Safeguarding from the Sharks:
Board Representation in Minority Equity Partnerships

ABSTRACT

We study minority equity partnerships and the representation of investing firms on the boards of directors of their partners. In such alliances, an investor firm owns a minority position in the investee partner, and may or may not secure a board seat. Prior alliance governance research has largely focused on the choice between equity and non-equity forms of alliances, and has paid little attention to the particular administrative features of these organizational forms (e.g., governing boards). We extend corporate governance research that has emphasized the monitoring and advisory roles of boards by examining how an investee's concerns about knowledge misappropriation can reduce the likelihood an investor obtains board representation. We suggest that although there exist opportunities for an investee to benefit from the investor's advice, the investor's ability to use an investee's knowledge by itself, and indirectly with the help of its other partners, negatively affect the likelihood of a board seat for the investor. We further argue that this negative effect is amplified when the investee has particularly valuable technologies at risk of appropriation by the investor. Our evidence from minority equity partnerships in the biopharmaceutical industry indicates why and when investors often do not obtain board seats despite the monitoring and advisory benefits that directors can bring to cooperative commercialization agreements.

INTRODUCTION

Interorganizational relationships enable firms to overcome resource constraints and quickly access technological, human or financial inputs (e.g., Ahuja, 2000; Katila, Rosenberger and Eisenhardt, 2008) and play an important part in the innovation strategy of firms in high-technology sectors (Dushnitsky and Lenox, 2005a; Anand, Oriani and Vassolo, 2010). It is well recognized, however, that interorganizational arrangements face substantial collaborative challenges, which require a suitable means to organize and govern the joint activities (Gulati *et al.*, 2005; Gulati and Singh, 1998). To fulfill these purposes, firms can support the exchange by a contract, or by a contract combined with an equity exchange as in a minority equity partnership (Pisano, 1989). Each of these archetypes of interorganizational relationships entails a rich array of design choices for the partners to deal with various collaboration challenges they potentially encounter.

In broad terms, partners can incorporate various formal governance design elements as contractual or organizational features that promote cooperation. For example, recent research has documented and analyzed several aspects of the architecture of contracts such as pay-off structures, contingency planning, technical task descriptions, and control rights, among other facets of collaborative agreements (Adegbesan and Higgins, 2011; Argyres *et al.*, 2007; Parkhe 1993b; Poppo and Zenger, 2002; Vanneste and Puranam, 2010). This research, however, has not paid adequate attention to other formal governance mechanisms enabling firms to govern their relationships *ex post*. In particular, organizational features such as governing boards and the structuring and staffing of the collaboration provide hierarchical controls, and they also assist in monitoring partner behavior to facilitate collaboration across organizational boundaries. These control mechanisms at various organizational levels shape how resources are deployed as well as how partners reconcile differences in objectives, access and evaluate information, and resolve conflicts.

A primary hierarchical control mechanism in equity alliances is the board of directors (Geringer and Hebert, 1989; Pisano, 1989). In minority equity relationships, the board of the investee firm represents the highest level at which partners can interface with each other to manage strategic interdependencies and information flows between them (Kumar and Seth, 1998). Because the board approves business plans, capital investment and other budgetary decisions, representation on the investee board allows the investor to monitor and offer advice about resource commitments and activities of the investee partner (Garcia-Canal, 1996; Yan and Gray, 1994). Investors taking minority equity positions may or may not secure board seats with either voting rights or observational rights to gain knowledge about the venture or liaise with it (Dushnitsky and Lenox, 2006; Maula, Autio, and Murray, 2009). Therefore, the board is a key governance instrument for the partners to exercise organizational control and ensure realization of collaborative benefits.

The aforementioned benefits of board level oversight in equity alliances relate to improving the cooperative side of the relationship. However, offering a position to the investor partner at the highest organizational level also presents an investee partner with some important potential downsides. By allowing board representation for the investor firm, investee firms may risk the possibility of exposure of strategic information and imitation, which can adversely affect the value of the firm's technological knowledge and harm future its market prospects (Katila, Rosenberger, and Eisenhardt, 2008; Dushnitsky and Shaver, 2009). Thus, despite the monitoring and advisory benefits of directors emphasized in corporate governance research, board representation can also make the investee firm vulnerable to misappropriation hazards. Although some recent studies have examined the impact of these knowledge leakage considerations on the formation of collaborative agreements (e.g., Diestre and Rajagopalan, 2012), we know little about how partners elect to structure boards to govern equity alliances in the face of these problems.

In this study, we investigate how knowledge leakage concerns faced by the investee partner affect board level monitoring in equity alliances. Specifically, we focus on minority equity partnerships in biopharmaceuticals and address the following research question: How does an investor firm's ability to take advantage of the knowledge position of the investee partner affect board representation in minority equity partnerships? Minority equity partnerships are equity alliances in which one firm buys an equity stake (less than 50 percent) in the partner firm. Established corporations often partner with new ventures by taking a minority interest in a new venture (Gompers and Lerner, 1998). Unlike joint ventures that are also equity alliances, in the case of minority equity partnerships no separate legal entity is created, so the investee partner becomes the main site of collaborative activity. Prior research suggests that the ability of equity alliances to mitigate opportunism stems from the incentive alignment that the equity investment provides and the superior monitoring that the board facilitates (Pisano, 1989). Our study complements this work by considering sources of partner opportunism by the investor that might influence whether the investor secures a seat on the investee partner's board.

We employ concepts from organizational economics to investigate the determinants of board representation by the investor. Specifically, we rely on the discriminating alignment hypothesis of transaction cost theory to identify transaction conditions that have an impact on the choice of administrative controls (Williamson, 1991). We also build on corporate governance research that suggests boards perform monitoring and advisory functions for the benefit of the investors and the managers (Westphal and Carpenter, 2001; Adams and Ferreira, 2007). However, we build upon and extend this research by emphasizing that board representation provides the investor with access to information on the investee partner's key resources, so representation on the investee's board can also increase knowledge leakage concerns in certain circumstances (e.g., Pahnke, McDonald, Wang, and Hallen, 2014). Accordingly, we argue that the investor's ability to opportunistically gain from using the information by itself, or with the help of other partners, can negatively influence the investee partner's expectations about the value of offering board representation to the investor.

R&D collaborations in biotechnology provide a fertile context for examining our research question. Alliances between pharmaceutical firms and biotechnology firms have been the principal vehicles for organizing drug discovery and development (Robinson and Stuart, 2007a). In this context, the contracting environment has provided an interesting and appropriate setting for examining administrative responses to monitoring problems, given that the process of drug discovery and development is highly uncertain and opaque to third-party verification. In such collaborations, firms are also subject to hazards presented by opportunism, mainly from misappropriation of valuable knowledge, and they rely on formal and relational governance mechanisms to support their collaborative agreements (Diestre and Rajagopalan, 2012). Our empirical analysis reveals that greater overlap of an investee's technologies with the investor as well the investor's on-going alliances with competitors of the investee reduce the likelihood of board seats for the investor. In addition, these relations are magnified when the investee has particularly valuable technologies at risk of appropriation. Thus, while board representation by investors can offer certain benefits to investees and their collaborations that we consider, the findings shed light on the potential downsides of such representation to investees.

This study contributes to the alliance governance literature by expanding research into administrative mechanism choices in equity alliances. First, by revealing a systematic relationship between board level governance choices and alliance characteristics, we show that boards are not only important instruments for addressing collaborative concerns in equity alliances, but boards themselves can present exchange hazards to partners. Our paper therefore complements recent research on formal governance in alliances that has emphasized contractual safeguards and the role of partner incentives. Second, our study also extends the corporate governance literature that investigates agency concerns and the need for managerial monitoring as key determinants of board structure in unitary corporate forms. In particular, our findings suggest that board composition may also be determined by exchange hazards such as misappropriation concerns and differences in objectives across partners in equity alliances. Finally, our findings can also inform the broader literature on minority investments, including corporate venture capital, by identifying some antecedent conditions of board representation and the hazards that these collaborations can face (e.g., Dushnitsky and Shaver, 2009; Maula *et al.*, 2009).

BACKGROUND LITERATURE

Contracting problems are endemic to R&D agreements between firms (Aghion and Tirole, 1994), and the risk of partner opportunism and misappropriation in particular can therefore render interfirm exchange inefficient. From a transaction cost perspective, a variety of hybrid organizational forms along the market-hierarchy continuum arise in response to contracting problems in collaborative R&D activity. As per the discriminating alignment hypothesis (Williamson, 1991), transaction characteristics must be aligned with characteristics of the organization form chosen, in order to govern the transaction efficiently. Specifically, the need for coordinated adaptation, incentive alignment and monitoring determine the choice of governance mode. Building on transaction cost theory, prior research has argued that equity based hierarchical modes, including minority equity partnerships, support exchange in R&D alliances by aligning incentives and by providing administrative controls (Pisano, 1989).

An important mechanism for exercising administrative control is membership on the board of directors. The board of directors is a central element of the governance structure of the firm (Baysinger and Hoskisson, 1990; Fama and Jensen, 1983). It is a mechanism that safeguards the interests of the shareholders who are exposed to a threat of expropriation from managers and others (Williamson, 1984). Among the several functions the board serves, two broad categories of their roles are control and advice (Dalton *et al.*, 1998; Zahra and Pearce, 1989). The control function entails monitoring management on behalf of investors, approving decisions like major investments and acquisitions that shape the strategic direction of the firm, and overseeing risk management of the firm and executive compensation (Fama and Jensen, 1983; Tirole, 2006). Positioned at the apex of the decision hierarchy of the firm, the board safeguards shareholders' interests through ratification and monitoring of decisions initiated and implemented by managers (Fama and Jensen, 1983). From the perspective of the partnership, these control functions of boards enable the investing partner to protect its interests and specifically oversee the collaborative activities. The advisory function entails providing counsel to the CEO and the top management team in formulating and implementing strategy by drawing on board members' expertise and understanding of the general environment and the specific business problems the firm faces (Adams and Ferreira, 2007; Baysinger and Butler, 1985).

