GOING FAST OR FASTIDIOUS: EXAMINING THE INFLUENCE OF DIRECTOR EXPERIENCE ON EXTERNAL KNOWLEDGE SOURCING

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ABSTRACT

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High technology firms are increasingly dependent on the external environment as a source of knowledge. Recent governance studies indicate that the board of directors is uniquely positioned to help such firms notice and obtain outside knowledge. However, the extant research is yet to examine how directors' backgrounds might shape the firm's external knowledge sourcing strategies. This omission is critical because the firm can obtain external knowledge using distinct modes, and directors will likely favor modes that reflect their orientation toward technology and market issues. In my dissertation, I address this gap by examining the link between directors' experience and three widely studied knowledge sourcing modes: inventor recruitment, R&D alliances, and technology acquisitions. Drawing on upper echelons theory and the innovation literature, I argue that boards populated by directors with technical and marketing experience will evidence differing patterns in knowledge sourcing. The findings show that while technical experience enables directors to shape all examined modes, marketing experience appears to have little impact on the firm's knowledge sourcing choices. Specifically, I find that directors with technical experience increase knowledge sourcing via inventor recruitment and R&D alliances and decrease technology acquisitions. More importantly, these relationships are contingent on the quality of the firm's knowledge capabilities and the latest technological developments in the competitive environment. I discuss the theoretical implications of the dissertation and potential future directions.

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INTRODUCTION

Recent advances in the governance literature suggest that boards are increasingly involved in monitoring and advising innovation strategies and performance (Balsmeier, Buchwald, & Stiebale, 2014; Balsmeier, Fleming, & Manso, 2017; Dalziel, Gentry, & Bowerman, 2011; Howard, Withers, & Tihanyi, 2017; Kang, Liu, Low, & Zhang, 2018; Katila, Thatchenkery, Christensen, & Zenios, 2017; Klarner, Probst, & Useem, 2020). Directors can exercise their authority at the "apex of control" to monitor innovation investments and the firm's efforts to adapt to technological and market trends (Dalziel et al., 2011; Faleye, Hoitash, & Hoitash, 2011). Further, directors with the right expertise can help manage innovation complexities by providing strategic advice, channeling valuable information between organizations, and keeping the management abreast of critical developments (Balsmeier et al., 2014; Hillman & Dalziel, 2003; Howard et al., 2017; Klarner et al., 2020).

An emerging contribution of directors to innovation activities is helping the firm recognize and source external knowledge (Balsmeier et al., 2014; Klarner et al., 2020; Howard et al., 2017). External knowledge sourcing is an innovation activity that has grown in importance over the past three decades (Teece et al., 2010). It is the result of a shift by high technology firms from relying extensively on internal research and development (R&D) to sourcing innovation ideas and resources from external actors (Aggarwal, 2020; Arora, Belenzon, & Patacconi, 2018; Cassiman & Veugelers, 2006; Laursen & Salter, 2006; Teece, 2010). This shift is in response to increasingly dynamic and complex technological and competitive landscapes (Chen, Lin, & Michel, 2010; Eggers & Park, 2018; Schilling, 1998) that have made it critical for executives to maintain external awareness and ensure timely adaptation (Kaplan, 2008). However, due to bounded rationality, executives hold inherently incomplete views of the external environment

and the relevant opportunities and threats (Eggers & Kaplan, 2013).

Against this backdrop, firms are turning to their boards to enhance external awareness and formulate knowledge sourcing strategies. (Howard et al., 2017; Klarner et al., 2020). As one of the primary linkages between the firm and its environment (Pfeffer & Salancik, 2003), the board can monitor whether the firm's internal capabilities align with external trends and provide valuable inputs to this end. For instance, two recent studies illustrate the importance of the board to knowledge sourcing. First, Howard et al. (2017) showed that firms rely on interlocking directors to mitigate patent litigation and increase inter-firm cooperation. Second, Klarner et al. (2020) revealed a substantial involvement from directors with scientific experience in identifying and adapting to emerging technologies in the pharmaceutical industry. These studies highlight the board's increased involvement in strategy-making and directors' critical role as "strategic partners" with the CEO (Boivie, Graffin, Withers, & Corley, 2021).

This dissertation builds on the recent insights regarding board involvement in strategy-making and knowledge decisions, particularly, and advances this line of inquiry by investigating two important questions. First, if directors increase awareness of relevant issues in the innovation landscape, how do their attentional models shape the firm's approach to outside knowledge? In this vein, the strategic leadership literature holds that decision-makers most attentive to innovation are those with technical and marketing backgrounds (i.e., output-oriented) (Barker & Mueller, 2002; Hambrick & Mason, 1984; Tuggle et al., 2010). Those who work in technical and marketing functions perform essential innovation activities, namely, invention and commercialization (Becker & Lillemark, 2006). However, the innovation literature shows that technical and marketing backgrounds engender different thought worlds (Dougherty, 1992). This suggests that even if directors are concerned with the firm's knowledge capabilities, they might

not prefer the same strategies for obtaining them. Second, through which modes does the board help the firm access outside knowledge? The firm can source knowledge through several modes; some are punctuated and strategic (e.g., strategic alliances and major acquisitions) and thus require the board's involvement and ratification (Boivie, Bednar, Aguilera, & Andrus, 2016). However, more frequent activities such as inventor recruitment and startup acquisitions are also critical for adding technological capabilities (Mawdsley & Somaya, 2016) but have received scant attention from the governance literature. If directors are becoming more involved in strategy-making, does their involvement extend to such frequent activities?

To answer these questions, I draw on upper echelons theory (Hambrick & Mason, 1984) and the ability-motivation framework (Blumberg & Pringle, 1982) and integrate insights from the innovation literature to link directors' technical and marketing experiences to knowledge sourcing. I argue that while both technical and marketing experiences sensitize directors to innovation information, they enable and motivate directors differently. On the one hand, technical experience enables directors to notice technology trends and understand the research and development process; it also motivates directors to regard advancing knowledge as a primary goal. On the other hand, marketing experience enables directors to notice market trends and understand the knowledge commercialization process and, at the same time, motivates them toward generating market growth. I develop theoretical arguments to explain how these differences will likely manifest in distinct approaches to sourcing knowledge.

Specifically, I link directors' technical and marketing experience to three knowledge sourcing modes: inventor recruitment, R&D alliances, and technology acquisitions. I focus on these modes for two reasons. First, the innovation literature indicates that these three modes are among the most strategically important linkages to the external environment (Arora &

Gambardella, 1990; Eggers & Park, 2018; Wagner & Goossen, 2018) and, therefore, are likely to draw the board's attention. Second, knowledge sourcing through hiring, cooperating with different types of partners, or acquiring different types of targets reflects distinct innovation motives in terms of expediency, risk, and integration (Carayannopoulos & Auster, 2010; Cassiman & Veugelers, 2006; Rosenkopf & Almeida, 2003).

I hypothesize that directors with technical experience will emphasize recruiting qualified inventors, expanding the alliance portfolio, and acquiring small entrepreneurial technology targets. This pattern reflects directors' ability to notice nascent technologies and recognize the challenges of assimilating sourced knowledge, and also reflects a motivation to achieve knowledge leaps. I also hypothesize that directors with marketing experience will emphasize alliances with established partners and acquisitions of established technology targets and will place less emphasis on inventor recruitment. Again, this pattern reflects directors' ability to comprehend commercialization issues and their motivation to speed up the innovation process and seize market opportunities. To further elucidate the underlying mechanisms, I examine moderators that align with the knowledge and attention of directors with technical and marketing experiences. Specifically, I examine the influence of directors with technical experience on knowledge sourcing under conditions of low knowledge quality and the influence of directors with marketing experience following rivals' breakthrough innovations (hereafter: *rivals' breakthroughs*).

This dissertation makes four distinct contributions to the literature. First, I provide a richer and more nuanced examination of the link between the board's composition and how the firm adds new technical capabilities. A burgeoning stream in this area indicates that directors with relevant expertise are vital to the firm's awareness of and engagement with the external

knowledge environment (Balsmeier et al., 2014; Howard et al., 2017; Klarner et al., 2020). However, this line of research is yet to integrate insights from upper echelons research at the board level to understand how directors' experience shapes and frames knowledge recognition and assimilation. Upper echelons theory is a useful theoretical lens in this regard because it posits that directors' attention to innovation issues reflects their functional experience (Finkelstein et al., 2009). In this vein, by integrating insights from both the strategic leadership and innovation literature, this dissertation suggests that knowledge sourcing activities appeal differently to directors with different innovation-related backgrounds. Offering a nuanced examination of director qualities and knowledge strategies is consistent with the shift in governance literature toward specifying the relationships between governance elements and strategic outcomes to improve our understanding of the board value (Hambrick et al., 2015; McDonald, Westphal, & Graebner, 2008).

Second, I contribute to the literature regarding the board's involvement in strategy-making. Recent observations of the inner workings of boards suggest that directors' roles extend beyond arm-length advice and control over major initiatives (Boivie et al., 2021; Klarner et al., 2020). I add to this line of inquiry by linking director experience to inventor recruitment and startup acquisitions—two activities that increase the firm's technical human capital. To date, the governance literature has paid little attention to the link between the board of directors and human resources (for an exception, see Griffin, Li, & Xu, 2021), presumably because the traditional view of the board duties has focused on punctuated events (Boivie et al., 2016). However, as boards become more involved in strategy-making, human resources represent a potential strategic domain whereby directors can influence knowledge sourcing.

Third, I contribute to upper echelons theory by differentiating between directors'

technical and marketing backgrounds. Upper echelons theory combines technical and marketing roles under output-oriented functions, suggesting that strategic leaders with backgrounds in these functions are more externally oriented than those with throughput-oriented backgrounds (Barker & Mueller, 2002; Hambrick & Mason, 1984; Tuggle et al., 2010). However, key differences likely exist in how output-oriented directors notice and respond to external technology and market developments (Katila et al., 2017). By comparing technical and marketing directors in their preference for utilizing external resources, this dissertation suggests that even if strategic leaders (e.g., CEOs, TMT members, and directors) are externally oriented, they likely differ in their perception of innovation threats and opportunities.

Finally, I contribute to the broader innovation literature by jointly examining multiple knowledge sourcing modes. For example, researchers have compared inventor recruitment to R&D alliances (Rosenkopf & Almeida, 2003; Tzabbar, Aharonson, & Amburgey, 2013) and R&D alliances to technology acquisitions (Carayannopoulos & Auster, 2010; Moeen & Mitchell, 2020). In addition to considering all three modes in a single study, examining inventor recruitment and technology acquisitions together is insightful given that they represent alternative approaches for obtaining technical workforce (Mawdsley & Somaya, 2016), and little is known about the firm's choice between these approaches.

LITERATURE REVIEW

To develop theory and hypotheses that link directors' experience to the firm's approach to external knowledge, I draw primarily on two strands of literature: the external knowledge sourcing and the board of directors literature. As such, in this section, I provide a broad review of these two areas of research. At the end of the review, I identify relevant gaps that this dissertation aims to fill.

External knowledge sourcing

With the growing dispersion of knowledge production among many participants in a technological field[1] (Eisenhardt & Santos, 2002), and the fast-paced nature of technological change (Brown & Eisenhardt, 1997), maintaining the core resources and capabilities necessary to innovation within the boundaries of individual firms is no longer an efficient or even tenable strategy. Instead, firms are increasingly innovating by complementing internal research and development efforts with external knowledge sourcing (Cassiman & Veugelers, 2006; Choi & McNamara, 2018; Laursen & Salter, 2006). External knowledge sourcing is a "process by which managers identify and gain access to relevant knowledge that is being created in the environment." (Eisenhardt & Santos, 2002, p. 145). This process is widely recognized as an essential innovation capability (Cohen & Levinthal, 1990; Eggers & Park, 2018). In fact, "the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments" (Teece, Pisano, & Shuen, 1997: 516) is at the heart of competitive advantage.

[1] The use of technology as a descriptor of some aspects of knowledge is purposeful. Technology is a subset of knowledge that is more relevant to theories of innovation. As Dosi (1982) noted, technology is a set of pieces of knowledge embodied in physical equipment, procedures, and methods or stored tacitly in the form of expertise and know-how. Throughout this manuscript, technology and knowledge are often used interchangeably.

Due to their central importance to innovation and strategic renewal, knowledge sourcing modes have received substantial interest from the innovation literature (Eisenhardt & Santos, 2002). Numerous linkages connect the firm to external knowledge actors, but reviewing them is beyond the scope of this dissertation. However, I consider three external sourcing modes that have received considerable attention: *inventor recruitment* (Eggers & Park, 2018; Mawdsley & Somaya, 2016; Rosenkopf & Almeida, 2003; Tzabbar, 2009; Wagner & Goossen, 2018), *R&D alliances* (Ahuja et al., 2008; Khanna, Gulati, & Nohria, 1998; Ryu, McCann, & Reuer, 2018; Wagner & Goossen, 2018; Yang, Zheng, & Zaheer, 2015), and *technology acquisitions* (Ahuja & Katila, 2001; Choi & McNamara, 2018; Graebner et al., 2010; Moeen & Mitchell, 2020; Younge, Tong, & Fleming, 2015). These activities are strategically important because they enable the firm to obtain tacit knowledge by transplanting new human capital and providing current employees with opportunities to observe and learn from others. Also, recruitment, alliances, and acquisitions satisfy different innovation needs (Carayannopoulos & Auster, 2010; Tzabbar et al., 2013) because they differ in the size and scope of the knowledge they channel, integration difficulties, and access to complementary resources. Studying the firm's propensity to engage in such activities could reveal differences in directors' attention and response to innovation issues.

Inventor recruitment. Also known as inventor mobility, inventor recruitment is a well-documented means for interorganizational knowledge spillover and the diffusion of competitive routines (for a review, see Mawdsley & Somaya, 2016). Inventors—mostly scientists or engineers (Gruber, Harhoff, & Hoisl, 2013)—are the locus of the combinative processes underlying innovation and are the repositories of tacit knowledge. As inventors move, they transfer knowledge to distal geographic and technological domains, enabling the receiving

organization to break from local and path-dependent learning routines (Song, Almeida, & Wu, 2003; Tzabbar, 2009). Simon captures the logic of learning via hiring in his assertion that "an organization learns in only two ways: (a) by the learning of its members, or (b) by ingesting new members who have knowledge the organization did not previously have." (Simon, 1991, p. 125). The later mechanism is immediate; hired workers bring valuable tacit knowledge that is difficult to transfer without the physical movement of those who embody it (Dosi, 1988). However, mobility also entails the former mechanism, whereby social interactions between incoming and incumbent employees diffuse knowledge throughout the hiring firm (Nonaka, 1994).

The knowledge that the hiring firm receives comes in the form of technical know-how and path-breaking routines. As several large-scale studies have demonstrated, inventor recruitment transfers knowledge across organizational (Rosenkopf & Almeida, 2003), geographic (Almeida & Kogut, 1999), and technological boundaries (Song et al., 2003). Further, the flow of human capital between organizations is critical to adaptation. For example, Keum (2020) found that following the adoption of employee protection laws, which reduce labor movement, firms needing to adjust their technical capabilities fell even farther behind their rivals. Indeed, hiring qualified inventors enables the firm to adjust to technological change and explore new domains. For example, Kim (1997) showed that Samsung entered the semiconductor industry by hiring engineers and scientists from pioneering semiconductor firms such as Intel and IBM. Similarly, Eggers (2016) found that IBM began its pivot from plasma to LCD flat panel displays by hiring two scientists with expertise that IBM did not possess internally. Further, adapting through recruitment is attractive due to the limited integration frictions that otherwise could inhibit the firm from assimilating outside knowledge (Rosenkopf & Almeida, 2003; Tzabbar et al., 2013).

