H2b	Bilateral monitoring	Exploratory		Yes		Yes		
H3	Management roles	Both			Yes			
H4a	Contract states	Exploitative	Yes	Yes	Yes		Yes	Yes
H4b	Contract states	Exploratory		Yes				