Corporate governance research has investigated the size as well as composition of corporate boards, with special emphasis given to the enhanced monitoring and advice provided by outside directors. For instance, theoretical and empirical research in this literature emphasizes that the informational requirements for providing oversight determine the structure of boards (Adams and Ferreira, 2007; Hermalin and Weisbach, 1998; Raheja, 2005). Accordingly, the complexity of operations of the firm or the extent of private benefits managers might enjoy determine the composition of boards (Boone *et al.*, 2007; Coles *et al.*, 2008; Linck *et al.*, 2008). This broad idea implies that board structure is endogenous to the board's information needs for directing managerial action and mitigating managerial opportunism in light of the costs that monitoring entails (Hermalin and Weisbach, 2003). The information and control properties of boards allow board members to fulfill monitoring as well as advisory functions for the managers of the firm (Carpenter and Westphal, 2001; Adams, Hermalin and Weisbach, 2009). For instance, the guidance from the board of directors can particularly benefit new ventures and newly-public firms in overcoming any inexperience in dealing with the challenges of navigating new product launches, financial market access, and regulatory hurdles (Rosenstein, 1988; Field, Lowry, and Mkrtchyan, 2013). Board membership also serves as a link between the senior management of both the firms which can facilitate access to partner resources and the resolution of disputes (Ivanov and Xie, 2010).

Despite these and other benefits to the partnering firms, board membership can also come at a significant cost to investee firms. These costs stem from the investor harboring commercial interests which diverge from the investee, and the investor is in a position to take advantage of its board representation by either deliberately directing the investee in a direction which limits the investee's growth prospects, or by misappropriating the investee's technology. While the investor may not gain a substantial ability to steer the investee in specific ways merely by its limited equity stake and presence on the board, it can use the opportunity to educate itself about the investee's technology and commercial prospects. By making activities within and beyond the confines of the collaboration transparent to the investing firm, the investee firm also risks leakage of competitively material information (Alvarez and Barney, 2001; Dushnitsky and Shaver, 2009). The strategy of the investee firm as well as its trade secrets can become exposed at the board level, and can result in wider dissemination not only within the investor firm but also to its other affiliates (Pahnke, McDonald, Wang, and Hallen, 2015). Given these threats of misappropriation for the investee partner, the decision to allow board representation for the investor may follow from a consideration of the net benefits to the partnership. Applying the discriminating alignment hypothesis to the choice of this administrative mechanism, below we identify several transaction attributes that have been associated with a substantive increase in the threat of misappropriation, so we expect that they will, all else equal, reduce the likelihood that the investor secures a seat on the investee partner's board.

RESEARCH HYPOTHESES

While representation by an investor on an investee partner's board can facilitate monitoring and the provision of advice to management on technology commercialization and other strategic matters (e.g., Ahuja, 2001; Rothaermel and Boeker, 2008; Diestre and Rajagopalan, 2012), board representation also can increase the threat of opportunistic behavior faced by the investee partner, as we have suggested. This threat is apt to be more significant under specific conditions that are the focus of our hypotheses development, and our core proposition is that investee firms will be less willing to grant a board seat to investors when substantial threats of misappropriation are anticipated due to the exposure of critical information. Our starting premise for hypothesis development is that investors vary in their ability to exploit any information gained from privileged access to board-level information and decision-making. Specifically, in the hypotheses developed below, we tie the appropriation risk faced by the investee to the investor's ability to appreciate and absorb the investee's technological knowledge as well as the investor's participation in competing R&D collaborations in the same technological domain. We also develop the prediction that these problems magnify when the investor's incentive to appropriate is greater owing to the value of the technological knowledge possessed by the investee partner.

Technology Overlap

The starting point of our argument about the effect of technology overlap is that investee firms are likely to consider both the benefits and the cost of committing a board seat to the investor as a part of the governance structure of the minority equity partnership. Boards of directors serve shareholders in exerting decision control over managers by helping to select projects that enhance the long-term value of the firm (Fama & Jensen, 1983). Selection of valuable projects partly depends on how board members can apply their expertise in helping managers of the investee firm screen new ideas that require efficient deployment of human and financial capital, which are already in short supply for investee firms (Lerner et al., 2003). Having a board representative from the investor can be particularly beneficial because alliance relationships account for a significant portion of the value of investee firms, and any advice that enhances strategic alignment with the investor and helps unlock complementarities can have a substantive impact on the value of the investee (Das, Sen and Sengupta, 1998; Nicholson, Danzon and McCullough, 2005). However, the extent to which the investee can derive such benefits is influenced by whether the investor and its representatives possesses the relevant knowledge to provide useful counsel in project selection and execution leading up to technology commercialization. Accordingly, at low levels of overlap, board membership for the investor may not yield many advisory benefits for the investee or the partnership because of the lack of relevant knowledge in the technology domain of the collaboration. As the investor's shared expertise increases with technology overlap, it will enable the investor to productively serve the advisory role and bring benefits to the partnership and the investee firm.

Counteracting these advisory benefits, the threat of misappropriation may also increase with the extent to which the investee partner's knowledge is related to and overlaps with that of the investor partner. Minority equity relationships are frequently the sources of strategic synergies for the investors (Hellmann, 2002). For example, an investor may attempt to accelerate ongoing R&D projects, seek experimental beds for breakthrough innovation (Ahuja and Lampert, 2001), or gain a window on closely related emerging technologies (Dushnitsky and Lenox, 2006). The investor can realize the synergies by quickly absorbing the knowledge and effectively utilizing it (Gompers and Lerner, 1998). Greater familiarity of the investor with the investee's core technological base heightens the threat of opportunistic absorption and utilization in order to gain private benefits (Khanna, Gulati and Nohria, 1998; Alvarez and Barney, 2001). These conditions are particularly threatening to investee partners that are entrepreneurial ventures, which may not be able to defend themselves either because their knowledge is weakly protected (Dushnitsky and Lenox, 2005a; Dushnitsky and Shaver, 2009) or because they lack strong defense mechanisms (Katila *et al.*, 2008).

In settings where investees face non-trivial appropriation concerns (e.g., R&D partnerships in high tech domains), two different possibilities theoretically exist for the relationship between the likelihood of board seat and overlap in technological resources. It is possible that although advisory benefits exceed appropriation costs for all levels of overlap, the rate at which misappropriation costs increase at high levels of overlap far exceed the rate of increase in advisory benefits. Under such conditions, the net benefits are likely to take an inverted-U shaped profile (see Figure 1).[i] To the extent that investee firms employ net benefit calculus to make the decision, we expect the likelihood of board representation for the investor to also follow an inverted-U shaped relationship with investor technology overlap. We thus hypothesize:

Hypothesis 1a: *The likelihood an investor has a board seat in a minority equity partnership will follow an inverted-U shaped relationship with the overlap of the partners' technological resources.*

It is also possible that the appropriation costs increase with overlap at a very high rate and even offset any advisory benefits, holding other things constant. Representation by the investor on the investee partner's board can severely escalate the appropriation threats and related costs for the investee for several reasons. Because the board is the apex decision body of the organization (Fama and Jensen, 1983), a board seat for the investor provides strategic insight into the technological know-how as well as its product market potential. An investor with greater familiarity with the investee partner's technologies is more likely to experience such insight and effectively utilize it (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998) to imitate or even race ahead of the investee firm (Khanna *et al.*, 1998), and this can erode any competitive advantage of the investee firm. In addition, although a board seat for the investor may provide limited control over the investee's investments, policies, and overall strategic direction, it does provide a systematic means to access information and know-how that can be opportunistically exploited by the investor. Finally, a board level role for an investor may also threaten other potential partners with the leakage of sensitive information, thus foreclosing potential collaboration opportunities that the investee partner might have (Park and Steensma, 2012). Inasmuch as the threat of knowledge misappropriation rises when the technological resource endowments of the investor and investee are more similar, and board representation provides a means by which the investor obtains access to proprietary knowledge of the investee partner, the investee partner is less willing to grant board membership to the investor firm during the course of alliance negotiations (see Figure 2). Thus, we posit:

Hypothesis 1b: The likelihood an investor has a board seat in a minority equity partnership will decrease with the overlap of the partners' technological resources.

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Competing Collaborations by the Investor

In developing the foregoing hypothesis, we considered the potential threat of erosion of an investee partner's value that arises from the absorption and utilization of its proprietary information by the investor. A second set of leakage concerns stems from the collaborative agreements the investor maintains with other firms that already compete with, or can become potential competitors of, the investee partner. Such ties not only provide a different source of misappropriation risks but are less likely to directly shape the advisory benefits afforded to the investee firm. More specifically, because interorganizational relationships facilitate learning and serve as conduits for the transfer of information and knowledge (Mowery, Oxley and Silverman, 1996; Gomes-Casseres, Hagedoorn and Jaffe, 2006; Wadhwa, Phelps and Kota, 2016), an investor's collaborative agreements with competitors can significantly harm the prospects and innovation outcomes of the investee partner.