Inventor mobility is also a means for building competitive learning routines. In addition to technical knowledge, hired inventors can help reconfigure the firm's existing capabilities and break away from path dependency (Mawdsley & Somaya, 2016). This is because the knowledge of hired inventors likely contains unfamiliar heuristics (Tzabbar, 2009) that could facilitate a "creative abrasion" process, which Leonard-Barton (1995: 64) argued is necessary to prevent the rigidification of learning capabilities. As such, recruits could motivate the firm to reinvigorate its innovation processes and reduce its commitment to established routines. Indeed, Tzabbar (2009) demonstrated that firms that hired inventors from unfamiliar technological domains repositioned from path-dependent trajectories to novel knowledge combinations. Similarly, Lacetera, Cockburn, and Henderson (2004) found that pharmaceutical firms relied on hired scientists to change their product development capability toward a science-based drug discovery process.

R&D alliances. R&D alliances are voluntary agreements among firms and other organizations to share knowledge and resources for the co-development of products and technologies (Inkpen & Tsang, 2007). Firms form alliances for multiple purposes, such as marketing, distribution, risk-sharing, and access to foreign markets. However, the most strategically important alliances have been learning-oriented alliances (e.g., R&D alliances), which are formed for the primary purpose of developing new knowledge and sharing existing knowledge among partners (Ahuja et al., 2008; Inkpen & Tsang, 2007; Khanna et al., 1998). Such alliances provide an alternative to costly internal development and risky outright acquisitions (Inkpen & Tsang, 2007), especially when the returns to knowledge are uncertain or only partially appropriable (Grant, 1996).

Alliances link firms with distinct competencies, acting as conduits for knowledge sharing and technology transfer (Mowery, Oxley, & Silverman, 1996). Learning takes place in alliances

"through the shared execution of the alliance task, mutual interdependence and problem solving, and observation of alliance activities and outcomes." (Inkpen, 2000, p. 1019). Alliances facilitate these learning mechanisms because cooperative interactions are often deep and meaningful and expose partners to each other's skills, technical know-how, and innovative capabilities (Fey & Birkinshaw, 2005). More importantly, alliances transfer highly tacit and context-specific knowledge by providing a social context for interactions and observations among partners' employees (Fey & Birkinshaw, 2005; Inkpen, 2000).

Empirical evidence demonstrates that alliances lead to inter-firm knowledge transfer. Most of this evidence comes from studies utilizing patent citations to assess inter-firm knowledge flows. For example, Mowery and colleagues (1996) found that equity alliances increased cross citations among alliance partners. However, patents represent codified knowledge, while the true value of alliances is the transfer of tacit knowledge. To this end, results from survey data suggest that alliances lead to tacit knowledge diffusion and, in so doing, facilitate the assimilation of codified knowledge (Dhanaraj, Lyles, Steensma, & Tihanyi, 2004). Consistent with this idea, Gomes-Casseres, Hagedoorn, and Jaffe (2006) demonstrated that firms cited patents of alliance partners at a higher rate than they cited non-partners, suggesting that the alliance assisted in explaining the processes and routines that generated patents. Further, evidence from stock market reactions to alliance formation supports their role in facilitating knowledge acquisition. For example, knowledge-intensive firms positioned to learn more from the alliance enjoyed higher abnormal returns following an alliance announcement (Kale, Dyer, & Singh, 2002; Yang et al., 2015).

Firms enter an alliance arrangement expecting both common and private benefits. According to Khanna (1998: 341): "private benefits are defined as those that accrue to subsets of

participants in an alliance while common benefits are defined as those that accrue collectively to all participants." Common benefits are symbiotic gains that reflect the alliance's overt objective, whereby partners complete a specified task and realize a shared goal. They result from leveraging complementary resources, increasing knowledge inputs to the innovation process, and achieving economies of scale (Ahuja et al., 2008). On the other hand, private benefits reflect opportunistic learning behavior where one partner attempts to outlearn the other or internalize its core capabilities (Khanna et al., 1998). In this respect, Hamel (1991: 87) observed: "Some partners may regard internalization of scarce skills as a primary benefit of…collaboration." In essence, an alliance provides the firm with a rare opportunity to observe and imitate knowledge deeply embedded within the partner's processes, people, and routines (Inkpen & Tsang, 2007).

The alliance literature makes a key distinction between cooperating with new and repeat partners (Goerzen, 2007; Gulati, 1995; Lavie & Rosenkopf, 2006). These two types of alliances involve important learning tradeoffs. On the one hand, alliances with new partners are rich in novel ideas and challenging routines that could help partners expand their knowledge base and capitalize on new opportunities (Zheng & Yang, 2015). However, new partnerships are challenging to manage due to the lack of partner-specific experience needed to facilitate task coordination (Kale, Singh, & Perlmutter, 2000). On the other hand, repeat alliances facilitate quicker learning through partner-specific learning routines (Zollo, Reuer, & Singh, 2002). As partners collaborate repeatedly, they grow accustomed to each other's routines, develop a shared understanding, and establish an absorptive capacity of partners' knowledge (Kim & Inkpen, 2005). However, familiarity could lock the firm into arrangements that contain redundant knowledge (Goerzen, 2007). Further, research on mental schemas suggests that repeated interactions among creative personnel give rise to shared mental models that converge on

familiar ideas and filter out novelty and diversity (Skilton & Dooley, 2010).

Technology acquisitions. When it comes to sourcing external knowledge, technology acquisitions provide a complete means to expanding the firm's knowledge stock and product portfolio (for a review, see Graebner et al., 2010). Compared to the previously examined sourcing activities (i.e., recruitment and alliances), acquisitions offer two distinct advantages: speed and quality of access to outside knowledge (Carayannopoulos & Auster, 2010). While access in recruitment and alliances can be limited or temporary, acquisitions enable the firm to transplant the target's entire knowledge stock, socially embedded routines, valuable human capital, and complementary resources (Carayannopoulos & Auster, 2010; Ranft & Lord, 2000). Moreover, acquisitions improve the acquirer's market position by eliminating competitors, preempting key resources, and expanding the customer base and market footprint (Graebner et al., 2010). Against this backdrop, a recent M&A survey found: "Corporate respondents ranked acquiring technology assets as the No. 1 strategic driver for their M&A deals." (Deloitte, 2019: 10). However, technology acquisitions can fall short of their promise due to the difficulties of assessing the target's intangible knowledge assets (Coff, 1999) and integrating the combined knowledge bases and human capital (Puranam et al., 2006). As such, technology acquisitions have a high failure rate. For example, the CEO of the serial technology acquirer Cisco estimated the failure rate of technology acquisitions to be 90% (Graebner et al., 2010).

Firms undertake technology acquisitions to leverage their existing resources (Capron & Mitchell, 2009), generate new technological combinations (Choi & McNamara, 2018), adapt to technology change (Chen, Hsu, Officer, & Wang, 2020), shorten the product development cycle (Puranam et al., 2003), and enter new markets (Moeen & Mitchell, 2020). Overall, the extant literature classifies technology acquisitions into two categories: knowledge-driven acquisitions

that add novel knowledge inputs and ready to market products (Choi & McNamara, 2018; Puranam et al., 2003) and market-driven acquisitions that enhance market power, customer knowledge, and downstream capabilities (Cassiman et al., 2005; Lee & Kim, 2016).

In knowledge-driven acquisitions, acquirers gain technological recombination opportunities and obtain ready-to-market products (Puranam & Srikanth, 2007). Synergies in such acquisitions result from expanding the ideas pool and knowledge recombination potential (Ahuja & Katila, 2001; Choi & McNamara, 2018) and from redeploying the acquirer's marketing capabilities to launch acquired technologies (King et al., 2008; Puranam & Srikanth, 2007). In market-driven acquisitions, the acquirer obtains new knowledge and realizes synergies from combining downstream market resources (Lee & Kim, 2016). Such acquisitions improve innovation by (1) providing knowledge about new customer segments and market trends and (2) providing access to co-specialized complementary assets necessary for marketing technology. These co-specialized assets are important to acquisition outcomes because they might not exist in the acquirer's portfolio of generic commercialization capabilities (Moeen & Mitchell, 2020; Ranft and Lord, 2000). Thus, market-driven technology acquisitions are more likely to accelerate market response time (Lee & Kim, 2016).

The distinction between knowledge-driven and market-driven acquisitions translates into a distinction between the targets better suited to serving these motives. In this vein, small entrepreneurial firms (i.e., startups) align better with the knowledge motive (Aggarwal & Hsu, 2014; Poulsen & Stegemoller, 2008). Such targets possess an entrepreneurial culture and venture capital backing that support experimentation with risky research projects and are not subject to financial markets' short-time horizons and regulatory requirements that curtail innovation (Aggarwal & Hsu, 2014). Indeed, evidence shows that innovation quality is the highest among

privately-owned startup firms (Aggarwal & Hsu, 2014). As such, the motive behind acquiring small firms is often the desire by established firms to explore emerging technologies and capitalize on small firms' comparative research advantage (Graebner et al., 2010). By contrast, acquisition targets that align with market objectives are large, established firms. Such targets possess marketing, manufacturing, and operational capabilities and thus could provide quicker access to market opportunities (Lee & Kim, 2016). In addition, established firms are likely to have a larger market footprint and deep knowledge of customers, allowing the acquirer to enhance market power and thwart competitive pressures.

Next, I turn to the governance literature to review the link between the board of directors and the firm's knowledge.

The Board of directors

The governance literature classifies the board activities into two functions: monitoring and advising. The monitoring activities include overseeing the firm's overall strategy, aligning managerial incentives with shareholder interests, and approving strategic initiatives (Boivie et al., 2016; Fama & Jensen, 1983; Hambrick et al., 2015). The advising activities include supporting the firm management, providing strategic advice and resources, and conferring legitimacy (Hillman & Dalziel, 2003; Pfeffer & Salancik, 2003; Westphal, 1999). Effective monitoring requires directors to have the requisite independence, domain expertise, bandwidth, and motivation to engage deeply, objectively, and proactively in governing the firm (Hambrick et al., 2015). By contrast, directors should possess relevant human and social capital to fulfill the advising function (Hillman & Dalziel, 2003). Human capital refers to "an individual's expertise, experience, knowledge, reputation, and skills." (Haynes and Hillman, 2010: 1146), and social capital refers to "the sum of the actual and potential resources embedded within, available

through, and derived from, the network of relationships possessed by an individual." (Nahapiet & Ghoshal, 1998: 243).

The board can impact significant strategic issues because it represents the apex of control and often consists of members with diverse experiences and connections. One such issue that has increasingly interested the governance literature is innovation (Balsmeier et al., 2014; Howard et al., 2017; Kang et al., 2018; Klarner et al., 2020). Academic attention to the intersection of the board and innovation accompanies growing calls from practitioners for the board to take an active role in innovation and technology issues (Hill & Davis, 2017). Such involvement is a necessary response to technology's growing complexity and dynamism and the firm's dependence on external knowledge providers. As mediators between the firm and the environment, directors can bring unique perspectives and resources to firms competing in high technology industries (Howard et al., 2017).

Governance scholars have examined the intersection of the board and innovation in terms of monitoring and advising functions. Studies linking monitoring levers to innovation efforts and outcomes indicate that monitoring might exacerbate innovation risks and challenges. For example, Balsmeier et al. (2017) demonstrated that board independence is associated with more patenting activities and received citations but fewer influential patents. In a similar vein, Faleye et al. (2011) found that intense monitoring reduces R&D spending and lowers patenting quality. These findings are consistent with agency theory's (Jensen & Meckling, 1976) prediction that strong oversight may cause risk-averse managers to forgo bold investments and focus on predictable, low variance projects. Kang et al. (2018) add to this argument by showing that friendly ties between directors and the CEO improve innovation outcomes, suggesting that the board should provide the advice and support managers need to pursue long-term initiatives.

These findings echo a broader view in the financial economics literature that monitoring crowds out advising (Adams & Ferreira, 2007).

The strategic management view—to which this dissertation subscribes—holds that directors employ monitoring and advising levers in tandem to enhance governance effectiveness and aid executives (Hillman & Dalziel, 2003). Indeed, the right expertise enables outside directors to comprehend the issues at hand, evaluate the firm's strategic direction, and channel relevant resources and advice (Hambrick et al., 2015). Given its complexity and risky nature, innovation is a domain that benefits from independent directors with specialized expertise and connections. In line with this reasoning, Sundaramurthy, Pukthuanthong, and Kor (2014) showed that biotechnology startups realized a better IPO performance when the board employed directors with industry experience and scientific background. Moreover, Balsmeier et al. (2014) found that directors who manage innovative firms (CEO-directors) were associated with higher quality patents while directors from noninnovative firms were associated with lower quality patents. They assert: "External managers with an appropriate professional background help to transfer crucial information and provide scarce specific knowledge and expertise to the board." (p. 1812).

A few studies have explicitly examined the board as a conduit of outside knowledge. This line of research shows that directors' domain-specific expertise and relevant connections are important preconditions in this regard. Two relevant studies are especially worthy of review. First, Klarner and colleagues (2020) conducted a qualitative study to uncover how directors with scientific backgrounds monitored and advised innovation at four large pharmaceutical companies. They showed that directors with such specialized human capital engaged deeply and meaningfully in various innovation issues, often outside formal board meetings and with non-executive R&D staff. Scientific directors were not just reactive to information presented by the

management; instead, they proactively presented the firm's scientists and engineers with new ideas and engaged in substantive discussions about scientific pathways to innovation. More importantly, scientific directors helped link these firms to the external knowledge environment. By drawing attention to the latest developments they encountered in their research fields and identifying potential acquisition targets, these directors filled gaps in the firm's external awareness. In a similar vein, they monitored the firm external sourcing strategies, for example, by evaluating the innovation capabilities of acquisition targets and pressing the management on the ability to leverage such capabilities.

Second, Howard and colleagues (2017) examined board interlocks between firms operating in high technology industries (e.g., semiconductors, medical devices, and communications). They showed that knowledge dependence among innovative firms leads to the formation of board interlocks. In interviews with technology firms' executives, Howard and colleagues revealed that firms selected directors with innovation expertise and connections to respond to innovation uncertainty. Indeed, their study showed that knowledge interlocks helped mitigate knowledge dependence by reducing patent litigation between interlocked firms and increasing R&D alliances.

Together, these two studies, and the broader literature reviewed here, indicate that with the shift toward external knowledge as a driver of innovation, board directors can play a pivotal role in monitoring and advising innovation. Moreover, the evidence of directors' meaningful involvement in innovation is consistent with an emerging view of board directors as strategic partners with the CEO (Boivie et al., 2021). This view suggests that directors with relevant domain-specific expertise provide critical inputs into strategies initially proposed by the CEO and shape the ultimate strategy (Boivie et al., 2021). The studies reviewed above reveal that such

a strategic partnership can improve the effectiveness of the firm's knowledge strategies. Also, they suggest that opportunities exist to examine the influence of expert directors on knowledge sourcing activities that do not constitute major strategic initiatives but impact the firm's innovation capabilities (e.g., inventor recruitment, startup acquisitions). Below, I discuss these and other contribution opportunities.

Opportunities for contribution

Based on the literature review, there are two opportunities for contributing to the link between the board of directors and innovation. First, this line of research can be expanded into the board's influence on external knowledge sourcing activities. Doing so will explicate the mediating mechanisms through which the board contributes to distal outcomes such as innovation performance. Specifically, examining a broader set of knowledge sourcing activities with varying benefits and drawbacks will allow a comprehensive treatment of how the board drives knowledge sourcing. In this vein, while the extant literature shows that boards influence alliances and acquisitions, it remains unclear how directors differ in their influence on different types of technology-driven alliances and acquisitions. At the same time, it remains unclear whether the board shapes knowledge sourcing via alternative modes such as inventor recruitment.