The alliances the investor firm has entered into with other firms can increase the risk of widespread diffusion of any sensitive and proprietary knowledge of the investee partner, which was exposed to the investor during the course of periodic interactions at the board level. That is, even if the investor may not possess the necessary capabilities to independently take advantage of the information it learns from the investee partner, it can opportunistically re-direct such information to other partner firms that are positioned to jointly generate benefits for the investor. Moreover, a first-order concern of the investee firm is that it has limited control over how information gets shared through intra-organizational interactions and inter-organizational collaborations, so spillovers can arise to other partners of the investor. Considering these potential avenues through which strategic information and knowledge can spread to other firms, the investee partner can better regulate the outward spillovers by limiting access to privileged information to the investor partner. Faced with these risks, the investee partner will have a preference to not grant board membership to an investor, whereas the investee partner would have an interest in obtaining some of the advice or other benefits of board membership by the investor when the risk of such spillovers is lower. We therefore hypothesize:

Hypothesis 2: *The likelihood an investor has a board seat in a minority equity partnership will decrease with the number of the investor's collaborative agreements with potential competitors to the investee partner.*

Knowledge Value and Competitive Leakage Concerns

The previous two hypotheses draw attention to leakage concerns emerging in two different ways whereby the investor can take advantage of access to privileged information through a seat on the board of the investee partner. The extent to which these potential leakage concerns affect the prospect of board membership for the investor partner depend on the how they impact the potential losses the investee foresees. Specifically, the two conditions we have discussed previously can escalate the investee's anticipated losses and make it much less likely for the investor to secure a board seat. The two sources of leakage concerns stem from the ability of other firms, whether the investor or its collaborators, to misappropriate knowledge of the investee partner through the investor's board representation (e.g., Diestre and Rajagopalan, 2012; Pahnke *et al.*, 2014). However, such misappropriation concerns the investee partner faces are further amplified by the specific incentives that an investor has to engage in opportunistic behavior in the first place. The incentives for the investor stem from the potential benefits that follow from exploiting the spillovers, whose value depends significantly on the value of the technological core of the investee partner. Consideration of the value of the investee firm's technological resources therefore helps in isolating the investee's costs of board representation by the investor in the face of misappropriation hazards.

Valuable knowledge is heterogeneously distributed across firms because of differences in their intrinsic R&D capabilities or because of the specific investments they have made (Knott, 2008). Investor firms are naturally less likely to be interested in assimilating inferior or superfluous knowledge compared to knowledge that is of high quality, so the misappropriation risks attending board representation by the investor will vary across minority equity partnerships. As alliance research has noted, capability differences between partners can induce firms to act opportunistically, and the attendant risk of know-how exposure and leakage has an effect on alliance structuring decisions (e.g., Oxley and Sampson, 2004). Because learning from partners is not a costless process (e.g., Khanna, 1998) and often requires redeployment of specialized resources from other productive purposes, the incentive for the investor to use its ability to take advantage of an investee partner's knowledge will increase as this knowledge becomes more valuable. Accordingly, investee partners that possess particularly valuable knowledge and technical capabilities will be more exposed to the leakage and spillovers discussed above, should they cede board membership to an investor. By contrast, the misappropriation risks we have discussed in developing H1 and H2 will be less consequential when an investor has less incentive to misappropriate an investee partner's knowledge through representation on the board. We therefore suggest that the value of an investee partner's knowledge will be an important boundary condition for the hypotheses developed earlier:

Hypothesis 3*:* *The negative effect of the overlap of partners' technological resources on the likelihood the investor has a board seat will strengthen with the value of the investee partner's knowledge.*

Hypothesis 4*:* *The negative effect of the investor's competitive collaborations on the likelihood the investor has a board seat will strengthen with the value of the investee partner's knowledge.*

METHODS

To test these hypotheses, we employ a sample of biotechnology research agreements between pharmaceutical and biotechnology firms. The biopharmaceutical industry serves as a useful empirical setting because firms in this sector commonly engage in inter-organizational arrangements to secure the required research, manufacturing, and marketing resources that enable them to develop and launch new products (Baum, Calabrese and Silverman, 2000; Rothaermel, 2001). An important consideration for partnering firms in this sector arises from the need to shield proprietary knowledge material from being overly exposed to the partners (e.g., Diestre and Rajagopalan, 2012). One popular example that illustrates these concerns is the legal battle between Genentech and Eli Lilly about the misappropriation of knowledge related to the production of recombinant insulin (Genentech, 1994). Indeed, firms routinely indicate that the leakage of proprietary knowledge is an important risk they face in the conduct of their business.

For our study, we derive data from Thomson Reuters' Recap database (Recap). Originally established in 1988 in San Francisco, Recap specializes in providing information services to the biopharmaceutical industry. Recap licenses the data to biotechnology, pharmaceutical, venture capital, and investment banking firms. Several recent studies in economics and management have employed Recap data for investigating questions about contract theory and strategic alliances (e.g., Adegbesan and Higgins, 2011; Lerner and Merges, 1998). A recent study also finds Recap to be robust in terms of coverage and reliability, noting the depth of information provided as a key advantage of the database (Schilling, 2009). The database provides transaction-level information assembled from various public sources, including Securities and Exchange Commission (SEC) filings, industry conferences and news publications. The transaction-level information includes the date of agreement, type of agreement signed, therapeutic area, stage of drug development cycle at which the agreement is signed, and so forth. We enrich this data by merging it with the data from the strategic alliance module of the Securities Data Corporation (SDC) database maintained by Thomson Financial. We also use patent data from the US Patent and Trademark Office (USPTO) database for characterizing the technological domains of the partners.

We analyze partnerships with an equity investment and established between biotech firms and pharmaceutical firms during the 1990-2006 timeframe. This time frame includes a timeframe in which there has been substantial alliance activity in the biotechnology industry (Schilling, 2009). We sample on deals for which alliances Recap provides contracts or proprietary contractual analysis. The database may contain a greater proportion of deals that involve research firms that are more likely to succeed and go public after the deal. We include transactions that are in the discovery or development phase and exclude transactions that do not contain an R&D component (contracts that Recap does not classify as "Collaboration", "Co-Development", "Research" and "Development") (Lerner and Malmendier, 2010). We exclude transactions that involve other forms of transactions (e.g., acquisition, asset purchase, assignment and merger, etc.) and other forms of collaborative activity such as joint ventures and non-equity agreements because joint ventures are uncommon in this industry and non-equity agreements do not have a board of directors. In supplemental analyses described below we also consider potential sample selection biases in our study. The sample we analyze consists of 337 transactions after accounting for missing data.

Measures

Dependent Variable. Our empirical analysis focuses upon an investor's representation on the board of directors in minority equity partnerships. Accordingly, our main dependent variable measures whether or not the investing partner secures membership on the board of the investee firm (Robinson and Stuart, 2007a). Thus, *Board representation* is a dichotomous variable which equals one when the investor firm receives board membership and zero otherwise. We obtain the board membership data for each transaction from Recap. Because this dependent variable is dichotomous, we specify a probit model to test our hypotheses, and in robustness analyses we also verified our results using linear probability models using the weighted regression approach which corrects for the inefficiency of coefficient estimates in such models (Maddala, 1983).[ii]

Independent Variables. Our first theoretical variable captures the extent to which the investor's knowledge stock matches with the knowledge stock of the investee partner. We employ six-digit patent classifications of the USPTO to define a measure for the overlap in patent portfolios. The USPTO classifies each patent it issues under a primary and three digit class and a secondary six digit class. For example, the principal three digit class number 435 pertains to the area of molecular biology and microbiology and deals with the various processes, syntheses, derivatives and applications of microorganisms and enzymes. The principal patent class 435 contains about 500 subclasses whose subject matter ranges from tissue culture to apparatus to nucleic acids. This means that even though two firms may have obtained patents in the same primary class, the subject matters of the patents can differ considerably depending on the secondary class. We measured *Investee technology overlap* as the proportion of the investee partner's patents whose six-digit classification also occurs in the investor firm's patent portfolio. Accordingly, *Investee technology overlap* is given by the following formula:

(1) *Investee technology overlap* = $\frac{\sum(Investee\ patents\ in\ overlap\ technology\ classes)}{\sum Investee\ patents}$

This variable ranges between 0 and 1, and higher values of this variable correspond to greater overlap of the investee partner's portfolio with that of the investor's (e.g., Sears and Hoetker, 2014). We also conducted two robustness checks for the construction of this measure. We first measured technology overlap based upon the total number of patents in overlapping classes (as opposed to the scaled, relative measure in equation (1)), and this alternative measure yielded consistent results. We also examined whether our results for investee technology overlap are sensitive to the level of patenting by the investor in the overlapping technology areas, and we found that they did not depend upon the investor's patenting activities.

Our second theoretical variable considers the threat of leakage to competing firms of the investee partner via the investor. We measure this variable, which we label *Investor competing alliances*, by taking the logarithm of the number of both equity and non-equity R&D collaborations formed by the investor in the same therapeutic area as the focal alliance. Therapeutic categories refer to the organ or system in the human body which is the target for the drug. For example, drugs classified under antineoplastic category target various types of cancer and autoimmune diseases. Based on prior evidence about the duration of R&D collaborations in the biotechnology sector, we use the R&D collaborations formed by the partner in the five-year window before the focal deal to quantify this measure (e.g., Ahuja and Katila, 2001).

Our third theoretical variable, which captures the investor's incentive to misappropriate knowledge, is the value of the investee partner's knowledge in the technological areas where the investor is active. In order to develop a measure for this variable, we relied upon the established precedent of using patents to characterize the investee partner's underlying knowledge and the number of forward patent citations to determine the importance of patents. We first identified the six-digit patent classes common to both the partners, and then constructed a subset of patents applied for by the investee firm in a ten-year window before the focal alliance and ultimately issued by the USPTO, and which are classified in any of the common six-digit patent classes. For each patent in this overlap set we counted the number of forward citations received in the 5-year window after the grant. We defined the variable *Investee knowledge value (overlap tech.)* as the average number of citations received by the patents in the overlap set. Higher values of this variable correspond to greater value of the knowledge of the investee firm in the overlapping technologies.

Control Variables. We include several control variables at the partner and alliance levels that may be related to board representation by the investor and relate to the explanatory variables discussed above. At the alliance level, we control for the scope of alliance activity as broader scope alliances might benefit from more oversight and advice as well as present greater appropriation concerns. We use a dummy variable to indicate whether the partnership includes activities beyond R&D (Li *et al.*, 2008; Oxley and Sampson, 2004). In addition to R&D, the partners can also agree to do commercialization, manufacturing, and supply activities. The variable *Alliance scope* equals one when R&D and any of the other activities are also performed, and zero when only R&D is carried out. As a residual claimant, the investor is more likely to get a board seat when it has invested more equity in the investee firm. The share of ownership that the investor attains through the equity investment also partly determines whether the investor gets a seat on the board of the investees. Both these variables are potentially endogenous and to control for their effects and mitigate concerns about misspecification, we first estimate models for equity amount (*Equity*) and equity of the investee owned by the investor (*Equity share*) and use the residuals from these first stage estimations in the second stage estimation of board representation for the investor (Terza, Basu, & Rathouz, 2008). We also simultaneously modeled equity stakes and board representation and obtained consistent results (Table 3). We conducted an extensive search in different filings (e.g., S-1, S-3, Schedule 14) made by the investee firms with the Securities and Exchange Commission (SEC) and supplemented it with a search in Factiva to obtain information about equity stakes held by the investors.

We measure *Prior equity received by the investee* as the log transformation of the amount of equity investment received by the investee from previous partners and include it in the model estimating equity share. We also control for whether the alliance is between partners from different countries (*International alliance*). We denote this by a dummy variable that equals one if the partners' headquarters are located in different nations (Gulati, 1995; Gulati and Singh, 1998), and zero otherwise.

We also include several control variables at the partner level that may relate to the allocation of board seats to the investor as well as the other explanatory variables. Firms learn from prior partnering experience to better manage alliances (Anand and Khanna, 2000; Gulati *et al.*, 2009; Hoang and Rothaermel, 2005; Kale *et al.*, 2002) and may, in turn, have less need for board monitoring. Similar arguments can apply to an investee firm, who can also use previous alliances to help establish its position in the industry (Robinson and Stuart, 2007b), which weakens incentives for opportunistic action. For these reasons, we control for the alliance experience of the investee partner (*Investee alliance experience*) and the investor (*Investor alliance experience*). We measure alliance experience by counting the number of alliances entered into in the five years prior to the alliance formation and take a logarithmic transformation to address positive skewness evident for the untransformed variables.

We also control for the partners' technological knowledge stocks for two reasons. First, greater knowledge stocks may increase the efficiency of knowledge absorption (Cohen and Levinthal, 1990) and allow the investor firm to bridge knowledge gaps to facilitate better monitoring of the activities performed by the investee firm. Moreover, an investee partner with greater technological resources may have developed the capabilities to organize and conduct commercial R&D and may require less intense monitoring and direction from the board level. We measure *Investee patent stock* and *Investor patent stock* as the patent counts of patents issued in the ten years prior to alliance formation (Argyres and Silverman, 2004), using a logarithmic transformation for these two variables. We also include a Herfindahl-Hirschman type index at the three-digit patent class level to control for the concentration of the patent portfolio of the investee firm (*Investee patent concentration)* and the investor (*Investor patent concentration)* (e.g., Oxley and Wada, 2009). In order to control for the patent portfolio features of the investee partner that may be related to the value of its knowledge in overlapping technologies as well as to account for the bargaining position of the investee firm originating from its knowledge stocks, we include the total number of citations received by the investee (*Investee patent citations*) as well as a measure similar to the third theoretical variable but in technological areas that do not overlap with the partner (*Investee knowledge value (non-overlap tech.*)). We use data from the USPTO to obtain these measures.

Prior research has shown that alliances substitute for public capital markets in providing financial resources to new ventures, so equity market conditions may affect the bargaining power of the investee partner (Lerner *et al*., 2003). To control for this effect, we include *Biotech equity index* using the total amount of equity raised through IPOs and other public issues in US public markets in a given year (Lerner, 1994). We also control for the public status of the investee firm to account for the differences between public firms and private firms which can arise from access to funding, corporate governance standards, the scrutiny of regulatory agencies, and disclosure rules. *Investee firm is public* is a binary variable that equals one if the investee partner is public at the time the partnership was formed, and zero otherwise. Finally, we include the indicator variable *Investee firm has no patent* to account for the possibility that the investee firm has not applied for any patents before the focal deal.

We also controlled for several unobserved effects at the alliance level. We control for the stage of the alliance within the drug development cycle by including the dummy variables *Formulation*, *Preclinical*, *Phase 1*, *Phase 2*, and *Phase 3*, with the discovery stage being the reference category. We also incorporated a series of fixed effects for the focal therapeutic indication for the alliance (*Therapeutic area effects*) (Macher and Boerner, 2006) and its technological domain (*Technology area effects*) (Adegbesan and Higgins, 2011). We control for the effects by time by including *Period fixed effects*.

RESULTS

In Table 1, we present descriptive statistics and the correlation matrix for the sample of 337 minority equity partnerships included in the empirical analyses. With respect to our main dependent variable, we observe investor firms having board seats in 14 percent of the sample partnerships. Thus, despite the investor having an equity stake in the investee partner, it is noteworthy that in most cases the investor does not have a seat on the board of directors. The average ownership stake that investor partners secure is about 8 percent, however. We find that the average equity stake obtained by investors when they also have board representation is about 11 percent, which is higher than the 7 percent stake investors secure when they do not have any representation on the investee's board (difference is significant at $p<0.001$). The majority of the sampled partnerships also tend to extend beyond R&D to include commercialization, manufacturing, or supply components. Alliances with local and international partners are evenly balanced in our sample. As expected, the likelihood of board seats is positively correlated with the amount of equity invested ($p<0.05$). The descriptive statistics also reveal some interesting patterns concerning the correlates of board membership by investors. For instance, we find that investors are half as likely to secure a board seat when the *investee technology overlap* is above the mean, relative to those cases with *investee technology overlap* below the mean. We also find a similar decrease in the likelihood of board seat for investor when *investor competing alliances* is above the median, relative to those with *investor competing alliances* below the median. The mean variance inflation factor is 2.5 (maximum of 9.5), indicating that multicollinearity is not a concern for model estimation.

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Insert Table 1 about here
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The focus of our analysis is the likelihood the investor obtains board representation in light of an investee partner's knowledge misappropriation concerns. Our dependent variable for board representation of the investor on the investee's board is binary, so we present in columns 1 – 6 of Table 2 several probit specifications of board representation for the investor firm and interpret these estimates. We also show robust estimates from a linear probability model using weighted least squares in column 7 of Table 2 (Goldberger, 1964; Maddala, 1983). For interpreting the results, a positive parameter estimate in this table indicates that an increase in a variable increases the likelihood of board representation by the investor firm. Column 1 reports estimates for control variables, and Column 2 includes the main explanatory variables and column 3 shows the model for testing the inverted-U shaped relationship. Columns 4 and 5 separately introduce the two interaction effects, and Column 6 includes them together and is the full model. All the models are highly significant (p<0.001). Likelihood ratio tests for the joint significance of models with our core explanatory variables shown in Columns 2 - 6 are significant at the 0.001 level. Moreover, classification tables show that the sensitivity (*i.e.,* model correctly classifies true instances) of our full model in Column 7 is 43.5% which is as improvement from the 30.4% of our baseline model.

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Insert Table 2 about here
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In our first hypotheses, we suggest that the likelihood of board seat for the investor depends on the trade-off between potential advisory benefits from the investor's membership on the board vis-à-vis potential misappropriation concerns arising from the investor's ability to absorb and utilize proprietary knowledge. More specifically, we posited two contrasting relationships between investor technology overlap and the likelihood of board seat for the investor depending on how the net benefits from board seat investor vary with investor technology overlap. In H1a we proposed an inverted-U shaped relationship in which the likelihood of board representation first increases at low to intermediate levels but then decreases at higher levels of overlap of the investee firm's technologies with the investor firm's. In H1b we posited that the likelihood of board representation monotonically decreases with an increase in the extent to which the investee firm's technologies overlap with the investor firm. To test these hypotheses, we introduce the first-degree term of *Investee technology overlap* in the model shown in column 2, and then also include the quadratic term in the model shown in column 3. A positive coefficient for the first-degree term and a negative coefficient for the second-degree term of *Investee technology overlap* would be consistent with H1a while a negative coefficient for *Investee technology overlap* would support H1b. We find that the coefficient of *Investee technology overlap* is negative and significant (p=0.033) in column 2. The coefficient of first degree term of *Investee technology overlap* continues to be negative in column 3 (p=0.09) and the quadratic term is positive and not significantly different from zero (p=0.53), which is consistent with H1b but not with H1a. Given the nonlinear specification of the probit model, the estimated impact of investee technology overlap on the likelihood of board representation for the investor firm will depend on the values of all of the variables in the model. To illustrate the marginal effect of this hypothesized variable, we use estimates from column 2, use covariates held at observed values in the sample, and find that the probability of the investor firm securing board representation decreases by 5.2 percentage points (p=0.04) for a one standard deviation increase from the mean of investee technology overlap. The negative, monotonic effect we observed is in accord with our argument that concerns about the loss of proprietary technological knowledge and the impairment of the investee firm's ability to benefit from such knowledge attain first order importance in shaping board representation.