Second, the relationship between director human capital and knowledge is an area that needs further investigation as most large-scale studies in this area have limited their focus to director social capital (Balsmeier et al., 2014; Howard et al., 2017). In this respect, because innovation is a complex and multistage process, it should interest directors from different backgrounds that bear on the generation and commercialization of new technological concepts. While directors with a background in science and engineering deal with knowledge inputs and

the combinative processes that generate inventions—making them obvious candidates for linking innovation to governance—innovation is incomplete without commercialization efforts (Teece, 2010). As such, directors with a background related to the market side of innovation are also important to examine.

THEORY DEVELOPMENT

The governance literature has long recognized experience as a key indicator of a director's value to the firm (Fama & Jensen, 1983; Hambrick et al., 2015; Hillman & Dalziel, 2003; Pfeffer & Salancik, 2003). Nevertheless, with the shift in viewing directors not only as independent monitors but also as providers of critical advice and strategic partners with the firm's management (Boivie et al., 2021), the governance field is witnessing a renewed interest in director expertise (Hambrick et al., 2015; Lungeanu & Zajac, 2019). Recent insights indicate that experience gives directors an outsized influence on the firm's strategy (Lungeanu & Zajac, 2019) and board discussions of domain-relevant issues (Boivie et al., 2021; Klarner et al., 2020). However, while experience enhances decision-making quality, it also blinds decision-makers to issues outside their domain of expertise (Walsh, 1995). As such, governance researchers are interested in how experience explains directors' attention to and influence over various elements of the firm's strategy (Golden & Zajac, 2001; Tuggle et al., 2010).

In this vein, upper echelons theory posits that experience influences how directors scan, filter, and interpret information in the firm's environment (Finkelstein et al., 2009; Hambrick & Mason, 1984). At first, experience familiarizes directors with specific stimuli and, in so doing, delimits their fields of vision. Second, experience influences selective perception by conditioning directors to regard certain stimuli as more relevant. Finally, directors rely on heuristics, analogies, and abstract rules—honed through experience—to assign meaning to noticed stimuli (McDonald et al., 2008). The filtering process proposed by upper echelons theory describes board members' strategic orientation and priorities (Golden & Zajac, 2001). Because directors have limited time and information processing capacities to allocate among many complex governance matters (Boivie et al., 2016), they will naturally overlook issues incongruent with

existing knowledge structures. Indeed, in a study of board meeting minutes, Tuggle and colleagues (2010) found that the issues that the board emphasized differed based on directors' functional experience.

These insights suggest that the extent to which the board will influence knowledge sourcing strategies depends on whether directors' mental models allow for noticing innovation-related developments. To this end, prior literature indicates that established firms source outside knowledge for two primary reasons: (1) renew innovation capabilities and expand knowledge recombination possibilities (Arora & Gambardella, 1990; Tzabbar, 2009) and (2) respond to market pressures and opportunities with ready-to-market products and related complementary assets (Chen et al., 2020; Gimeno, 2004; Puranam et al., 2003). Thus, boards populated by directors who pay attention to technology and market developments are more likely to influence how the firm obtains knowledge. More specifically, upper echelons theory argues that directors with output-oriented backgrounds (i.e., engineering/R&D, marketing/sales) scan for and assign a higher weight to information related to technology and products (Finkelstein et al., 2009). According to Hambrick and Mason (1984: 199), output-oriented functions "emphasize growth and the search for new domain opportunities and are responsible for monitoring and adjusting products and markets." Indeed, empirical evidence from the strategic leadership literature shows that technical and marketing experiences are associated with a prospector innovation strategy (Thomas, Litschert, and Ramaswamy, 1991), increased R&D spending (Barker & Mueller, 2002), attention to new product and market opportunities (Tuggle et al., 2010), external knowledge acquisition (Klarner et al., 2020), and better growth performance (Whitler et al., 2018).

However, while responsible for innovation activities, technical and marketing functions

are specific to different aspects of the innovation process (Becker & Lillemark, 2006; Griffin & Hauser, 1996). This process consists of invention and commercialization stages (Fleming, 2001; Kline & Rosenberg, 1986); technical experience familiarizes directors with the former stage, and marketing experience familiarizes directors with the latter (c.f. Katila et al., 2017). Thus, output-oriented directors—driven by specialization routines—will likely occupy different thought worlds (Dougherty, 1992) and hold distinct beliefs and preferences. In this vein, I draw on the ability-motivation framework and build theoretical arguments examining how such beliefs and preferences might shape directors' approaches to knowledge sourcing.

Technical and marketing experience: Ability and motivation

The extant governance literature suggests that directors respond to governance complexities by focusing on tasks aligned with their ability and motivation (Hambrick et al., 2015; Hillman et al., 2008; Shropshire, 2010). Whereas ability refers to the sum of knowledge, skills, and cognitive capacities (Blumberg & Pringle, 1982), motivation is "concerned with the energetic forces… that influence the initiation, direction, intensity, and duration of action." (Kanfer & Chen, 2016: 7). The strategic leadership literature indicates that prior functional experience is a proxy for decision makers' ability and motivation (Finkelstein et al., 2009; Waller, Huber, & Glick, 1995; Walsh, 1995). More specifically, experience helps directors develop efficiently organized knowledge structures that serve as the basis for attention and decision-making (Finkelstein et al., 2009; Walsh, 1995). Such knowledge structures consist primarily of abstract heuristics and analogies (Bingeham & Eisenhardt, 2011), which serve to chunk complex information into overarching concepts and patterns and map novel situations to past encounters with meaningful similarities (Chase & Simon, 1973; Gavetti, Levinthal, & Rivkin, 2005; McDonald et al., 2008; Walsh, 1995).

Experience is also closely associated with director motivation for two reasons. First, individuals are likely to select into careers that fit with their intrinsic motivation (Amabile, 1993) and, at the same time, employers screen candidates based on motivational fit (Derfler-Rozin & Pitesa, 2020). Second, career socialization processes accustom individuals to specific goals and condition relevant actions (Epstein, 2003; Feldman, 1981). In fact," with the passage of time and the accumulation of successes in a functional area, an individual becomes more and more socialized and inculcated with the mode of thinking and acting that is typical for that professional area." (Finkelstein et al., 2009: 88). Therefore, one can describe director motivation by assuming that functional experience shapes and frames what goals directors consider important.

Below, I examine key attributes of output-oriented directors' ability and motivation and their relevance to knowledge sourcing.

Director ability. Technical and marketing experiences enable directors to provide inputs that could spur a search for new knowledge. More specifically, technical experience reflects an understanding of scientific, engineering, and technological concepts and the processes and routines that facilitate inventing. Directors with technical experience are primarily scientists and engineers trained in academic research institutions and industrial R&D (Klarner et al., 2020). As scientists and engineers, "it is through their knowledge and skills that technological components get recombined and potentially path-breaking inventions created." (Gruber et al., 2013: 838). Moreover, prior research indicates that high technology firms appoint technical experts with remarkable achievements (e.g., Nobel laureates) to benefit from their specialized human capital and signal organizational legitimacy (Chen, Hambrick, & Pollock, 2008; Klarner et al., 2020).

As such, technical experience likely enables directors to shape knowledge sourcing by increasing attention to the latest technology trends and the firm's research and invention activities.

First, directors with technical experience can influence knowledge sourcing by helping the firm notice nascent technology trends within directors' domain expertise. These directors likely possess mental models that facilitate an expansive and accurate detection of emerging technologies. This is because the ideas that scientists and engineers need to generate novel and impactful knowledge reside mostly in distant technological and organizational domains (Fleming & Sorenson, 2004; Rosenkopf & Nerkar, 2001). Therefore, keeping abreast of the latest scientific and technological developments is a requisite skill in technical fields (Amabile & Gryskiewicz, 1987; Cockburn & Henderson, 1998). In addition to recognizing the current state of knowledge, technical expertise allows directors to anticipate its trajectory. After all, knowledge tends to develop along combinative and path-dependent trajectories (Dosi, 1982; Kogut & Zander, 1992). By knowing existing knowledge components and their latent interrelations, directors with technical experience can foresee how such components would interact to produce future knowledge. Second, in addition to domain-specific knowledge, technical experience facilitates a general understanding of the knowledge development process, which entails assimilating, transforming, and exploiting sourced knowledge (Cohen & Levinthal, 1990). Directors with a technical background are likely to have worked as agents of learning new ideas and shaping them into innovative products (c.f., Gruber et al., 2013). By being familiar with such activities, such directors can understand the challenges of knowledge transfer and assimilation. Thus, such directors are well-positioned to evaluate whether a sourcing strategy facilitates or hinders knowledge diffusion across organizational boundaries.

By contrast, directors' marketing experience pertains to the commercial side of

innovation. A marketing background orients decision-makers toward the customer and competitor segments of the environment (Brower & Nath, 2018; Whitler et al., 2018). Through direct market contact, marketing experts develop cognitive schemas suited for processing dynamic and heterogeneous information about customer segments and the competitive landscape and distill them into intelligent and actionable insights (Germann et al., 2015; Whitler et al., 2018). Moreover, such experience likely informs directors of the requisite activities and resources for commercializing knowledge and profiting from technology. Thus, directors with marketing experience can provide inputs critical for the selection of R&D projects and sourcing relevant knowledge. As Leonard-Barton (1995: 177) noted: "[Nothing] is more important to a technology-based firm than knowledge flowing in from the market, for this information shapes science into commercial product or service." As such, these directors can increase awareness of market trends and evaluate the firm's commercialization capabilities and resources.

First, directors with marketing experience can draw attention to promising market opportunities and trends requiring new knowledge. Perhaps more importantly, these directors can help the firm make sense of its market intelligence and convert "competitor information into demand-generating programs." (Whitler et al., 2018: 90). In this vein, evidence suggests that firms fail to respond effectively to market dynamics not for lack of information but due to inadequate use of readily available intelligence (Maltz & Kohli, 1996). This might be because internally entrenched routines and managerial beliefs fail to facilitate adaptation (Day, 2011; Tripsas & Gavetti, 2000). Against this backdrop, outside directors with marketing experience can help the firm gain fresh insights regarding market sensing and transforming intelligence into competitive actions. Second, marketing experience informs directors that profiting from innovation extends beyond technological competence to mobilizing complementary resources,

understanding market segments, and devising an optimal entry strategy (Pisano, 2006; Teece, 1986). As Teece (2010: 697) noted: "Many engineering-driven companies' brilliant ideas have never found (or created) a market." While this notion is evident to anyone working directly with customers, Dougherty (1992) observed that those removed from the market interface often hold naïve assumptions regarding how customers and competitors react to new products. To this end, marketing directors can help evaluate the firm's downstream strategy and resources—including customer knowledge— and will likely consider how sourced knowledge can strengthen this aspect of innovation.

Director motivation. The characterization of directors' motivation begins with understanding their goals. Goals are "the central focus of motivation" and "guide all human activity" (Diefendorff & Chandler, 2011: 67) by directing, energizing, and sustaining effort (Locke & Latham, 2002). Furthermore, goals also direct attention by motivating the search for new information and recalling stored knowledge (Locke & Latham, 2006). The motivation literature holds that individuals organize goals hierarchically into a few strategic, superordinate goals that reflect an idealized sense of self and action-oriented, subordinate goals at the center of decision-making and behavior (Austin & Vancouver, 1996). For instance, directors might consider serving shareholder interests as a superordinate goal but strive toward it using different means (e.g., monitoring, advising) (Hillman et al., 2008).

Functional backgrounds reflect directors' innate and enduring motives that likely guided their self-selection into a particular career path. They also reflect the socialization processes and reward systems that have conditioned directors toward goals typical of their professions (Finkelstein et al., 2009). In this regard, insights from studies at the personnel level indicate that needs for challenge, creativity, risk-taking, and experimentation motivate technical and

marketing professionals (Amabile, 1988; Sujan, Weitz, & Kumar, 1994). These motives likely persist among directors from such backgrounds and will draw their attention to innovation opportunities that the firm can tap through external knowledge. However, technical and marketing roles socialize directors into different modes of behavior. Specifically, the rewards and expectations in technical activities idealize the goal of generating truly novel knowledge, a requisite for obtaining career advancement, monetary compensation, and peer recognition (Giarratana, Mariani, & Weller, 2018; Lam, 2011). Evidence shows that fulfilling this goal is a ladder to success—for example, many high technology firms' CEOs are prolific inventors (Islam & Zein, 2020). By contrast, marketing emphasizes market growth (or performance orientation) as a superordinate goal and a key performance metric (Katsikeas, Morgan, Leonidou, & Hult, 2016). In fact: "Marketers are trained and incentivized throughout their careers to prioritize growth in their strategies, and CEOs hold marketers primarily accountable for driving revenue growth." (Whilter et al., 2018: 88).

Sourcing outside knowledge is an instrumental action to achieving these superordinate goals. From a technical perspective, searching in new technological and organizational domains can help uncover under-explored and novel knowledge components (Jung & Lee, 2016; Rosenkopf & Nerkar, 2001); otherwise, search in local domains tends to be exploitative and yield low-quality knowledge (March, 1991). As for marketers, the external knowledge environment is a primary source of technologies with proven concepts and promising potential. Compared to the uncertain and risky internal development, external sourcing brings the firm closer to market success (Puranam et al., 2003). Against this backdrop, technical and marketing experiences likely energize directors to utilize their expertise to initiate and support knowledge sourcing activities. However, given the directive function of goals (Locke & Latham, 2002),

directors will likely favor sourcing alternatives that align with either advancing knowledge or generating growth.

In this regard, advancing knowledge requires experimenting with various inputs and efforts because the uncertain nature of knowledge development makes it difficult to determine at the outset if trials will lead to dead ends or breakthroughs (Fleming, 2001). Therefore, directors with technical experience will be energized to orient the firm toward knowledge sourcing modes with the potential to expand the pool of ideas available as inputs to knowledge development. By contrast, achieving growth requires moving with speed to seize market opportunities ahead of rivals or catch up to rivals before they establish a dominant market position (Chen, Lin, & Michel, 2010). Therefore, marketing experience should focus directors' attention on selecting the most commercially viable ideas and shortening technology development lead time. This argument is similar to Katila et al.'s (2017) theorization that technical experts are concerned with variation as a means to innovation while market experts are concerned with selecting "good enough" ideas.

The distinction between directors with technical and marketing experience also reflects differences in their future temporal depth. According to the temporal depth literature (Bluedorn, 2002), decision-makers adopt short-term or long-term horizons; the former facilitates quick and flexible responses while the latter facilitates elaborate decisions (Nadkarni, Chen, 2014). Temporal depth tends to be a persistent and stable motivational attribute (Bluedorn, 2002) that shapes decision-makers' fields of vision, selective perception, and sensemaking (Gamache & McNamara, 2019). In this vein, Gupta, Raj, and Wilemon (1986) found that R&D managers at high technology companies spent most of their time working on long-term activities while marketing managers spent most of their time on short-term activities. Lawrence and Lorch

(1967) reported similar differences in time orientation between R&D and marketing managers. These findings suggest that directors with technical backgrounds are trained to consider the long-term implications of sourcing outside knowledge and its impact on the firm's future innovation pipeline, while directors with marketing backgrounds will focus on sourcing outside knowledge through modes that address short-term pressures.

HYPOTHESES DEVELOPMENT

The above theory indicates that technical and marketing experiences enable and motivate directors to monitor and advise knowledge sourcing. However, it also points that these experiences give rise to different ability and motivation attributes such that directors might consider distinct modes to adding new capabilities. This section explores this notion by linking technical and marketing experiences to knowledge sourcing through inventor recruitment, R&D alliances, and technology acquisitions. Figures 1A and 1B summarize the theoretical model discussed below.

Inventor recruitment hypotheses

Inventor recruitment is a primary means for transferring knowledge and diffusing routines across organizational boundaries (Mawdsley & Somaya, 2016; Tzabbar, 2009). It enables the hiring firm to overcome search "localness" and access tacitly held knowledge (Rosenkopf & Almeida, 2003). I argue that directors with technical experience possess the ability to increase knowledge sourcing via inventor recruitment.

Technical experience enables directors to comprehend and evaluate the processes and capabilities that the firm utilizes to generate new knowledge. Perhaps nothing is more important to knowledge development than the skills and competencies of the inventors who carry the discovery and recombination activities (Keum, 2020; Tzabbar, 2009). Directors with technical experience are directly familiar with inventors' norms and work routines; they could be inventors themselves or have at least managed and interacted extensively with inventors. Thus, the firm can benefit from directors' technical experience to institute policies to attract more inventors. This contribution is likely valuable because inventors are highly sought after (Akcigit, Baslandze, & Stantcheva, 2016) and more difficult to attract than other workers. For instance,

monetary inducements alone are insufficient hiring tools, especially if the job characteristics do not align with inventors' preference for autonomy and intellectual challenge (Stern, 2004). In this regard, directors with technical experience can help manage the complexities of becoming a preferred workplace for inventors. While research on the board's contribution to human resources is limited (Griffin et al., 2021), the practice of governance suggests that firms increasingly utilize directors' expertise to oversee strategic HR issues. For example, Zoetis, Inc. has an HR board committee whose mandate includes overseeing talent development. Similar committees exist at other high technology firms such as HP and Verizon. These governance practices indicate that firms will likely seek directors with technical experience to help develop and strengthen technical talent.

Beyond influencing inventor recruitment directly, directors with technical experience may help the firm identify technological trends that warrant adaption through recruitment. As theorized, technical experience enables directors to notice emerging and unrefined technologies within their domain of expertise. Before ideas become disruptive innovations, they undergo extensive development and evaluation against other emerging and existing designs until a dominant design is selected (Schilling, 1998; Tushman & Anderson, 1986). In this vein, directors with technical experience can notice and draw attention to such nascent technologies. Indeed, Klarner et al. (2020) found that scientific directors alerted the firm to new research ideas they encountered while engaging with the scientific community. Thus, by enhancing the early detection of technological trends, technical directors will likely increase recruitment activities. This is because the commercial potential of nascent technologies is often unclear, leading the firm to explore them through small-scale activities, such as hiring employees with relevant skills. For example, before moving aggressively into the LCD market through a strategic alliance with

Toshiba, IBM explored its potential by hiring scientists familiar with the technology (Eggers, 2016). Samsung also employed a similar approach when it started exploring the semiconductor market (Kim, 1997). In line with these findings, having technical experts as directors will result in higher inventor recruitment due to increased attention to nascent technologies that have promising potential but are not yet developed to necessitate an aggressive approach.

Sourcing outside knowledge via inventor recruitment also aligns with the motivational pulls of directors with technical experience. Specifically, technical experience conditions directors to strive toward generating cutting-edge technologies and adopt a long-term view of the innovation strategy. Such directors will likely view inventor recruitment as a goal-relevant strategy for two reasons. First, adjusting the firm's stock of technical human resources enables variation and experimentation and thus could facilitate breakthrough inventions (March, 1991). Specifically, a firm can hire inventors from different specialties and ask them to experiment with multiple projects simultaneously. Recruitment lends itself to such an explorative approach because the firm can hire and fire inventors with relative ease and flexibility (Keum, 2020) and probably at a lower cost than a wholesale commitment to a single trajectory. Indeed, the inventor mobility literature has described recruitment as a source of variation in technological ideas and learning routines (Rosenkopf & Almeida, 2003; Tzabbar, 2009). As such, the possibility for varying invention inputs and efforts through inventor recruitment might motivate directors with technical experience to emphasize this knowledge sourcing approach and lend their expertise to help the firm attract inventors.

Second, directors with technical experience might regard inventor recruitment as an effective source of variation because it presents fewer integration challenges and enables knowledge recombination (Tzabaar et al., 2013). Given that assimilating and exploiting sourced

knowledge is a tricky task (Cohen & Levinthal, 1990), ideas must be sourced in a manner that facilitates recombining them into new designs and technologies. Directors with technical expertise are likely cognizant of this process owing to their experience as knowledge generation agents. Thus, they might prefer inventor recruitment because "mobility is a one-time transplant of a particular engineer's skill set, knowledge, and productive effort from one firm to another, with no residual coordination required between the firms." (Roskenkopf and Almeida, 2003: 763). This discussion suggests the following hypothesis:

H1: The ratio of directors with technical experience will be positively associated with inventor recruitment.

By contrast, marketing experience is less likely to lead directors to emphasize inventor recruitment. From an ability perspective, marketing experience gives rise to knowledge structures that do not enable directors to investigate the quality of the firm's technical employees or comprehend whether their skills and competencies allow the firm to develop competitive products. To do this, such directors likely have to gather and analyze information of technical nature. However, with top-down processing as their dominant response to presented information, directors are less inclined to examine or ask for what they cannot readily understand (Tuggle et al., 2010). For example, if a semiconductor firm needs engineers skilled in quantum computing technology, marketing directors might find it cognitively taxing to analyze how well current employees perform in this domain. Thus, while all directors of a high technology firm might have a broad appreciation for the vitality of qualified technical talent, engaging comprehensively with this issue requires deep cognitive capacities. As such, issues related to technical human resources are likely to lie outside the fields of visions of directors with marketing experience.

Inattention to technical talent might imply a lack of association between marketing

experience and inventor recruitment. However, upper echelon researchers have argued that functional experience could inhibit performance in unrelated areas (Finkelstein et al., 2009). For example, Bayer et al. (1997) found that, among MBA students, marketing experience was negatively related to recognizing human resources issues. This finding suggests that directors with marketing experience might inadvertently limit discussions of talent issues and the resources committed to attracting inventors. Since managers might espouse biases against external knowledge (Katz & Allen, 1982; Laursen & Salter, 2006), directors' inattention to technical talent can have negative consequences. Specifically, managers might have erroneous beliefs regarding external knowledge, lack attention to the latest trends, or, as the so-called not invented here (NIH) syndrome (Laursen & Salter, 2006) suggests, have a general preference for internal capabilities. If the firm managers suffer from these limitations—which the literature suggests are widespread (Eggers & Kaplan, 2013)—then marketing expertise is less helpful in counterbalancing them. Therefore, focus on inventor recruitment could be absent at the management and the board level, leading to a negative association.

Further, directors with marketing experience could also decrease inventor recruitment by reducing the firm's capacity to notice nascent technologies. Marketing expertise pertains primarily to the customer and competitor segments of the environment. Directors with such expertise sample information related to changes in customer demands or competitor offerings (Whitler et al., 2018) and thus will not notice new knowledge until it becomes embodied in new market applications. As such, by the time they alert the firm to a new technology that appeared in their fields of vision, the firm will have to mount a response more aggressive than hiring individual inventors. Indeed, late adapters face significant pressures to catch up to pioneers who seize on early mover advantages (Schilling, 1998). Inventor recruitment can delay adaptation

because while inventors bring new and valuable ideas, they are less likely to bring ready to commercialize technologies.

Marketing experience could also decrease directors' motivation to devote time and attention to discussions of recruitment efforts. As theorized, the primary goal that motivates marketers to obtain outside knowledge (i.e., market growth) requires selecting proven technologies and accelerating market response time. Further, marketing experience shortens temporal depth (Gupta et al., 1986), such that directors will focus on addressing short-term trends. Inventor recruitment is less conducive to such aspirations for two reasons. First, because corporate inventors seldom hold the legal rights to their past inventions (Agarwal, Ganco, & Ziedonis, 2009), it is difficult to determine at the outset the exact technologies they might help the firm develop. Second, hired inventors will likely require some time before they start producing knowledge for the hiring firm, time that directors with marketing experience might prefer allocating toward commercialization. In this vein, given that individuals often ignore or discount information discrepant with aspirations (Kiesler & Sproull, 1982), directors with marketing experience are likely to hold a general belief that inventor recruitment represents an uncertain and slower pathway to market. Therefore, such directors might not evaluate the firm's effectiveness in attracting talented scientists and engineers for lacking the confidence that such an approach matches their preference for responding quickly to market developments. Given this rationale, I offer the following hypothesis:

H2: The ratio of directors with marketing experience will be negatively associated with inventor recruitment.

R&D alliances hypotheses

R&D alliances have become one of the essential activities underlying technological

progress in the past few decades (Ahuja et al., 2008). Alliances facilitate inter-organizational learning and knowledge transfer; they are usually formed for the primary purpose of joining learning capabilities (Inkpen & Tsang, 2007). Alliances help connect the firm to the broader innovation network, increasing its access to valuable knowledge and complementary resources (Ahuja et al., 2008; Powell et al., 1996). I argue that directors with technical experience will be associated with expanding the firm's alliances portfolio for several reasons that reflect their ability and motivation.

In terms of ability, technical directors can influence alliance formation by reducing partner selection uncertainty. Prior literature suggests that the board of directors can increase the likelihood of alliance formation by mitigating information asymmetries that inhibit firms from joining efforts (Gulati & Westphal, 1999; Howard et al., 2017). For example, firms considering an R&D alliance face uncertainty regarding partners' strategic behavior (Khanna et al., 1998) and knowledge capabilities (Wagner & Goossen, 2018). By having technical expertise, directors could help the firm mitigate, at least, the latter type of alliance uncertainty. Specifically, directors can employ their technical expertise to help executives interpret the information they gathered about potential partners and understand whether partners' capabilities fit with or complement the firm's. Relatedly, given that developing technical expertise involves maintaining boundary-spanning ties (Bozeman & Corely, 2004), directors with such expertise are likely able to obtain and channel critical information regarding the quality of a partner's technical competencies as well as the quality of resources committed to the alliance activity.

The ability of directors with technical experience to notice and identify external technological trends could also lead the firm to form more alliances. As theorized, technical experience enables directors to notice rich stimuli from the technology environment. As the firm

adds more directors with expertise in technology, it broadens awareness of emerging technologies. The firm can respond to such developments using multiple strategies that will likely include alliances—specifically when an alliance is optimal for adding new technical capabilities. For example, an alliance might be the optimal response when external developments present an imminent threat to the firm's current products and markets, or the alliance carries synergistic benefits for both partners (Rothaermel & Boeker, 2008). Further, an alliance is desired when the knowledge the firm is trying to obtain is deeply embedded within an organization's people and systems, such that transferring it requires broader exposure to that organization's internal capabilities (Inkpen, 2000). As such, by merely increasing the firm's awareness of technological opportunities outside its boundaries, directors could increase the likelihood of pursuing a greater number of alliances.

Additionally, alliances are relevant to the goals that motivate directors with technical experience. As theorized, these directors are motivated to increase exposure to new ideas and maximize the potential for generating novel knowledge. At the same time, their experience sensitizes them to the challenges involved in assimilating knowledge with enough accuracy to enable its exploitation. Alliances could balance these competing demands. In terms of exposure, alliances enhance knowledge inflows through knowledge sharing and resources committed to discovering new knowledge (Ahuja et al., 2008). In terms of accuracy, alliances help the firm obtain tacit and socially embedded knowledge through direct observation and joint problem solving (Inkpen & Tsang, 2007). Without such deep interactions, the firm might not fully assimilate external knowledge (Inkpen, 2000). Directors with technical experience are likely familiar with the unique benefits of learning from alliances because their work, as scientists and engineers, would take place within boundary-spanning collaborative networks (Bozeman &

Corley, 2004; Liebeskind et al., 1996). Therefore, a board with more technical experts will push the firm to increase alliance activities to enhance exposure to new ideas and improve knowledge transfer. Thus, I offer the following hypothesis:

H3a: The ratio of directors with technical experience will be positively associated with R&D alliances.

I further argue that directors with technical experience will orient the firm toward alliances with new partners. The arguments presented above suggest that such directors effectuate alliance formation by evaluating potential partners, drawing attention to new technology developments, and motivating the firm to increase exposure to new sources of knowledge. This logic implies that technical directors will drive the firm to expand the alliance portfolio into new partnerships. Otherwise, the firm will have less need for such directors' help to evaluate familiar partners' capabilities or notice their technological developments. Thus, if the firm learns about alliance opportunities through technical directors, such opportunities likely come from unfamiliar sources.

Furthermore, new ties are more conducive to knowledge discovery because they are rich in ideas that the firm has not exploited in previous agreements (Beckman, Haunschild, & Phillips, 2004), while familiar partnerships suffer from diminishing novelty (Zheng & Yang, 2015). Additionally, forming new ties is a form of exploration intended to move beyond current capabilities (Lavie & Rosenkopf, 2006). In this regard, recognizing the learning opportunities in new partnerships likely requires directors to be motivated by long-term prospects. For this reason, directors conditioned to be long-term oriented (i.e., those with technical experience) will realize that expanding the firm's alliance portfolio can create new sources of value. Therefore, I specify the previous hypothesis in the following way:

H3b: The ratio of directors with technical experience will be associated more positively with R&D alliances with new partners than with R&D alliances with repeat partners.

There are also reasons to believe that directors with marketing experience will also lead to more R&D alliances. From an ability perspective, the knowledge structure of directors with marketing experience can enhance awareness of competitive pressures, which prior literature has shown to increase alliance activities (Garcia-Pont & Nohria, 2002; Park & Zhou, 2005; Silverman & Baum, 2002). Marketers are trained and incentivized to monitor competitive actions and competitor capabilities (Brower & Nath, 2018), such that a marketing background biases directors toward competitive stimuli. For example, competitive dynamics researchers show that firms are more responsive to competitive threats when they have a higher number of marketing executives in the top management team (Smith, Grimm, Gannon, & Chen, 1991). Similarly, directors with marketing expertise will naturally devote more time to discuss and analyze competitive issues. Such directors might, for example, ask the management to emphasize competitive monitoring and draw attention to the firm's standing relative to competitors.

By increasing competitive awareness, directors will exhort the firm to join efforts with other firms to strengthen competitive positioning. Indeed, substantial evidence from the alliance literature shows that competitive pressures underlie alliance formation (e.g., Garcia-Pont & Nohria, 2002; Gimeno, 2004; Kogut, 1989; Silverman & Baum, 2002). Alliances represent an effective response to competitive pressures because they enable the firm to transfer or replicate rivals' technological capabilities (Gimeno, 2004) and channel important information about rivals' knowledge and resources (Powell et al., 1996). Hence, if directors with marketing experience increase attention to competitors, the firm response will likely manifest in more

alliance agreements.

Moreover, directors with marketing experience will likely sense technology change from observing developments in the product market, such as new product introductions, promotional campaigns, and market testing. Further, owing to their knowledge of commercialization difficulties, marketers might not be confident in the value of technologies that have not garnered commercial interest yet. After all, only a small percentage of inventions succeed commercially (Schilling, 2015). Hence, directors with marketing experience will focus on technological developments that present a credible opportunity/threat. Essentially, external technologies that have advanced in their development to the point where they are noticeable to market observers likely carry less commercial uncertainty and constitute an impending threat. By noticing such technologies, directors with marketing experience will engender a sense of urgency that warrants a strategic and risky move, such as entering into an alliance. Indeed, alliances are activities that firms utilize to reconfigure knowledge capabilities in response to competence-destroying technology change (Danneels, 2011; Eisenhardt & Martin, 2000). This is because firms might lack the capability or time-horizon to respond through internal development. Therefore, by bringing attention to technologies whose impact is less ambiguous, directors with marketing experience will likely make alliance decisions both attractive and justifiable.