Our second hypothesis follows arguments about misappropriation concerns arising from the investor's alliance relationships with potential competitors of the investee partner. We proposed a negative relationship between board representation for the investor firm and the number of the investor's alliances in areas that are technologically proximate to the focal alliance. Accordingly, we expect a negative sign for the coefficient of *Investor competing alliances*. Column 2 of Table 2 shows a negative sign as anticipated, providing support for this hypothesis (p=0.017). Using coefficient estimates from column 4 and holding covariates at observed values in the sample, this negative effect translates to a 5.3 percentage point decrease in the probability of board representation for the investor for a one standard deviation increase from the mean of the *Investor competing alliances* variable (p=0.023).

Our third and fourth hypotheses considered the moderating effects of the value of the investee partner's knowledge on the two variables discussed above, relying on the argument that the investor's incentive to misappropriate knowledge increases with the value of the investee's knowledge. If this concern amplifies the knowledge misappropriation risks associated with the investor having similar technological resources or partnerships with potential competitors of the investee partner, then both interactions should have a negative coefficient. The incentive to misappropriate knowledge is not only an interesting and important theoretical boundary condition for our arguments, but interactions with this variable enable us to unpack misappropriation concerns from other theoretical determinants of board representation. Coefficient estimates for the interaction term between the investee partner's knowledge value and investee technology overlap in both Column 4 and Column 6 are not significant and do not offer support to our third hypothesis. Both Columns 5 and 6 show a negative sign for the interaction with the investor's competing alliances (p=0.038), offering support to our fourth hypothesis.

Given the challenges in interpreting interaction effects in nonlinear models (e.g., Hoetker, 2007), we illustrate this interaction effect using graphs. Figure 3 illustrates the interaction between investor prior competing alliances and investee knowledge value for an ambivalent firm, using estimates from Column 5 of Table 2. The horizontal axis indicates standardized values of competing alliances by the investor, and the vertical axis shows the probability of board representation for the investor. We plot the solid curve with the investee knowledge value held at the mean and the dashed curve with the investee knowledge value held at one standard deviation above the mean. We demonstrate the interaction effect by noting that for a one standard deviation increase from the mean of prior competing alliances by the investor (i.e., from 0 to 1) the decrease in probability of the board representation for the investor when the investee knowledge value is held at one standard deviation above the mean is about 1.5 times larger than the corresponding decrease when the investee knowledge value is held at the mean.

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Insert Figure 3 about here
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Robustness Analysis

We conducted several supplemental analyses to assess the sensitivity of our results. First, we considered the possibility that board representation by investors is jointly determined with another key dimension of equity alliance design **--** the equity stake obtained by the investor. Unobservables that lead an investor to take a greater equity stake might also lead the investor to take a seat on the board of directors. Simultaneous estimation results from bivariate probit models remain consistent with those reported earlier (please see Table 3). With regard to the determinants of equity shares, we find that investors having more competing alliances prior to the partnership have a lower equity share. We also find that broad scope alliances are likely to have a higher equity share. These results establish that while board representation and equity stakes are related, their antecedents only partly coincide, which is one more reason why it is valuable to investigate boards more deeply and understand the determinants of board representation. The positive rho term (0.54; $p<0.001$) also indicates that unobservables leading an investor to have a board seat also lead it to take on a higher equity share.

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Insert Table 3 about here
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Next, we examined the potential for sample selection concerns to affect our interpretations. In this paper, we chose to focus on minority equity partnerships based on the notion that they represent one important way in which inter-organizational relationships are organized along the market-hierarchy continuum (Oxley, 1997). Joint ventures are an alternative form of equity alliances, and they have dedicated boards of directors, but given the small size and very limited resource base of entrepreneurial ventures in biotechnology, joint ventures are not common in this industry. Because we focus on minority equity partnerships as a form of equity alliance, the margin of choice by collaborators that might give rise to sample selection concerns is between a contractual alliance and an equity partnership within the hybrid portion of the governance continuum. In order to address this concern, we collected information on contractual alliances and estimated a two-stage model where the first stage model concerns the choice between an equity or nonequity alliance using several partner (alliance experience, knowledge stocks) as well as alliance characteristics (knowledge overlap between partners, prior ties, deal size) as explanatory variables (Wald Chi-Squared =307.1, $p<0.001$). Relying on assumptions about functional form, we re-estimating the models we used to test the hypotheses after including the inverse Mills ratio from the first stage. We found that our hypothesized relationships continue to hold, and the null hypothesis of no sample selection bias could not be rejected ($p=0.75$).

We also investigated the robustness of our results to alternative ways of constructing our dependent variable. Our main dependent variable is a binary measure for whether the investor secures a board seat. It is possible that the investor can secure multiple seats on the board of the investee. However, the incidence of multiple board seats is very rare in our sample. In fact, in only two cases did the investor obtain two board seats, and in no case did the investor obtain three or more seats on the board. We found that our results continued to hold even if we drop these two cases where an investor obtained more than one board seat, so these observations do not account for our findings. It is also possible that an investor obtains an observational seat on a board that does not confer voting privileges, and this occurs in 2 percent of the cases in our sample. We found that even if we included these observations as cases of board representation, we found results that were qualitatively the same as those presented earlier.

Finally, we examined the possibility that investors may seek to secure their minority interest by bargaining for alternative governance instruments in place of representation on the investee board. Specifically, previous research suggests that reversion of IP rights to the financier (investor), and contractual specification of diligence required from the R&D firm (investee) during contract execution function as potential contractual responses for dealing with the observability and verifiability problems in R&D investment partnerships (e.g., Lerner & Malmendier, 2010). We have used contract analyses supplied by Recap to examine the complexity of these two types of provisions included in the contract. We define complexity of these two provisions in terms of the number of words used to craft these clauses. In order to facilitate simultaneous estimation with the binary board representation variable, we defined the complexity of these provisions to be one if the number of words is above the mean and zero otherwise. In simultaneously estimated specifications for board representation, complexity of diligence provisions and complexity of intellectual property reversion, we found that the determinants for board representation remained consistent with our main set of results. The estimated correlation coefficients for the three dependent variables do not suggest that these other contractual mechanisms substitute for board representation. Overall, the evidence from our additional analyses offers further support to our hypotheses, and indicates that appropriation concerns investee firms face serve as important antecedents for whether the investor secures board representation.

DISCUSSION

Contributions and Implications

In this paper, we aim to contribute to our understanding of the design of administrative controls in alliances by analyzing the conditions under which investor firms secure board representation in minority equity partnerships. Our empirical setting draws on the biopharmaceutical industry, where small firms focusing on R&D activities commonly forge alliances with pharmaceutical companies in response to the financial constraints and downstream resource constraints they face. We suggested that board membership for the investor exposes an investee partner's proprietary information to the investor, and this raises the threat of the investor opportunistically utilizing such information. Specifically, we argued the investor partner's ability to take advantage of the exposed knowledge directly by itself, or with the help of other competing firms already partnering with it, can negatively influence whether the investor firm secures a board seat during alliance contracting. Next, we considered how the value of the investee's knowledge in technology areas it shares with the investor exacerbates these knowledge misappropriation concerns. We posited that more valuable knowledge of the investee partner amplifies the negative influence of an investor's ability to take benefit both directly through its own means, and indirectly with the help of other partnerships. Overall, our results indicate that appropriation concerns arising from an investor's interest and ability influence the design of administrative control interfaces between partners.

This study makes a number of contributions to the literatures on alliance governance and on interorganizational relationships more broadly. Recent studies have analyzed contractual provisions in great detail (Argyres *et al.*, 2007; Elfenbein and Lerner, 2009; Lumineau and Malhotra, 2011; Ryall and Sampson, 2009; Weber *et al.*, 2011), and our work extends this line of research by studying the choice of administrative control elements of governance in particular (Williamson, 1985). The administrative control mechanisms available to partners will differ in various hybrid organizational forms, and in minority equity partnerships the key venue for facilitating adaptation and affecting private ordering will be the board of directors. Although the alliance literature has long acknowledged the role of governing boards in supporting exchange in collaborative arrangements, little systematic empirical research has been devoted to understanding boards in equity alliances and the potential downsides they present to collaborators. Our theoretical arguments and findings are therefore novel and interesting because they highlight that board membership can not only promote cooperation and offer certain advantages to an investee (e.g., advice) but also be a vehicle for heightened exchange hazards in the form of knowledge misappropriation of an investee's knowledge. When considered in isolation the appropriation argument suggests a negative relationship between technology overlap and representation of the investor on the investee's board, whereas the advisory role suggests a positive relationship. However, both effects tend to be present concurrently, so the decision is likely to be the outcome of an evaluationof the potential net benefits or costs. Our results suggest that misappropriation costs faced by the investee at higher levels of technology overlap appear to weigh more heavily and induce investee firms to avoid board representation by the investor. For collaborations presenting such risks to investees, investors will need to find other safeguards to protect their interests. Our finding might reflect our focus on R&D partnerships in the biopharmaceuticals setting, in which misappropriation hazards are a first-order concern, yet in other research contexts the value of advice by investors might take on much more importance. Future research therefore needs to address the multiple mechanisms that firms might employ in addressing these tensions and the potential role of bargaining power in the design of alternative governance arrangements in collaborative agreements.