From a motivation standpoint, alliances could help generate market growth that directors with marketing experience aspire to achieve. Alliances facilitate growth in two primary ways. First, utilizing R&D alliances to source knowledge is consistent with marketing directors' preference for expediating the product development process. Alliances could shorten the product development cycle through technology sharing, increasing inputs to knowledge development, and R&D scale economies (Ahuja et al., 2008). In doing so, alliances could be a means to

addressing short-term pressures that command the attention of directors with marketing experience. In fact: “Through ‘learning alliances’ firms can speed capability development and minimize their exposure to technological uncertainties by acquiring and exploiting knowledge developed by others.” (Lane & Lubatkin, 1998: 461). Instead of getting slowed down by attempts to replicate others’ knowledge, the firm can capitalize on its comparative advantage to attract potential partners and trade access to each other’s capabilities (Kale et al., 2000; Kessler & Chakrabarti, 1996). Therefore, directors with marketing experience will likely encourage and push for developing technologies through alliances to bring the firm closer to market launch and improve the chances of capitalizing on growth opportunities.

Second, the motivation for market growth alerts directors with marketing experience to the need for obtaining complementary downstream resources and marketing capabilities, which are necessary for turning knowledge into profitable products (Schilling, 1998; Teece, 2010). In this vein, R&D alliances might meet marketing directors’ goals and aspirations for their role in helping the firm attain capabilities beyond technical knowledge. Specifically, R&D alliances are often a part of a broader agreement that covers downstream activities, too—so-called hybrid alliances (Lavie, Kang, & Rosenkopf, 2011). For example, Oxley and Sampson (2004) reported that as many as 37% of alliances in the electronic and telecommunication industries were hybrid. Likewise, partners may choose to capitalize on their shared experience and expand the scope of an R&D alliance into downstream activities. Indeed, the alliance evolution often follows a real options strategy, increasing commitment to the alliance as it proves beneficial (Pangarkar, Yuan, & Hussain, 2017). Moreover, the firm might access complementary knowledge from partners through competitive learning. While the overt goal of alliances is symbiotic gains, firms utilize the alliance to internalize partners’ most valuable knowledge and capabilities, often in areas

unrelated to the alliance task (Hamel, 1991; Khanna, Gulati, & Nohria, 1998). As such, marketing directors might perceive R&D alliances as channels for acquiring growth resources through developing market capabilities with partners or internalizing their existing capabilities. These arguments lead to the following hypothesis:

H4a: The ratio of directors with marketing experience will be positively associated with R&D alliances.

The arguments above suggest that awareness of external developments that require an immediate response, preference for speed, and short-term orientation underlie the relationship between directors' marketing experience and alliance formation. In line with reasoning, the alliances that appeal to such directors are likely alliances with repeat partners—partners with whom the firm is currently collaborating or had collaborated in the past. Collaborating repeatedly with the same partner helps achieve alliance objectives faster due to partner-specific learning (Inkpen & Tsang, 2007). This type of learning "involves learning about the partners' intended and emergent goals, how to redefine joint tasks over time, how to manage the alliance interface." (Kale et al., 2000: 220). In addition, shared experience allows partners to develop efficient routines that help minimize transaction costs, locate information faster, and resolve cultural and organizational differences (Inkpen & Tsang, 2007; Kale et al., 2000). Further, prior partner experience could accelerate the partner selection process (Al-Laham, Amburgey, & Bates, 2008). Otherwise, evaluating new partners involves a lengthy process of gathering relevant information and working out organizational barriers. Therefore, as directors with marketing experience increase awareness of imminent market trends and short-term pressures, the firm will likely respond by engaging existing partners. Thus, I further specify the previous hypothesis:

H4b: The ratio of directors with marketing experience will be associated more

positively with R&D alliances with repeat partners than with R&D alliances with new partners.

Technology acquisitions hypotheses

Technology acquisitions are the most comprehensive means for sourcing external knowledge (for a review, see Graebner et al., 2010). They allow the acquiring firm complete control over the target's assets and access to deeply embedded knowledge and socially complex capabilities (Carayannopoulos & Auster, 2010). As outlined in the literature review, firms pursue technology acquisitions to (1) obtain new knowledge inputs and inventive capabilities (Ahuja & Katila, 2001; Choi & McNamara, 2018; Puranam et al., 2003; Sears & Hoetker, 2014) and (2) to enhance market position (Graebner et al., 2010; Lee & Kim, 2016; Ranft & Lord, 2000). These two motives map into the knowledge and attention of directors with technical and marketing experience, respectively. Therefore, such directors will likely increase technology acquisitions, albeit for different reasons and, as a result, of different targets.

In this regard, the firm can appropriate directors' technical experience to increase awareness of technology acquisition opportunities and manage related decision-making complexities. Prior literature on the link between governance and M&A activities indicates that qualified directors can be instrumental in identifying potential acquisition targets (Klarner et al., 2020; Rousseau & Stroup, 2015). In this vein, directors with technical experience can provide valuable input on what targets possess promising and relevant technical capabilities. This contribution is critical because technology acquisitions targets are often new entrant startups (Graebner & Eisenhardt, 2004) with limited market visibility. Moreover, technology startups often innovate in path-breaking technological domains (Shane, 2000) and thus might be outside the vision fields of directors and executives who lack technical expertise. As such, the ability of

directors to notice emerging technologies and evaluate their potential can expand awareness of acquisition opportunities.

In addition to drawing attention to acquisition targets, technical experience enables directors to manage the informational complexities endemic to acquisition deals. As McDonald and colleagues (2008) argued, acquisition decisions present challenges that relate to "(1) information overload, (2) strict time constraints, and (3) the need to recognize the long-term strategic implications of potential acquisition" (p. 1162). Such challenges present information processing demands that might limit the number of acquisitions the firm can comprehensively evaluate and pursue. In technology acquisitions, information processing demands arise from the difficulty of evaluating the target's intangible, novel knowledge assets and their relevance to the acquirer's knowledge base (Coff, 1999; Paruchuri, Nerkar & Hambrick, 2006). In this vein, directors who are well versed in technology and understand the knowledge development process can enhance the firm's information processing capacity (c.f. Khanna, Jones, & Boivie, 2013), helping navigate the complexities of technology acquisition decisions. This might include, for example, identifying sources of knowledge synergies that would justify acquisitions or how to handle the post-acquisition integration process. Thus, having more technical experts on the board could enhance executives' confidence in pursuing more technology acquisitions.

Beyond engaging directly with specific acquisition deals, directors from technical backgrounds likely engender acquisitions by monitoring the firm's internal capabilities and relevant external developments, revealing needs and opportunities for strategic renewal through technology acquisitions. In this respect, acquisitions of knowledge-intensive firms that pioneer breakthrough technologies have become a standard practice that established high technology firms utilize to keep their R&D activities aligned with the technological field (Chen et al., 2020).

Thus, the discussions that directors with technical experience might promote regarding the firm's knowledge capabilities will likely lead to technology acquisitions. Indeed, anecdotal evidence suggests that the board's involvement in the innovation strategy often centers around augmenting inventive capabilities via acquisitions (Klarner et al., 2020). For instance, the charter of HP's board technology committee states that it "provide[s] guidance on technology as it may pertain to market entry and exit, investments, *mergers, acquisitions* and divestitures, research and development investments, and key competitor and partnership strategies." (Hewlett Packard Enterprise Company, 2016; emphasis added).

From a motivation standpoint, technology acquisitions are an instrumental strategy to achieving knowledge leaps, a goal that technologists hold dear (Griffin & Hauser, 1996). As pointed earlier, technology acquisition targets include small knowledge-intensive firms with a comparative advantage in research, entrepreneurial culture, and investor interests that emphasizes risk-taking and exploration (Aggarwal & Hsu, 2014; Arora & Gambardella, 1990; Benson and Ziedonis, 2009). Indeed, evidence shows that such firms are more effective than established firms at translating R&D inputs into new inventions (Kortum & Lerner, 2000) and, more importantly, producing higher quality inventions (Aggarwal & Hsu, 2014). Consequently, directors with technical experience should find the prospect of gaining breakthrough knowledge through technology acquisitions energizing. Specifically, the potential for renewing the firm's knowledge capabilities is likely to motivate these directors to utilize their technical expertise to expand awareness of valuable targets and improve acquisition evaluation. Following these arguments, I hypothesize the following:

H5a: The ratio of directors with technical experience will be positively associated with technology acquisitions.

Extending the logic of the previous arguments, I argue that the type of technology acquisitions associated with directors' technical experience will be acquisitions of small startup firms. In essence, directors with specialized technical knowledge contribute more to noticing and evaluating startups that pioneer novel technologies with uncertain payoffs. By contrast, established technology targets' assets and market potential are less uncertain, and their technological output is less novel (Aggarwal & Hsu, 2014). Thus, the board can determine whether they are worth pursuing without the help of technical experts. More importantly, startup targets are a likely source of breakthrough knowledge (Aggarwal & Hsu, 2014), and thus technical directors will regard them as the best means for renewing the firm's knowledge capabilities and extending long-term value. Finally, pursuing smaller targets might alleviate directors' concerns with how successfully the firm can integrate and exploit acquired knowledge. In essence, smaller targets present fewer structural barriers and require few integration resources (although the difference in work culture remains an impediment in this regard). Therefore, I offer the following hypothesis:

H5b: The ratio of directors with technical experience will be associated more positively with technology acquisitions of startup targets than with technology acquisitions of established targets

Technology acquisition decisions are also motivated by the desire to expand the firm's market, eliminate competitive threats, and access commercialization capabilities that are co-specialized to new technology (Lee & Kim, 2016; Moeen & Mitchell, 2020; Ranft & Lord, 2000; Santos & Eisenhardt, 2009). These motives indicate that technology acquisition decisions give rise to marketing and commercialization information processing demands (King et al., 2008) that directors with marketing experience can comprehend. Such demands might include

understanding whether the target's commercialization capabilities (e.g., branding assets, distribution channels, salesforce) would serve the firm's market objectives and improve the performance of the acquired technology. Perhaps more importantly, directors with marketing experience can help the acquiring firm analyze the target's specialized marketing resources. Although established acquirers often deploy their general marketing capabilities (Capron & Hulland, 1999), their ability to profit from acquired technology depends on access to complementary specialized assets (Teece, 1986). These assets are "applicable in a limited set of industries, and are closely interdependent with particular products or technologies." (Moeen & Mitchell, 2020: 1461). Examples of such assets include distribution channels for new software or special salesforce knowledge of a ground-breaking drug. Against this backdrop, having directors with marketing experience will naturally expand the board's information processing capacity, enabling the firm to contemplate and pursue more technology targets.

Directors with marketing experience could also increase technology acquisitions by enhancing competitive awareness. Indeed, prior literature shows that firms undertake technology acquisitions to respond to emerging competitive threats (Chen et al., 2020) or preempt anticipated ones (Santos & Eisenhardt, 2009). Directors cognizant of the competitive environment might find acquisitions especially attractive as such actions expand resources and customer base while eliminating rivals. Moreover, because marketing experience enables directors to evaluate the competitiveness of the firm's commercial capabilities, these directors might also motivate a search for acquisition targets that could provide such capabilities. In this vein, Ranft and Lord (2000) reported that "market or customer knowledge and sales relationships were identified as most important in 18% of [technology] acquisitions." (p. 305). In line with this finding, having directors who are oriented to monitor market capabilities could also lead to

strategic adaptation through technology acquisitions.

Additionally, technology acquisitions represent one of the fastest actions the firm could take to deliver products to markets and capitalize on growth opportunities (Puranam et al., 2003). Therefore, undertaking technology acquisitions aligns closely with marketers' short-term orientation and motivation for ensuring market growth. Specifically, technology acquisitions accelerate market entry by providing ready or near ready products and downstream resources and—for this reason—facilitate an immediate strategic response (Chen et al., 2020). These benefits should appeal to directors with marketing experience who sample and assign more weight to stimuli related to the firm's current and near-term competitiveness. As a result, such directors will likely regard acquisitions as goal-relevant actions and feel motivated to push the firm toward acquisitions and provide the necessary advice and support. Together, these arguments lead to the following hypothesis:

H6a: The ratio of directors with marketing experience will be positively associated with technology acquisitions.

I further argue that directors with marketing experience will be most instrumental in acquiring mature targets with an established market presence. This is because directors' marketing experience contributes to understanding the target's commercialization capabilities, which are more present among established technology firms. Able to comprehend the synergies in such deals, marketing directors will enhance the firm's capacity to pursue established targets. Further, such targets are more relevant to speed and market growth goals, which marketers find salient (Whitler et al., 2018). Specifically, the market potential and capabilities of established technology firms are more assured and quicker to adopt. Additionally, directors with marketing experience should favor established technology targets that are more suited to enhance the firm's

market power over customers and competitors through scale benefits. By contrast, marketers might not regard startup targets as adequate sources of innovation capabilities because they are likely to lack developed products, downstream resources, and a sizable market footprint to facilitate immediate growth. Therefore, I specify the previous hypothesis to technology acquisitions of established targets.

H6b: The ratio of directors with marketing experience will be associated more positively with technology acquisitions of established targets than with technology acquisitions of startup targets.

The moderating role of knowledge quality and rival's breakthroughs

The theoretical arguments in this dissertation suggest that directors' experience will influence how the firm adds external knowledge; specifically, focusing on the role of ability and motivation attributes prototypical of a given functional background. This section further explores mechanisms that could amplify the hypothesized relationships by focusing on the conditions under which directors' involvement in overseeing and advising knowledge sourcing is critical. Doing so is important because the extant governance literature indicates that boards usually become more engaged in governance when the firm faces challenges that directors can help resolve (Chatterjee & Harrison 2001; Lorsch & MacIver, 1989). In line with this reasoning, directors with technical experience will likely emphasize renewing technical capabilities to generate novel knowledge recombinations when the quality of the firm's knowledge stock starts to lag behind peer firms. This argument follows the assumption that technical experience focuses directors' attention on the state of knowledge and the firm's capacity to maintain future value. Likewise, directors with marketing experience will emphasize protecting the firm's market position and accelerating product development when rivals achieve breakthrough innovations.

This argument follows the assumption that marketing experience sensitizes directors to competitive and market developments and short-term pressures. Thus, these moderating conditions can further reinforce and elucidate some of the key theoretical mechanisms presented thus far.

Knowledge quality. Lower knowledge quality (on a relative basis) likely indicates to directors with technical experience the deficiency of the firm's knowledge capabilities and the need to break away from path dependency. In essence, these directors possess the requisite mental capacity to monitor the firm's knowledge stock relative to the broader technological field and help devise knowledge renewal strategies. Thus, in the face of low knowledge quality, the firm will have reasons to call on the expertise of technical directors, giving them more influence over knowledge sourcing activities. At the same time, lower knowledge quality will motivate directors to be proactive and exert the necessary effort to improve knowledge performance. This is because lower knowledge quality constitutes a discrepancy between technical directors' desired end-state of advancing knowledge and the actions taken to achieve such a goal. Further, the failure to generate high-quality knowledge will likely command the attention of directors with technical experience for the challenge it presents to the firm's long-term prospects. Because discrepancy reduction is a key determinant of information processing and effort (Diefendorff & Chandler, 2011), directors sensitive to shortfalls in knowledge performance should naturally push for infusing R&D activities with new talent, ideas, and routines.