The limitation of extant alliance research in neglecting boards is readily apparent when this body of work is juxtaposed with the vast literature on boards and corporate governance in economics, management and finance. Specifically, the structure of corporate boards and the value of outside directors has received extensive theoretical and empirical attention (Adams *et al.*, 2010; Boeker and Wiltbank, 2005; Certo *et al.*, 2001; Coles *et al.*, 2008; Ellstrand *et al.*, 2002; Harris and Raviv, 2008; Kor, 2006). Our arguments and findings suggest that investigating the structuring of boards of equity alliances can shed more light on antecedents of board design as well as the implications of transaction cost considerations for the design of collaborative agreements. Collaborative agreements might not only be subject to principal-agent problems featured in prior corporate governance research, but also principal-principal problems beyond the ones we have highlighted in this paper. Just as the board can be the source of these problems, as we have noted for minority equity agreements in high-tech collaborations, boards provide also capacity for dispute resolution through private means rather than resorting to third parties (i.e., arbitration) or the court system. It would therefore be valuable to examine explicitly whether the authority embedded in boards might provide meaningful coordinated adaptation in collaborative agreements. Research in this direction might also consider other forms of hybrid organizations (e.g., boards governing joint ventures) as well as investigate other theoretical antecedents of board composition. Such research could be valuable in invigorating corporate governance research by pursuing research opportunities in new organizational and institutional domains.

Our study also broadly contributes to the research that explores how cooperative and competitive tendencies amongst firms shape interorganizational relationships. Scholars in this line of research have suggested that potential complementarities between the resource base of firms support the formation of interorganizational ties (e.g., Arora and Gambardella, 1994; Rothaermel and Boeker, 2008). Emerging research has also suggested the potential downside of such ties, particularly for new firms in high-tech settings, and this research has showed the serious risks that collaborations can entail because of the leakage of valuable information to partners and other competitors (Diestre and Rajagopalan, 2012; Pahnke *et al.*, 2014; Katila *et al.*, 2008). Given these negative effects on performance, several recent studies have demonstrated how tie formation is affected by the ability of firms to construct defenses that safeguard proprietary resources to keep undesirable exposure under check, and prevent the erosion of their value (Hallen *et al.*, 2014; Hernandez *et al.*, 2015). The present study complements this research by providing empirical evidence which shows that the defense against misappropriation not only shapes alliance formation but also how relationships are governed.

Limitations and Future Research Directions

In addition to the research areas suggested earlier, future research can also address some of the specific limitations of this study. First, as already noted, the generalizability of our results can be tested in several related contexts. For instance, it would be interesting to examine partners' board-level choices in manufacturing or marketing oriented alliances, and in sectors that have different appropriability regimes than biotechnology. Such lines of investigation will help in specifying the boundary conditions for the choice of different governance arrangements in minority equity partnerships.

Second, while our study highlights the appropriation concerns raised by boards in the context of minority equity partnerships, corporate governance research emphasizes that directors can serve other functions such as accessing external resources as well as providing advice to management (Hillman and Dalziel, 2003). A research opportunity exists to use other theories to examine the roles provided by directors from the investor and to compare explicitly the functions of such directors to other outside directors in the investee organization. In addition to examining the director roles identified by corporate governance research, it would be valuable to identify director involvement in activities unique to equity alliances as organizational forms. For instance, it would be valuable to study the extent to which directors are involved in facilitating coordination of collaborative activities (Gulati and Singh, 1998) as well as addressing conflicts and disputes between partners (e.g., Lumineau and Malhotra, 2011), functions that don't extend to directors serving stand-alone corporations in general.

Third, our study focuses on appropriation concerns in minority equity partnerships, in which investors generally obtain only one board seat, so the investor will be limited by itself to commandeer the strategic direction of the investee in ways that are favorable to its own objectives at the expense of the investee's long term interests. Further, many investees in our sample are relatively young firms which are yet to go public and may be subject to specific preexisting contractual covenants between VCs and founders/managers (Kaplan and Stromberg, 2002). However, concerns about divergent incentives of the investor and potential conflicts among owners (e.g., VCs, founders, etc.) may arise by allowing board representation by the investor. It would be valuable to join research on corporate governance with work on corporate venturing to examine the effects of board composition (founders, VCs, corporate venture capitalists, etc.) on the extent to which investor partners in minority equity partnerships potentially influence the strategic behavior of investee firms. Such future extensions may also consider other domains in which misappropriation concerns are less prominent compared to other hazards. For instance, such research might investigate horizontal alliances rather than vertical ones to examine whether the firms are competing in end markets as this can exacerbate conflicts of interests concerning the strategic direction of the venture.

Finally, our study investigates determinants of board-level representation and relies on the discriminating alignment hypothesis to do so. Given that our empirical analyses consider whether the investor partner takes a seat on the investee partner's board, it would be interesting to examine the implications of such choices. For example, future research can examine how board-level choices in equity alliances can affect the achievement of partner objectives such as increasing the rate of innovation or new product introductions. Given that we focus on firms' governance choices at the inception of the partnership, it would be valuable to study how boards change over time and how partners' monitoring efforts evolve with their collaboration and other governance mechanisms (e.g., Ariño and Torre, 1998). Board-level changes might not only entail changes in the structure and composition of the board but also in the specific responsibilities delegated to board members by the parents. Furthermore, board-level governance changes can also arise because of learning that occurs over the course of the partnership or as specific contingencies arise that were not considered by the partners when the alliance was initially formed (Argyres *et al.*, 2007). Research in directions such as these will enrich the literature on alliance governance and advance more recent research devoted to the contractual foundations of strategic alliances and the design of collaborative agreements.

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Table 1: Correlation table and descriptive statistics

#	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	Board representation	1.00																				
2	Investee technology overlap	-0.09	1																			
3	Investor competing alliances	-0.09	0.34	1																		
4	Investee knowledge value (overlap tech.)	0.05	0.43	0.07	1																	
5	Investor competing alliances X Investee knowledge value (overlap tech.)	0.06	0.29	0.01	0.66	1																
6	Investor competing alliances X Investee knowledge value (overlap tech.)	-0.08	0.02	0.02	0.15	0.28	1															
7	Alliance scope	0.03	0.2	0.15	0.12	-0.01	-0.08	1														
8	Equity	0.15	0.28	0.20	0.09	-0.05	0.01	0.23	1													
9	Equity share	0.26	0.05	-0.02	0.02	0.03	-0.05	0.13	0.48	1												
10	International deal	0.09	-0.01	-0.07	-0.07	-0.1	-0.07	-0.04	0.03	-0.02	1											
11	Investee alliance experience	-0.07	0.10	0.08	0.05	-0.05	-0.02	0.02	0.18	0.02	-0.08	1										
12	Investor alliance experience	0.02	0.26	0.37	0.13	0.03	-0.06	0.17	0.17	0.10	0.00	0.03	1									
13	Investee patent stock	-0.13	0.39	0.26	0.23	-0.04	-0.06	0.16	0.40	-0.01	0.01	0.3	0.12	1								
14	Investor patent stock	0.06	0.46	0.32	0.23	0.03	-0.02	0.12	0.24	0.10	0.06	-0.01	0.64	0.2	1							
15	Investee patent conc.	-0.01	0.06	-0.05	-0.03	0.07	0.01	0.04	-0.13	0.04	0.00	-0.11	0.00	-0.22	-0.11	1						
16	Investor patent conc.	-0.02	-0.19	0.01	-0.12	-0.02	-0.04	0.01	-0.11	-0.05	-0.06	0.03	-0.22	-0.06	-0.52	0.04	1					
17	Investee patent citations	-0.04	0.28	0.11	0.34	0.13	0.01	0.10	0.32	0.00	-0.04	0.24	0.03	0.81	0.09	-0.08	-0.03	1				
18	Investee knowledge value (nonoverlap tech.)	0.10	-0.1	-0.09	0.22	0.05	0.06	-0.07	0.02	-0.05	0.00	0.01	-0.02	0.17	-0.11	0.13	0.05	0.48	1			
19	Equity index	-0.15	0.34	0.33	0.06	-0.08	-0.06	0.16	0.28	-0.04	0.04	0.08	0.04	0.41	0.23	-0.14	-0.11	0.24	-0.11	1		
20	Investee is public firm	-0.09	0.10	0.11	-0.03	-0.12	-0.01	0.02	0.22	0.01	-0.03	0.32	0.15	0.38	0.11	-0.13	0.03	0.23	-0.01	0.13	1	
21	Investee has no patent	0.11	-0.28	-0.13	-0.19	-0.05	0.02	-0.14	-0.2	-0.05	0.02	-0.15	-0.04	-0.6	-0.02	-0.33	-0.01	-0.77	-0.30	-0.18	-0.15	1
	Mean	0.14	0.18	0.67	3.57	0.42	0.07	0.71	2.19	0.07	0.48	1.08	2.56	2.00	5.31	0.23	0.07	3.19	7.96	0.29	0.37	0.23
	S.D.	0.34	0.28	0.76	8.34	1.55	0.98	0.46	0.93	0.06	0.50	0.83	1.16	1.45	2.45	0.27	0.20	2.28	11.77	0.30	0.48	0.42

N=337. Correlation coefficient with absolute value > 0.11 are significant at $p<0.05$.

Table 2: Determinants of board representation by the investor

Variables	1	2	3	4	5	6	7
Investor competing alliances X Investee knowledge value (overlap. tech.)					-0.252*	-0.241*	-0.040**
					(0.113)	(0.116)	(0.013)
Investee technology overlap X Investee knowledge value (overlap. tech.)				0.063		0.100	0.015+
				(0.076)		(0.115)	(0.008)
Investor competing alliances		-0.403*	-0.404*	-0.401*	-0.352*	-0.352*	-0.025**
		(0.169)	(0.169)	(0.167)	(0.168)	(0.168)	(0.009)
Investee technology overlap squared			0.083				
			(0.133)				
Investee technology overlap		-0.394*	-0.528+	-0.441*	-0.450*	-0.505*	-0.015*
		(0.185)	(0.320)	(0.196)	(0.195)	(0.219)	(0.008)
Investee knowledge value (overlap. tech.)	-0.044	0.085	0.099	0.038	0.079	0.045	0.005
	(0.097)	(0.114)	(0.114)	(0.139)	(0.120)	(0.142)	(0.019)
Alliance scope	0.244	0.188	0.203	0.207	0.123	0.157	0.020
	(0.310)	(0.320)	(0.325)	(0.318)	(0.309)	(0.306)	(0.020)
International deal	0.640*	0.588*	0.599*	0.603*	0.560+	0.572+	0.046**
	(0.256)	(0.289)	(0.290)	(0.293)	(0.295)	(0.298)	(0.014)
Investee alliance experience	0.102	0.068	0.062	0.071	0.078	0.077	-0.003
	(0.125)	(0.143)	(0.142)	(0.142)	(0.140)	(0.139)	(0.009)
Investor alliance experience	-0.222	-0.170	-0.171	-0.178	-0.204	-0.204	-0.004
	(0.145)	(0.154)	(0.154)	(0.154)	(0.162)	(0.162)	(0.012)
Investee patent stock	-0.382+	-0.281	-0.273	-0.253	-0.268	-0.241	-0.023+
	(0.224)	(0.211)	(0.215)	(0.224)	(0.211)	(0.227)	(0.013)
Investor patent stock	0.260**	0.364***	0.374***	0.377***	0.382***	0.390***	0.019**
	(0.095)	(0.096)	(0.098)	(0.099)	(0.102)	(0.103)	(0.006)
Investee patent conc.	0.865*	1.390**	1.258*	1.354**	1.335**	1.307*	-0.021
	(0.431)	(0.509)	(0.548)	(0.517)	(0.512)	(0.520)	(0.044)
Investor patent conc.	0.567	1.273*	1.279*	1.287*	1.077*	1.090*	0.100***
	(0.512)	(0.553)	(0.552)	(0.556)	(0.531)	(0.534)	(0.030)
Investee patent citations	0.390*	0.484**	0.465*	0.460*	0.436*	0.419*	0.010
	(0.193)	(0.183)	(0.189)	(0.188)	(0.188)	(0.193)	(0.010)
Investee knowledge value	0.014	0.009	0.010	0.011	0.016	0.017	0.003+
(nonoverlap. tech.)	(0.010)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.002)
Equity index	-0.720	-0.542	-0.493	-0.432	-0.529	-0.460	-0.042**
	(0.622)	(0.688)	(0.693)	(0.659)	(0.650)	(0.630)	(0.015)
Investee is public firm	-0.242	-0.384	-0.385	-0.390	-0.393	-0.389	-0.006
	(0.249)	(0.249)	(0.247)	(0.249)	(0.259)	(0.258)	(0.016)
Investee has no patent	1.286*	1.872**	1.727**	1.799**	1.689**	1.645**	0.020
	(0.518)	(0.580)	(0.624)	(0.588)	(0.593)	(0.603)	(0.031)
Equity share (residual)	6.873**	8.006**	7.917**	7.960**	7.552**	7.446**	0.703**
	(2.261)	(2.513)	(2.497)	(2.517)	(2.568)	(2.619)	(0.241)
Equity amount (residual)	0.223*	0.266*	0.278*	0.280*	0.318*	0.327*	0.018*
	(0.107)	(0.117)	(0.117)	(0.120)	(0.131)	(0.134)	(0.009)
Constant	-6.409***	-7.849***	-7.930***	-8.012***	-7.740***	-7.863***	-0.101+
	(1.075)	(1.254)	(1.272)	(1.307)	(1.269)	(1.285)	(0.054)
Pipeline fixed effects [b]	7.43	7.97	8.12	7.70	6.58	7.05	5.84
Therapeutic area effects [b]	20.33**	29.27***	29.68***	29.48***	30.07***	30.27***	25.11***
Technology area effects [b]	18.26**	22.33**	21.54**	21.83**	21.05**	20.97**	11.46+
Period effects [b]	7.75*	7.92*	7.90*	8.24*	8.99*	9.33**	6.67*
Log likelihood	-86.68	-82.08	-81.98	-81.87	-79.88	-79.73	-718.37
χ^2	138.5	171.2	167.91	174.5	196.9	200.0	

[a] N=337. *** p<0.001, ** p<0.01, * p<0.05, + p<0.1. Clustered robust standard errors in parentheses (clusters = 119). [b] Table entries show χ^2 values for joint significance.

Table 3: Joint estimation of board representation by the investor and equity share

Variables	Board representation	Equity share	Board representation	Equity share
Investor competing alliances X Investee knowledge value (overlap tech.)			-0.220*	-0.003
			(0.112)	(0.003)
Investee technology overlap X Investee knowledge value (overlap tech.)			0.066	0.001
			(0.107)	(0.002)
Investor competing alliances	-0.310*	-0.007*	-0.267+	-0.007*
	(0.152)	(0.003)	(0.150)	(0.003)
Investee technology overlap	-0.313*	0.001	-0.385*	0.001
	(0.153)	(0.002)	(0.175)	(0.003)
Investee knowledge value (overlap tech.)	0.049	0.000	0.040	0.000
	(0.104)	(0.003)	(0.117)	(0.004)
Alliance scope	0.154	0.012	0.124	0.012+
	(0.269)	(0.006)	(0.257)	(0.006)
Investee prior equity received	-0.076	-0.003	-0.094	-0.004
	(0.100)	(0.002)	(0.102)	(0.003)
International deal	0.538*	0.000	0.521+	-0.000
	().259)	(0.005)	(0.266)	(0.006)
Investee alliance experience	0.106	0.003	0.124	0.004
	(0.114)	(0.003)	(0.111)	(0.004)
Investor alliance experience	-0.159	0.002	-0.191	0.002
	(0.140)	(0.003)	(0.147)	(0.003)
Investee patent stock	-0.283	-0.004	-0.266	-0.004
	(0.184)	(0.004)	(0.194)	(0.005)
Investor patent stock	0.312	0.003	0.329***	0.003
	(0.084)	(0.002)	(0.090)	(0.002)
Investee patent conc.	1.109*	0.000	1.019*	0.000
	(0.444)	(0.012)	(0.451)	(0.013)
Investor patent conc.	1.005*	0.006	0.852+	0.005
	0.505	(0.013)	(0.486)	(0.013)
Investee patent citations	0.450**	0.000	0.407*	0.000
	(0.159)	(0.002)	(0.168)	(0.003)
Investee knowledge value	0.007	-0.000	0.013	-0.000
(non-overlap tech.)	(0.010)	(0.000)	(0.010)	(0.000)
Equity index	-0.351	-0.015	-0.336	-0.015
	(0.569)	(0.011)	(0.530)	(0.011)
Investee is public firm	-0.284	0.004	-0.266	0.005
	(0.223)	(0.007)	(0.226)	(0.007)
Investee has no patent	1.641***	-0.013	1.473**	-0.013
	(0.495)	(0.012)	(0.515)	(0.012)
Constant	-6.728***	0.062**	-6.622***	0.065**
	(0.976)	(0.023)	(0.986)	(0.024)
Pipeline fixed effects [b]	5.89	8.39	5.34	8.29
Therapeutic area effects [b]	27.11***	4.89	27.90***	4.86
Technology area effects [b]	24.69***	19.16***	23.29***	20.08***
Period effects [b]	7.32	0.38	8.41*	0.41
Rho	0.539***		0.543***	
	(0.104)		(0.105)	
Log likelihood	461.36		463.70	
χ^2	908.9***		1576.7***	

[a]N=337. *** p<0.001, ** p<0.01, * p<0.05, + p<0.1. Clustered robust standard errors in parentheses (clusters =119).
[b]Table entries show χ^2 values for joint significance.