Specifically, under conditions of low knowledge quality, directors with technical experience will likely emphasize adjusting the firm's technical human capital via greater investments in inventor recruitment. Due to their scientific and engineering background, these directors are likely aware that hiring new inventors can channel valuable external knowledge that

the firm has failed to develop internally and, more importantly, path-breaking routines that would reorient research and invention processes (Tzabbar, 2009). Similarly, directors with technical experience will sense a greater need to expand the alliance portfolio into new partnerships that could expose the firm to unfamiliar knowledge. After all, technical expertise is a socially embedded competence (Liebeskind et al., 1996) such that directors who have it likely recognize that new ties are excellent conduits of novel ideas, which are more needed when the firm's current knowledge stock is lagging (Zheng & Yang, 2015).

Finally, lower knowledge quality strongly motivates transplanting new knowledge stock and human capital through technology acquisitions. Technology acquisitions are among the most adopted responses to internal development failures (Puranam et al., 2003). However, the firm will likely emphasize small startup targets when the board includes more directors with technical experience. Such targets provide better opportunities for knowledge renewal for two reasons. First, they are research-intensive and pioneer new technological domains, making them a good source of novel knowledge. Second, acquiring them is a more appropriate remedy to lagging knowledge because the firm does not have to incur the cost of other assets irrelevant to knowledge objectives (e.g., physical equipment, large workforce). Therefore, the contribution of directors with technical experience to identifying and evaluating small technology targets will become more relevant and pronounced under lower knowledge quality. Taken together, I offer the following hypotheses:

H7: knowledge quality moderates the relationships between the ratio of directors with technical experience and a) inventor recruitment, b) R&D alliances with new partners, and c) technology acquisitions of startup targets such that these relationships are stronger when the firm's knowledge quality is low.

Rivals' breakthroughs. By contrast, the influence of directors with marketing experience on knowledge sourcing will be amplified by rivals' breakthroughs—newly introduced products that depart significantly from existing standards (Henderson & Clark, 1990). Such innovations constitute an impending threat because they have the potential to limit the firm's growth opportunities and even displace its current competitive advantage (Christensen & Bower, 1996; Tushman & Anderson, 1986). Given the nature of their knowledge structures and attentional models, directors with marketing experience are likely to notice changes in rivals' products and recognize their strategic threat. Essentially, a marketing experience familiarizes directors with the drastic impact of radical innovations on customer preferences and the value of the firm's existing products. More importantly, directors with marketing experience can make sense of market intelligence and help with "converting external market consumer, and competitor information into demand-generating programs." (Whitler et al., 2018: 90). Thus, their strategic role on the board will become more relevant following rivals' breakthroughs. Furthermore, rivals' breakthroughs represent a clear and near-term threat to growth and thus engender a performance discrepancy that will motivate marketing directors to exert more effort to remedy it.

Directors with marketing experience are likely to place even less emphasis on inventor recruitment in response to rivals' breakthroughs. As argued earlier, marketing experience raises concerns about how quickly the firm can appropriate the skills and knowledge of newly hired inventors to develop products. Such concerns will become more salient following rivals' breakthroughs because such innovations could realize increasing returns to adoption and, in turn, emerge as the new dominant design before incumbents could replicate rivals' advantage (Schilling, 1998). Considering that directors with marketing experience are likely concerned with entry timing and product development speed (c.f. Gupta et al., 1986), they should shift resources

toward actions that shorten R&D lead time and allow the firm to catch up to competitors before it suffers technological lockout. In the same vein, rivals' breakthroughs give marketing directors more reasons to prod the firm to respond through alliances with familiar partners. Worried about growth prospects, these directors are likely to view familiar alliances as the appropriate response for the speed advantages they involve—namely, a streamlined partner selection process and existing partner-specific experience that could enhance shared problem-solving.

Finally, prior literature shows that firms respond to rivals' breakthroughs via technology acquisitions (Chen et al., 2020). The presence of marketing experience on the board will likely facilitate acquisitions of established technology firms as a means for adaptation. This is because rivals' breakthroughs lead directors with marketing experience to recognize the need for acquiring technologies with higher market certainty and complementary resources. As such, these directors are likely to view acquisitions of established technology targets as an appropriate strategy. Thus, I offer the following hypotheses:

H8: Rivals' breakthroughs moderate the relationships between the ratio of directors with marketing experience and a) inventor recruitment, b) R&D alliances with repeat partners, and c) technology acquisitions of established targets such that these relationships are stronger following rivals' breakthroughs.

METHODOLOGY

Sample & data sources

This dissertation examines the relationships between directors' experience and knowledge sourcing activities at the firm-year level. Therefore, I constructed a panel of high technology firms starting in 2007 and ending in 2018. Following prior research (Balkin, Markman, & Gomez-Mejia, 2000; Lim, 2015), I identified high technology firms as those operating in the following industries: pharmaceutical (SIC 283), high-tech manufacturing (SIC 357, 365, 366, 367, 381, 382, 384, and 386), high-tech services (SIC 481, 482, 484, and 489), and computer and software services (SIC 737). I included in the sample firms listed in the S&P 1500 index as of January 1st, 2007. As such, I excluded firms that joined the index later and kept tracking sampled firms regardless of whether they remained in the index (as long as public information on them was available). The final sample includes 319 unique firms and 2,952 firm-year observations. The panel is unbalanced due to M&A activities, bankruptcy, and other delisting reasons.

This sampling approach offers several methodological advantages. First, high technology firms rely extensively on obtaining technical knowledge from the external environment, especially through inventor recruitment (Agarwal et al., 2009; Wagner & Goossen, 2018), R&D alliances (Howard et al., 2017; Sampson, 2007; Wagner & Goossen, 2018), and technology acquisitions (Choi & McNamara, 2018; Puranam & Srikanth, 2007). As such, the theoretical model is relevant to predicting important knowledge decisions in this context. Second, because external sourcing activities are strategically vital to the performance and survival of high technology firms (Eggers & Park, 2018), directors are likely interested in monitoring such activities and lend their expertise to help with innovation issues and knowledge dependence

(Howard et al., 2017; Klarner et al., 2020). Thus, innovation-related expertise is a relevant quality for governing technology-intensive firms. Third, this context offers detailed and consistent data on knowledge activities. Specifically, the high propensity of high technology firms to patent their inventions (Hall, Jaffe, & Trajtenberg, 2005) gives researchers a reliable and convenient methodology to track various aspects of the firm's knowledge stocks and flows.

I utilized multiple data sources to construct the sample and variables of interest. First, I obtained data on the board's composition and director backgrounds from BoardEx, a leading source of governance data. BoardEx provides detailed profiles of corporate directors and senior management, including education and experience details. Second, I obtained patent data from PatentsView, a collaborative platform supported by the U.S. Patent and Trademark Office (USPTO) that compiles patent and inventor information. In this regard, identifying which patents belong to a specific firm is a well-known problem in patents research (Hall et al., 2005). Although researchers could identify a firm's patents using the assignee name on the patent, the assignee name is often a different spelling of the firm's official name, a former name, or a subsidiary's name. Therefore, I relied on a matching solution contributed by Kogan, Papanikolaou, Seru, & Stoffman (2017), who used matching algorithms to assign nearly 2 million patents (granted between 1976 and 2020) to publicly traded firms[2].

Third, I obtained alliance data from the SDC platinum database and acquisition data from Thompson ONE Deals, two leading sources that track corporate activities across the globe and an extended range of industries. I supplemented acquisition data with data from Crunchbase and Pitchbook, which provide additional information on targets' founding year employee size. Fourth, to measure rivals' breakthroughs, I obtained a list of R&D 100 award winners from R&D

[2] The authors keep updating the matching file annually. This file is available at https://host.kelley.iu.edu/nstoffma/

Magazine (Chen et al., 2020) and a list of rivals from Hoberg and Philips' (2010) text-based network industry classification (TNIC), which measures product and market similarity between firms using text mining of 10K filings. Finally, I obtained information related to the company financials and executive and director compensation from Compustat and Execucomp.

Dependent variables

Inventor recruitment. I measured inventor recruitment as the number of inventors who joined the firm in the focal year. Following prior research, I identified recruitment instances using patent records, whereby a change in the assignee organization for the same inventor indicates a change of employers (Rosenkopf & Almeida, 2003; Tzabbar, 2009). To illustrate, suppose an inventor who applied for a patent assigned to Intel Corp subsequently applies for another patent assigned to Nvidia Corp. In this case, that inventor has moved to Nvidia (Tzabbar, 2009), and the year of recruitment is the midpoint between the application dates of the last patent filed with Intel and the first patent filed with Nvidia (Hombert & Matray, 2017). To focus on voluntary movements, which are the subject of my theorization, I excluded inventors whose last patent before the assignee change belonged to a target acquired by the focal firm.

This methodology is not without limitations. First, it requires inventors to file patents with each firm they join; otherwise, it would be impossible to detect recruitment. Thus, patent records provide, at best, conservative estimates of inventor recruitment. Second, false positives are not uncommon in this methodology. Specifically, when an inventor collaborates independently with a different organization without changing employer, the inclusion of a new assignee in her record would lead to a false recruitment event (Wagner & Gooossen, 2018). To minimize such false positives, I eliminated inventors who moved back and forth between the same two firms, which could result from collaboration projects instead of mobility. Finally, the

recruitment date estimated from application dates is inherently imprecise (Ge et al., 2016). To this end, I also estimated the recruitment date at 1/4th and 3/4th the distance between application dates and obtained consistent results[3].

R&D alliances. I measured R&D alliances as the number of joint research and development and technology-sharing alliances the firm entered in the focal year. Whereas partners in joint R&D alliances perform activities to develop new technology, partners in technology-sharing alliances combine or transfer their existing technological capabilities (Wagner & Goossen, 2018). Joint R&D and technology-sharing alliances are identified separately in the SDC database; however, they frequently overlap in a single alliance deal (Wagner & Goossen, 2018). These two types of alliances constitute external knowledge sourcing activities that closely match the theorization. Specifically, joint R&D alliances capture sourcing through co-development and obtaining socially embedded knowledge, while technology-sharing alliances capture technological complementarities.

To test hypotheses 3b and 4b, I separated R&D alliances into two count measures: R&D alliances with new partners and R&D alliances with repeat partners. Following prior research (Lavie & Rosenkopf, 2006), I classified partners into new and repeat alliances based on whether the firm had previously entered into an R&D alliance with the focal partner.

Technology acquisitions. I measured technology acquisitions as the number of high technology targets the firm acquired in the focal year. Consistent with prior technology acquisitions studies (Choi & McNamara, 2018; Puranam & Srikanth, 2007; Sears & Hoetker, 2014), I identified an acquisition as a technology acquisition if (1) the target belonged to one of

[3] Ge et al (2016) recommended using employee profiles from LinkedIn to verify employment dates and events. However, this approach proved inadequate because employees often keep their profiles hidden from users who are not members of their networks. I attempted this approach by searching for 300 recruited inventors (identified from patent records) and was able to obtain less than 8% reliable matches.

the technology-intensive industries identified with three-digit SIC codes in the sample description, and (2) the acquirer obtained a controlling stake (i.e., > 50% ownership).

To test hypotheses 5b and 6b, I separated targets into startups and established firms based on whether the target age is less than 12 years (founding year minus acquisition year) and employed less than 500 employees at the time of the acquisition. The 12 years cutoff is suggested by Benson and Ziedonis (2009) and is consistent with venture capital investment horizons, after which they force startups to liquidate either through an IPO or an acquisition. However, results remained consistent when using ten or eight years as the age cutoff point. The employee size cutoff is based on the U.S. Small Business Administration's definition of small firms (Sears & Hoetker, 2014).

Independent variables

Directors with technical experience. To measure directors with technical experience, I first identified all board members (excluding the CEO) with backgrounds in engineering and science using job titles and role descriptions from BoardEx. Science and engineering are two fields that are closely associated with technology development and knowledge generation (Kline & Rosenberg, 1986; Teece, 2010). Scientists and engineers perform the creative activities that could produce new inventions (Fleming & Sorenson, 2004; Gruber et al., 2013), thus matching the theoretical account of technical expertise. In fact, scientists and engineers make up between 66% and 80% of R&D employees in high technology industries (National Science Foundation, 2016). Second, I assigned directors a value of zero if they never held a science or engineering position, one if they held such positions at the entry or middle management level, and two if they held a senior-level technical position (e.g., VP of R&D, Chief Science Officer). For academic directors, I assigned a value of two to tenured professors and one to assistant professors. The

goal of this approach is to capture differences in the magnitude of directors' technical experience. While a better approach would rely on the length of experience, employment dates are missing or unclear[4] from BoardEx for a nontrivial portion of the sample (as high as 32%). Nevertheless, I assume that directors who held senior technical positions (or tenured academic positions) are more experienced. Indeed, when employment dates were available, experience measured by rank correlated strongly with experience measured by years ($r = 0.83$, $p < 0.0000$). Finally, I summed directors' rank scores and divided them by the board size to create a firm-year measure of directors with technical experience.

Directors with marketing experience. Similar to Whitler et al. (2018), I identified directors with marketing experience as board members (excluding the CEO) whose roles involved marketing, branding, sales, merchandising, or retail responsibilities. I followed the same coding approach I used to measure directors' technical experience. Again, among directors with complete employment dates, experience measured by rank correlated strongly with experience measured by years ($r = 0.71$, $p < 0.0000$). I summed directors' rank scores and divided them by the board size to create a firm-year measure of directors with marketing experience.

Moderators

Knowledge quality. Consistent with prior research, I measured knowledge quality as the firm-year average of the forward citations that the firm's patents received (Balsmeier et al., 2017). Because patents lose value over time and become less indicative of current knowledge performance (Trajtenberg, 1990), I followed prior research and depreciated patents and their forward citations at an annual rate of 20% (Shane & Klock, 1997). However, I obtained

[4] BoardEx often provides one employment date for a collection of roles, labeling them as "various positions", with a firm which makes it hard to determine the time spent in a specific role.

consistent results with an undepreciated measure. I limited the patents included in the measure to those granted five years prior to knowledge sourcing activities. For example, the knowledge quality measure predicting acquisitions initiated in 2015 included citations for patents granted between 2010 and 2014. The results are also consistent when with a 3-year measure. Finally, I subtracted the firm's average citations from the industry's average to capture knowledge quality on a relative basis.

Rivals' breakthroughs. Identifying breakthrough innovations at the outset is challenging because the true impact of newly introduced products takes time to manifest (Eggers & Park, 2018). Prior research has utilized the opinions of major industry publications to assess the innovativeness of new products (Chen et al., 2020). Consistent with this research, I used R&D Magazine's R&D 100 Award to capture breakthrough innovations. This award "is often regarded as the "Oscar of Invention" by the community of industrial researchers and managers" (Chen et al., 2020: 1). R&D Magazine has published the award since 1965. Evidence shows that the R&D 100 awards correlate significantly with patent-based novelty measures (Verhoeven, Bakker, & Veugelers, 2016). However, using this measure instead of patent citations is more appropriate for the theoretical arguments because R&D Magazine requires submitted inventions to have been introduced in the market (Chen et al., 2020), making products included in this list credible market threats. I measured rivals' breakthroughs as the number of R&D 100 awards that the firm's top 10 rivals (and their subsidiaries) received in the prior three years. The results are also consistent with a two-year measure.

I identified the focal firm's rivals using Hoberg and Phillips's (2010) TNIC methodology. TNIC uses text-based analysis of 10-K filings to measure product and market similarities among firms. Hoberg and Phillips (2010) consider the ten firms with the highest similarity scores as the

firm's rivals. This measure is firm-centric and dynamic and does not suffer from the static limitations of the SIC classification.

Control variables

I considered a comprehensive set of controls to account for variables influencing the relationship between directors' technical and marketing experience and knowledge sourcing activities. Following Carlson and Wu (2012), I retained only control variables that correlated at |0.10| or higher with the dependent, independent, or moderator variables or impacted the results[5].

First, I controlled for director-level factors that could influence directors' attention to the external knowledge environment. More specifically, I controlled for *director age* to account for the possibility that younger directors are more familiar with technological developments (Hitt & Tyler, 1991). I also controlled for *director social ties*, using the size of the director network as estimated by BoardEx, to account for the influence of social capital on directors' awareness of the external environment. Moreover, to isolate the effect of education, I controlled for *director education level*, using a binary variable indicating whether the director has a graduate degree. Additionally, to isolate the effect of output-oriented experiences from other functional experiences, I controlled for the *director throughput experience*, using a binary variable indicating whether the director held positions in operations, HR, legal, accounting, or finance functions. Finally, I aggregated these variables to the firm-year level.

Second, I controlled for board-level factors that could determine the board's ability to monitor and provide advice. Specifically, I controlled for *board independence* (ratio of insider directors) *and CEO duality*. I included these controls because the power dynamics between the board and the CEO have important implications for the board's involvement in strategy (Haynes

[5] Controls that did not meet the correlation threshold included return on sales, director industry experience, and advertising intensity

& Hillman, 2010). I also controlled for *director compensation* by taking the log of directors' average compensation. Director compensation can influence the board's involvement in risky strategies (Deutsch, Keil, & Laamanen, 2011) such as innovation. Third, at the CEO level, I controlled for the log of *CEO compensation,* which may motivate the CEO to emphasize innovation (Balkin et al., 2000). I also controlled for *CEO tenure* because CEOs are more likely to renew the firm strategy early in their tenure and seek the board's guidance (Shen, 2003). Finally, to isolate the effect of directors' expertise from that of the CEO, I controlled for *CEO technical experience* and *CEO marketing experience* using the same approach to director experience.

Fourth, I controlled for firm-level factors that could determine the firm's capacity to acquire additional resources from the external environment. Therefore, I controlled for *firm size*, using the log of assets, *firm debt*, using the log of long-term debt, and *financial slack*, using the log of cash and short-term investments. I also controlled for *R&D intensity,* by dividing R&D expenses by sales, to proxy for absorptive capacity, which increases external knowledge sourcing (Cohen & Levinthal, 1990). Further, to capture the change in the firm's sourcing strategies associated with board composition and isolate inertial effects in the firm's knowledge sourcing strategy, I controlled for *prior inventor recruitment*, *prior R&D alliances*, and *prior technology acquisitions* by taking the sum of the firm's activities in each sourcing mode over the prior three years. Another reason for controlling for prior activities is that experience with these knowledge sourcing activities likely enhances the firm's ability to undertake similar actions in the future (Tzabbar et al., 2013; Zollo & Singh, 2004) and may attenuate the need for counsel from directors with a background related to innovation. Finally, I included year and industry fixed effects (2 digit SIC codes) and dummies capturing S&P1500 segments (i.e., S&P500, S&P400,

and S&P600).

Analytical approach

I estimated the relationships between directors' experience and knowledge sourcing modes with generalized estimation equations (GEEs) using the *xtgee* command in State 16. The GEEs technique offers the following advantages. First, GEEs account for the nested nature of panel data and adjust for the nonindependence among observations belonging to the same firm (Ballinger, 2004). Second, GEEs are well suited to estimating limited range dependent variables such as the count variables I used to measure knowledge sourcing activities (Ballinger, 2004). Third, GEEs capture both within and between firm variance in the hypothesized relationships. Capturing more variance in the analysis increases statistical power (Certo, Withers, & Semadeni, 2017). This advantage is important in the current context because the board composition could exhibit limited within-firm variation. I specified negative binomial GEE models (appropriate for estimating overdispersed count outcomes) with log link function, exchangeable correlation matrix, and robust standard errors.

Endogeneity concerns. In the current context, endogeneity could arise if an omitted variable explains the presence of directors with specific experience and knowledge sourcing activities. In addition to including a comprehensive set of controls, I addressed the threat of endogeneity using a control function (CF) approach (Wooldridge, 2015). The CF approach is an instrumental variable (IV) methodology that, unlike traditional IV, can be implemented in nonlinear models such as negative binomial models (Wooldridge, 2015). In a CF approach, the endogenous independent variable is first regressed on the instrument (plus all covariates). Then, a control function term that captures the residuals from the first equation is included in the main model (while excluding the instrument) (Wooldridge, 2015). A statistically significant control

function indicates the presence of endogeneity and requires keeping the control function term to obtain unbiased coefficients. However, if the control function is insignificant, the coefficients obtained without the IV estimation are consistent and efficient (Wooldridge, 2015). In fact, models including instrumental variables when endogeneity is not detected almost always produce large standard errors and a type II error (Semadeni, Withers, & Certo, 2014).

As with traditional IV, CF requires a valid instrument that correlates with the endogenous regressors (relevance) but has no theoretical relationship with the dependent variable (exogeneity). To this end, I followed prior upper echelons research (Germann, Ebbes, & Grewal, 2015; Withers et al., 2018) and instrumented for the ratio of directors with technical (marketing) experience with the industry average of directors with the same experience—after excluding the focal firm. I also excluded firms with direct interlock ties to the focal firm to minimize the effect of inter-firm coordination. In short, Germann et al. (2015) argued that the industry average of an upper echelon's demographic provides a valid instrument for two reasons. First, firms operating in the same industry face similar environments and thus coverage on similar leadership characteristics. For this reason, the industry average of directors with technical (marketing) experience should predict the presence of directors with similar experience at the focal firm. To this end, the Kleibergen-Paap Wald rk F statistic for the two instruments is 10.68, exceeding the value for instrument weakness (7.03; two instruments and two endogenous regressors) (Stock, Yogo, & Andrews, 2005). Therefore, these instruments meet the relevance criterion.

Second, firms operating in the same industry are unlikely to observe or act collectively on a firm-specific omitted variable causing the endogeneity issue. As such, the instrument should meet the exogeneity criterion (i.e., uncorrelated with the error term) (Angrist & Pischke, 2009). Establishing exogeneity requires multiple relevant instruments for each independent variable

(Semadeni et al., 2014). For technical experience, another instrument that met the relevance criterion was the industry average of directors with a master's degree. The Hansen J statistic was highly insignificant ($p = 0.87$), suggesting that the industry average of directors with technical experience is a valid instrument. Unfortunately, no other instruments for directors with marketing experience met the relevance criterion. Finally, including time and industry-fixed effects should alleviate concerns that industry-wide trends or factors are behind the observed relationships between director experience and knowledge sourcing (Germann et al., 2015).

RESULTS

Tables 1 and 2 include the descriptive statistics and correlation matrix. Following the CF approach, I obtained control functions from first stage OLS models predicting the presence of directors with technical and marketing experience and included them in the second stage GEE models. The control functions are only significant when instrumenting for directors with technical experience in models predicting technology acquisitions ($p = 0.024$) and technology acquisitions of established targets ($p = 0.004$). Because the inclusion of instruments produces large standard errors even for exogenous independent variables (Semadeni et al., 2014), I retained control function terms only in models when such terms are significant. These models are shown in Tables (3-9). For the sake of organization, I group the results by each knowledge sourcing mode instead of the order of the hypotheses.

Inventor recruitment results

Table 3 presents negative binomial models predicting the number of inventors that the focal firm hired each year. Model (3-1) includes the full set of controls. Some of the results in this model are interesting. For instance, The CEO's technical experience is positively related to inventor recruitment ($b = 0.103$, $p = 0.009$), consistent with the upper echelons theory predictions regarding executives' technical backgrounds and innovation efforts (Barker & Mueller, 2002).

Model (3-2) tests the main effects in hypotheses 1 and 2. First, hypothesis 1 predicted that directors with technical experience would be positively related to inventor recruitment. In support of this hypothesis, the coefficient for directors with technical experience is positive and significant ($b = 0.124$, $p = 0.031$), suggesting that firms appropriate the technical expertise of their directors to help with attracting more inventors. This effect is also practically meaningful as

the incidence ratio rate (IRR) is 1.13, which means that a one standard deviation increase in directors with technical experience is associated, on average, with a 13% increase in inventor recruitment, holding everything else constant[6]. Second, hypothesis 2 predicted that directors with marketing experience would be negatively related to inventor recruitment. The coefficient for directors with marketing experience is not significant (b = 0.075, p = 0.176). Thus hypothesis 2 is not supported.

Model (3-3) tests the interaction effects in hypotheses 7a and 8a. First, hypothesis 7a predicted that the relationship between directors with technical experience and inventor recruitment would be stronger when the firm experiences lower knowledge quality. Supporting this hypothesis, the coefficient for the interaction between directors with technical experience and knowledge quality is negative and significant (b = -0.060, p = 0.009). Figure 2 reveals that the positive relationship between directors with technical experience and inventor recruitment is steeper when the firm's knowledge quality is one standard deviation below the mean. Further, simple slope analysis (Cohen, Cohen, West, & Aiken, 2002) shows that the effect of directors with technical experience on inventor recruitment is positive and significant at one standard deviation below the mean of knowledge quality (p = 0.019), marginally significant at the mean (p = 0.081), and not significant at higher values. As such, directors with technical experience contribute to strengthening the firm's technical talent primarily when existing capabilities are deficient.

Second, hypothesis 8a predicted that the relationship between directors with marketing experience and inventor recruitment would be stronger when rivals achieve breakthroughs. The

[6] Considering that the use of patents to capture inventor recruitment results in a high rate of false negatives (Rosenkopf & Almeida, 2003), the true effect of directors with technical experience on inventor recruitment is potentially higher.

coefficient for the interaction between directors with marketing experience and rivals' breakthroughs is not significant (b = 0.000, p = 0.991). Thus, hypothesis 8a is not supported.

R&D alliances results

Table 4 presents negative binomial models predicting the number of R&D alliances that the firm entered in the focal year, and Tables 5 and 6 separate alliances into R&D alliances with new and repeat partners, respectively. Models (4-1, 5-1, and 6-1) include the full set of controls. Some of the results for the control variables in Model (4-1) are worth noting. First, prior inventor recruitment is positively related to R&D alliances (b = 0.127, p = 0.041), in accordance with prior findings showing that mobile inventors help the hiring firm discover and evaluate collaboration opportunities (Wagner & Goossen, 2018). Second, The CEO's technical experience is positively related to alliance formation (b = 0.093, p = 0.031). This result is consistent with prior work that has found that executives with technical backgrounds evaluate technology collaborations positively (Tyler & Steensma, 1998).

Models (4-2, 5-2, and 6-2) test the main effects in hypotheses 3a, 3b, 4a, and 4b. First, hypothesis 3a predicted that directors with technical experience would be positively related to the number of R&D alliances. The coefficient for directors with technical experience in Model (4-2) is positive and significant (b = 0.160, p = 0.003), supporting hypothesis 3a and suggesting that technical expertise on the board helps connect the firm to other technology firms and motivates alliance formation. In practical terms, a one standard deviation increase in directors with technical experience is associated, on average, with a 17% increase in R&D alliances activities. Second, hypothesis 3b predicted that directors with technical experience would be related to more R&D alliances with new partners than with repeat partners. Model (5-2) shows that the effect of directors with technical experience on R&D alliances with new partners is

positive and significant (b = 0.153, p = 0.010), and Model (6-2) shows that their effect on R&D alliances with repeat partners is not significant (b = 0.131, p = 0.373). To determine whether these coefficients are statistically different, I use the following equation (Paternoster et al., 1998):

$$Z = \frac{b_1 - b_2}{\sqrt{SEb_1{}^2 + SEb_2{}^2}} \qquad (1),$$

where b is the regression coefficient, and SE is the standard error. Equation 1 estimates that the difference between these two coefficients is not statistically significant (z= 0.139), and therefore hypothesis 3b is not supported.

Third, hypothesis 4a predicted that directors with marketing experience would be positively related to R&D alliances. Model (4-2) reports that the coefficient for directors with marketing experience is not significant (b = 0.095, p = 0.125), failing to support hypothesis 4a. Fourth, hypothesis 4b predicted that directors with marketing experience would be related to more R&D alliances with repeat partners than with new partners. Models (6-2 and 5-2) show that the coefficient for directors with marketing experience is not significantly related to R&D alliances with either repeat (b = 0.279, p = 0.111) or new partners (b = 0.077, p = 0.215). Therefore, hypothesis 4b is not supported.

Models (4-3, 5-3, and 6-3) test the interaction effects in hypotheses 7b and 8b. First, hypothesis 7b predicted that directors with technical experience would be related to more R&D alliances with new partners when the firm's knowledge quality is low. The coefficient for this interaction in Model (5-3) is negative and significant (b = -0.071, p = 0.015). At the same time, Model (6-2) shows that the coefficient for the same interaction on R&D alliances with repeat partners is positive and significant (b = 0.19, p = 0.001). Furthermore, the difference between these two coefficients is statistically significant (z = -4.02). Together, these results provide

strong support for hypothesis 7b and suggest that among firms whose boards include more directors with technical experience, the choice between new and repeat partners depends on the state of the firm's knowledge capabilities.

Figures 3 and 4 provide visual representations for these interactions. Figure 3 shows that the relationship between directors with technical experience and R&D alliances with new partners is stronger when knowledge quality is low. Likewise, simple slope analysis reveals that this relationship is positive and significant at one standard deviation below the mean of knowledge quality ($p = 0.002$), positive and marginally significant at the mean ($p = 0.078$), and not significant at higher values. In contrast, Figure 4 shows that the relationship between directors with technical experience and R&D alliances with repeat partners is stronger when knowledge quality is high. Simple slope analysis confirms that the relationship is positive and significant at one standard deviation above the mean of knowledge quality ($p = 0.031$) but not at lower values.

Second, hypothesis 8b predicted that the relationship between directors with marketing experience and R&D alliances with repeat partners would be stronger when rivals' breakthroughs are high. The coefficient for this interaction in Model (6-3) is not significant ($b = -0.437$, $p = 0.296$), and therefore hypothesis 8b is not supported.

Technology acquisitions results

Table 7 presents negative binomial models predicting the number of technology acquisitions that the firm undertook in the focal year, and Tables 8 and 9 separate technology acquisitions into acquisitions of startup and established targets, respectively. Models (7-1, 8-1, and 9-1) include the full set of controls. Some of the results in the control models are interesting. First, Model (7-1) reports that prior inventor recruitment is positively related to technology

acquisitions (b = 0.102, p = 0.003). This effect could be due to firms expanding the strategic scope of their knowledge sourcing activities after exploring via inventor recruitment (Kim, 1997) or due to hired inventors, subsequently reducing information asymmetry between acquirers and targets (c.f. Wagner and Goossen, 2018). Second, Model (8-1) shows a negative relationship between the average age of board members and technology acquisitions of startup targets (b = -0.161, p = 0.014), which is likely because older directors have established fields of vision and informational routines (Hambrick & Mason, 1984) that could limit their attention to emerging technologies developed by startup firms. Finally, similar to the finding by Chen et al. (2020), rivals' breakthroughs in Model (7-2) have a positive and significant effect on technology acquisitions (b = 0.059, p = 0.013).

Models (7-2, 8-2, and 9-2) test the main effects in hypotheses 5a, 5b, 6a, and 6b. First, hypothesis 5a predicted that directors with technical experience would be positively related to technology acquisitions. Contrary to expectations, Model (7-2) shows that the coefficient for directors with technical experience is negative and significant (b = -0.759, p = 0.024), and thus hypothesis 5a is not supported. This coefficient has an IRR value of 0.47, which indicates that a one standard deviation increase in directors with technical experience is associated, on average, with a 53% reduction in acquisition activities. This finding suggests that directors with technical experience do not value knowledge sourcing activities equally. I discuss the potential reasons in the Discussion.