Figure 1: Advisory-Appropriation trade-offs under Hypothesis 1a

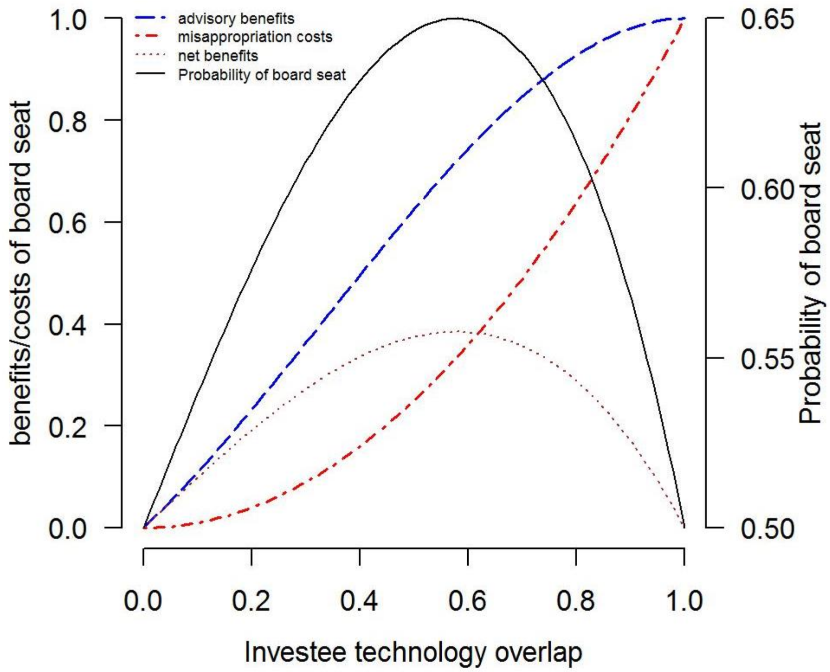


Figure 2: Advisory-Appropriation trade-offs under Hypothesis 1b

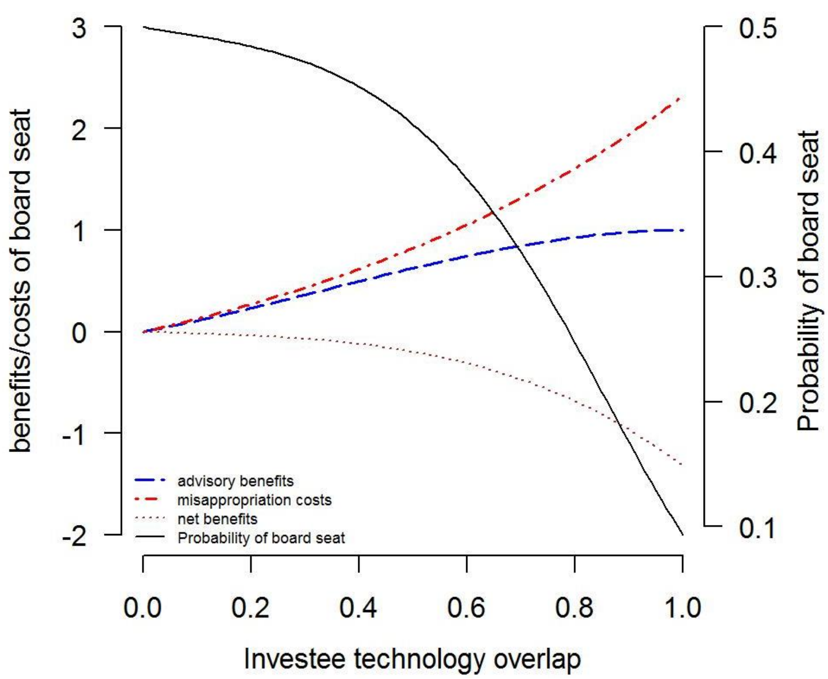
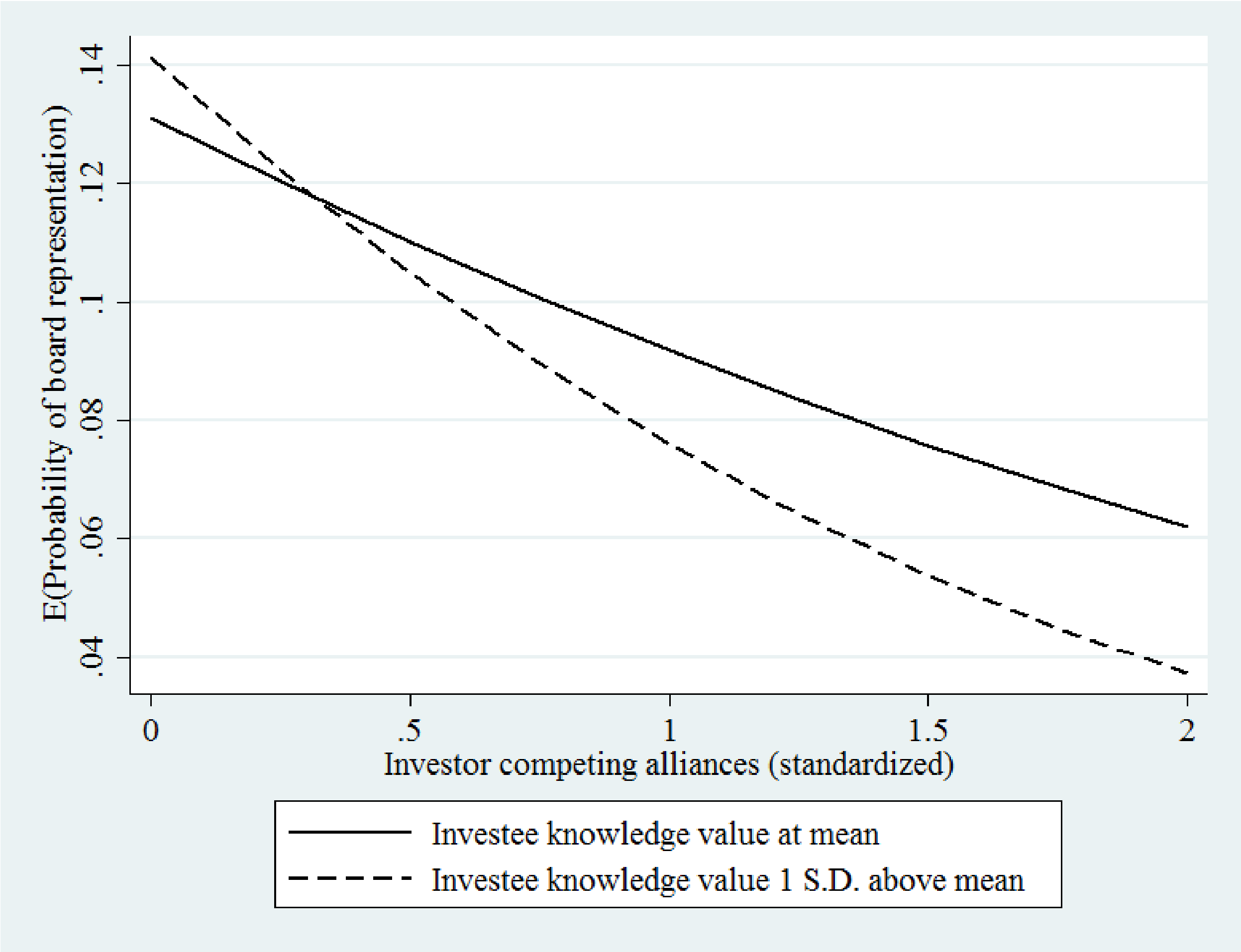


Figure 3: Interaction between investor prior competing alliances and investee knowledge value



ENDNOTES

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[i] We plot Figures 1 and 2 using a simple stylized model. We consider a setup in which investee firms are identical in every other way but the extent of technology overlap with the investor. Benefits to receiving advice from an investee board member increase throughout the theoretical range of the overlap (i.e., [0,1]). It is reasonable to assume that the incremental benefit that an investee firm obtains with a slightly higher level of overlap decreases at high levels of overlap because of limitations on other inputs such as technological or financial resources. We fix the profile of benefits from the advisory function of directors, and vary the behavior of appropriation costs for investees. Because our interest lies in examining R&D partnerships and scenarios where appropriation costs are nontrivial, we vary the behavior of appropriation costs with an increase in overlap, specifically the rate at which appropriation costs for these otherwise identical investee firms increase with overlap. The "shark behavior" of the investors is captured by the convexity of the appropriation costs function. Following the latent variable interpretation of a standard probit function, we model the probability of board seat as a function of net potential benefits in the following way:

- $Net\ benefits_i = Advisory\ benefits_i - Appropriation\ costs_i + \varepsilon_i$, where error ε_i is standard normally distributed i.e., $\varepsilon_i \sim N(0,1)$
- P(Board seat for investor) = $P(Net\ benefits_i > 0)$

  = $P[\varepsilon_i > -(Advisory\ benefits_i - Appropriation\ costs_i)]$

  = $1 - \Phi[-(Advisory\ benefits_i - Appropriation\ costs_i)]$, where Φ is the standard normal cumulative distribution function.

[ii] Our dependent variable for board representation of the investor on the investee's board is binary, and using OLS to model such binary dependent variables is problematic for two main reasons. First, the use of OLS is that predicted values $\hat{y}$ can take values below zero or above 1, which lie outside the natural bounds of a probability measure. Second, it creates a heteroscedasticity problem because the error is $\hat{y}$ when the observed value is zero and 1-$\hat{y}$ when the observed value is one, so the variance of the error term is thus $\hat{y}$ (1-$\hat{y}$) and thus heteroscedastic. To adjust for this, Goldberger's (1964) approach weights the dependent variable by 1/($\sqrt{\hat{y}}$ (1-$\hat{y}$). To address this issue, Goldberger suggested substituting a value close to 0 when $\hat{y}$ is negative and a value close to 1 when $\hat{y}$ is greater than 1. When we estimated an OLS model, we found that the upper limit of the predicted values is below 1, but there exist a large number of observations (over 20% of the sample) for which the values are below zero, again making OLS inappropriate. For these cases, when estimating WLS we substituted the predicted values with 0.001 for calculating weights (please see results below). However, our results remain consistent even if we do not replace the negative predicted values and simply use the remaining sample of 265 observations and the weighting approach noted above to address heteroscedasticity.