Second, hypothesis 5b predicted that directors with technical experience would be related to more technology acquisitions of startup targets than of established targets. Model (8-2) reports that directors with technical experience have no significant effect on technology acquisitions of startup targets (b = -0.013, p = 0.818), while Model (9-2) shows that they have a negative and

significant effect on technology acquisitions of established targets (b = -0.975, p = 0.004). The difference between these two coefficients is statistically significant (z = 2.812). In practical terms, a one standard deviation increase in directors with technical experience is associated, on average, with a 62% reduction in technology acquisitions of established targets. Overall, hypothesis 5b is not supported.

Third, hypothesis 6a predicted that directors with marketing experience would be positively related to technology acquisitions. The coefficient for directors with marketing experience in Model (7-2) is not significant (b = -0.085, p = 0.158), failing to support hypothesis 6a. Fourth, hypothesis 6b predicted that directors with marketing experience would be related to more technology acquisitions of established targets than of startup targets. Contrary to expectations, Model (9-2) reveals that directors with marketing experience have a negative and significant effect on technology acquisitions of established targets (b = -0.138, p = 0.019), while Model (8-2) shows that their effect on technology acquisitions of startup targets is not significant (b = -0.017, p = 0.785). These coefficients are statistically different (z = -1.78)[7]. In practical terms, a one standard deviation increase in directors with marketing experience is associated, on average, with a 13% decrease in technology acquisitions of established targets. Overall, hypothesis 6b is not supported.

Models (7-3, 8-3, and 9-3) test the interaction effects in hypotheses 7c and 8c. First, hypothesis 7c predicted that the relationship between directors with technical experience and technology acquisitions of startup targets would be stronger when knowledge quality is low. Model (8-3) shows that the coefficient for this interaction is not significant (b = 0.007, p = 0.763), thus hypothesis 7c is not supported. Second, hypothesis 8c predicted that the relationship

[7] One tail test given the directional nature of the comparison.

between directors with marketing experience and technology acquisitions of established targets would be stronger following rivals' breakthroughs. Contrary to hypothesis 8c, Model (9-3) reveals that the coefficient for this interaction is negative and marginally significant (b = -0.065, p = 0.071). Further, Model (8-3) shows that the same interaction has a negative and marginally significant effect (b = -0.064, p = 0.076) on technology acquisitions of startup targets. However, the difference between these two coefficients is not statistically different (z = 0.02). Figure 5 shows the relationship between directors with marketing experience and acquisitions of established targets at low and high levels of rivals' breakthroughs. Furthermore, simple slope analysis reveals that this relationship is negative and significant at one standard deviation above the mean of rivals' breakthrough innovation (p = 0.003), negative and significant at the mean (p = 0.018), and not significant at lower values. Instead of responding to competitive threats by pushing the firm to acquire firms with market presence and downstream resources, directors with marketing experience limit such acquisitions. I elaborate on this surprising finding in the Discussion.

Additional findings

In addition to the formal hypotheses, I report additional findings that show whether rivals' breakthroughs moderate the influence of directors with technical experience and, similarly, whether knowledge quality moderates the influence of directors with marketing experience. To this end, all interaction models in Tables (3-9) include interaction terms between directors with technical experience and rivals' breakthroughs and between directors with marketing experience and knowledge quality. Although I did not formally hypothesize these relationships, some results are worth noting.

The results indicate that rivals' breakthroughs moderate the relationship between

directors' technical experience and knowledge sourcing. More specifically, Model (3-3) shows that rivals' breakthroughs weaken the relationship between directors with technical experience and inventor recruitment (b = -0.062, p = 0.023). I provide a plot for this interaction in Figure 6, which shows the positive effect of directors with technical experience on inventor recruitment to disappear at higher values of rivals' breakthroughs. Consistent with the plot, simple slope analysis reveals that the effect of directors with technical experience is significant at one standard deviation below the mean of rivals' breakthroughs (p = 0.020) and not significant at higher values. This finding suggests that directors with technical experience place less emphasis on sourcing knowledge through recruitment when the firm is under threat of rivals' technological advances.

Interestingly though, Model (8-3) reveals that rivals' breakthroughs positively moderate the relationship between directors with technical experience and the acquisitions of technology startups (b = 0.073, p = 0.045), and this interaction is statistically different (z = 2.89) from the equivalent effect on acquisitions of established targets shown in Model (9-3) (b = -0.041, p = 0.205). Figure 7 depicts this relationship as a crossed interaction. However, simple slope analysis reveals that the effect of directors with technical experience on startup acquisitions is neither significant at one standard deviation below the mean of rivals' breakthroughs (p = 0.212) nor at one standard deviation above the mean (p = 0.409). This lack of significance does not invalidate the interaction effect because the simple slopes approach does not capture all information related to interactions (Finsaas and Goldstein, 2021). The significant interaction term means that the slopes of the relationship between directors with technical experience and startup acquisitions are different from each other (Cohen et al., 2002), even if the chosen points for evaluating the simple slopes are not significantly different from zero. This is often the case with low-base, naturally

skewed moderators (Finsaas and Goldstein, 2021)[8], such as technological breakthroughs.

Together, these findings suggest that directors with technical experience consider different pathways for obtaining technical talent, switching from recruitment to startup acquisitions in response to competitive threats. I elaborate on this in the Discussion section.

The results also show that knowledge quality is a relevant boundary condition to the role of directors with marketing experience. Specifically, Model (9-3) reports that knowledge quality moderates the relationship between directors with marketing experience and technology acquisitions of established targets such that the relationship is positive and significant ($b = 0.067$, $p = 0.010$). However, this effect is not statistically different ($z = 0.93$) from the equivalent effect on technology acquisitions of startup firms reported in Model (8-3) ($b = 0.029$, $p = 0.313$). Figure 8 depicts this interaction, showing a decreasing propensity of firms with more marketing expertise on the board to acquire established targets when knowledge quality is low. Simple slope analysis reveals that this effect is negative and significant at one standard deviation below the mean ($p = 0.001$) and the mean of knowledge quality ($p = 0.007$) but not at higher values.

Robustness checks

I conducted additional checks to ensure the consistency of the results under different specifications. First, I obtained consistent results after winsorizing the dependent, independent, and moderator variables at the 99% level. Thus, extreme values are not driving the observed effects. Second, I examined whether treating technical and marketing roles equally without accounting for seniority in the coding of experience measures changes the result materially. The

[8] Another limitation of simple slope analysis is that the choice of moderator impacts the significance of the slopes (Finsaas and Goldstein, 2021). When directors with technical experience is the moderator and rivals' breakthroughs is the independent variable, the relationship between rivals' breakthroughs and startup acquisitions becomes positive and significant at one standard deviation above the mean of directors with technical experience but not at lower values.

results remained consistent. Third, I examined whether the measures for knowledge quality and rivals' breakthroughs are sensitive to different measurement windows. I measured knowledge quality using a three-year window of patent citations (instead of five) and rivals' breakthroughs using a two-year window (instead of 3) of R&D 100 awards. Again, the results remained consistent. The results for knowledge quality were also robust to calculating the raw average of citations instead of applying a depreciation rate to account for patent age.

Finally, I examined whether the inventor recruitment results are consistent after restricting the recruitment measure to impactful inventors only (i.e., those above the citation median of inventors hired by firms in the same industry). Such inventors are arguably more relevant to renewing knowledge capabilities (Paruchuri et al., 2006). As such, if directors contribute to strategies concerning technical talent, their contribution should be evident in attracting high-impact inventors. To this end, the results remained consistent when predicting the recruitment of inventors above the citation median.

DISCUSSION

Corporate directors' role in informing and shaping the firm's strategies remains a subject of interest to governance scholars (Boivie et al., 2021; Hambrick et al., 2015; Lungeanu & Zajac, 2019). Recent studies have suggested that in the face of increasing dependence on external knowledge actors, directors with the right expertise can help the firm recognize and obtain valuable outside knowledge (Balsmeier et al., 2014; Howard et al., 2017; Klarner et al., 2020). However, prior work is yet to examine (1) the specific modes via which the board shapes knowledge sourcing, (2) how such modes interest directors with innovation-related but yet distinct backgrounds, and (3) whether technological and market developments, which motivate the search for new capabilities (Puranam et al., 2003), influence the choice of sourcing modes. These omissions are critical because the choice of how to source outside knowledge can have important learning and innovation implications (e.g., Carayannopoulos & Auster, 2010; Rosenkopf & Almeida, 2003).

In this dissertation, I sought to fill these gaps by examining the influence of directors with experiences most relevant to innovation (i.e., technical and marketing) on an extended range of knowledge sourcing modes, including sourcing activities that do not constitute major initiatives (e.g., hiring strategies), and under different conditions of internal capabilities and external threats. The empirical results offer broad support to the idea that directors shape knowledge sourcing in ways that reflect their ability and motivation. However, the results also reveal unexpected findings that could inform future research.

The role of directors with technical experience

The results indicate that technical experience enables and motivates directors to monitor and adjust the firm's knowledge capabilities. As such, this dissertation extends previous

governance studies in emphasizing the importance of domain-specific expertise to the board's functions (Boivie et al., 2021; Hambrick et al., 2015; McDonald et al., 2008). In addition, it contributes to the governance and innovation literature by showing through which modes and under which conditions directors with science and engineering backgrounds shape knowledge sourcing. In sum, such directors contribute to knowledge sourcing through the various modes examined—specifically, strategies that add to the firm's pool of technical talent (i.e., inventor recruitment and startup acquisitions) and R&D alliances. However, they do not treat all sourcing modes equally, as evident in their negative impact on major technology acquisitions. Additionally, such directors are sensitive to the firm's knowledge capabilities and technological disruptions stemming from the competitive environment.

The findings support the arguments regarding the distinct abilities of directors with technical experience. The positive effect of such directors on inventor recruitment illustrates that technical expertise equips directors with rich mental schemas that improve attention to ongoing aspects of the firm's knowledge operations (Boivie et al., 2016). In essence, contributing to continuous activities, such as those aimed at attracting qualified inventors, requires directors to go beyond their traditional roles of evaluating major initiatives and instead function as a "supra" top management team (Finkelstein et al., 2009) or strategic partners with the executive team (Boivie et al., 2021). In the same vein, the finding that such directors are associated with technology startup acquisitions—in response to rivals' breakthroughs—is evidence of their ability to keep abreast of emerging technological developments and enable timely adaptation.

The findings also support the argument that technical experience motivates directors to maintain and advance knowledge capabilities. This is evident in the stronger effect of directors with technical experience on inventor recruitment and R&D alliances with new partners when

the firm fails to generate high-quality knowledge. Pushing the firm to cooperate more with new partners than with repeat partners in response to weaknesses in the firm's knowledge performance likely reflects concerns with inventive capabilities (Goerzen, 2007). As such, this is further evidence that in the upper echelons, "science and engineering are concerned with progress, invention, and improvement" (Wiersema & Bantel, 1992: 100). Furthermore, the motivation for advancing knowledge could also explain these directors' negative association with major technology acquisitions. Prior studies have found that technology acquisitions disrupt knowledge workers' productivity (Paruchuri et al., 2006) and increase employee turnover (Seru, 2014). Because they can relate to the work of scientists and engineers, directors from technical backgrounds are likely cognizant of the adverse effects of major acquisitions and would not regard such actions as relevant to knowledge goals.

The results reveal that directors with technical experience are also attentive to market developments (i.e., rivals' breakthroughs). Although the theoretical arguments did not address these relationships, they are not surprising given the a priori evidence. First, decision-makers, especially those with business backgrounds, are familiar with various business domains, even if they sample more information from domains closer to their functional tracks (Tyler & Steensma, 1998). Therefore, the fields of vision of directors with technical experience likely encompass market developments as well. Second, introducing innovative products in the firm's markets strongly signals the need for adaptation (Eggers & Park, 2018), and the logic of bounded rationality dictates that salient stimuli will exert more influence on the decision-making of directors, who have limited time and cognitive resources to process all relevant stimuli (Finkelstein et al., 2009).

Perhaps the most novel findings in this dissertation concern how and when firms

governed by directors with technical expertise choose to obtain technical talent. Firms can obtain technical talent via recruiting individual inventors (Rosenkopf & Almeida, 2003) or acquiring small startup firms (Mawdsley & Somaya, 2016), a process known as "acqui-hiring" (Setor & Joseph, 2017). In this regard, directors with technical expertise utilize these modes differently when faced with internal weaknesses and external threats. More specifically, such directors increase inventor recruitment when knowledge quality is low but switch to startup acquisitions when the firm is threatened with potentially competence-destroying technological change. This pattern can be explained through the lens of the variation-selection model of innovation (Katila et al., 2017). When knowledge outputs stagnate, directors likely perceive a greater need for varying inventive inputs and invigorating the creative process with path-breaking routines. Hiring individual inventors aligns more with such an objective (Tzabbar, 2009). However, when the firm faces competitive threats, directors likely perceive a greater need for targeted knowledge sourcing activities and acquiring technical talent through startups to facilitate the selection process.

Together, the results extend the initial theorization by showing that technical experience also enables directors to monitor the innovative activities of rivals and that such activities motivate directors to shift toward more targeted and selective sourcing modes.

The role of directors with marketing experience

The results, taken together, indicate that directors with marketing experience have a limited impact on knowledge sourcing decisions. They do not shape inventor recruitment or R&D alliances activities, and their influence on technology acquisitions is negative, especially when the firm produces low knowledge quality or faces rivals' breakthroughs. Although the negative effect of directors with marketing experience on acquiring established technology firms

is similar to that of directors with technical experience, the latter group directs the firm toward alternative sourcing modes. As such, the most plausible takeaway is that marketing experience engenders less influence on how boards direct knowledge sourcing.

These findings are surprising and inconsistent with the role that marketing experience plays in enabling and motivating corporate leaders to enhance competitive advantage through superior knowledge capabilities. One might then question whether high technology firms involve directors with marketing experience in knowledge decisions. In other words, these directors might lack the opportunity to voice their opinions regarding outside knowledge. After all, having an adequate opportunity is necessary for translating ability and motivation into action (Blumberg & Pringle, 1982).

In this regard, research on group decision-making indicates that groups recognize a member's expertise based on the proximity of expertise cues to the task at hand (Bunderson, 2003). A longer distance between the cues and the task reduces the group's utilization of a member's expertise (Bunderson, 2003). In science and engineering intensive industries, marketing experience might not be perceived as a strong cue of domain-expertise as technical experience, which deals directly with recombining and transforming sourced knowledge into new products (Gruber et al., 2013). Furthermore, unlike technical knowledge, marketing knowledge tends to be embedded within specific markets and customer segments and might not diffuse easily to the focal firm (Griffith & Lusch, 2007). This feature of marketing capital could further weaken the perceived status of marketers as experts on the firm's knowledge needs. As such, when executives look for board members to advise on sourcing outside knowledge, they might overlook the potential contributions of directors with marketing experience. It is important to stress that this idea does not suggest that marketing is irrelevant to knowledge decisions.

Instead, it points that directors' opportunity (or lack thereof) to shape strategic outcomes is a potential explanation that future research could pursue to understand the limited impact of directors with marketing experience on knowledge sourcing.

Theoretical implications

This dissertation adds to the link between the board of directors and the strategic domain of knowledge. Prior studies have demonstrated the importance of the board to external knowledge sourcing (Howard et al., 2017; Klarner et al., 2020). By examining a comprehensive set of outcomes, this dissertation extends directors' contribution to underexamined sourcing activities. The findings show that qualified directors influence sourcing through multiple modes and, more importantly, hold preferences regarding which modes to utilize. In fact, directors with scientific and engineering backgrounds prefer renewing the firm's knowledge capabilities by obtaining technical talent and cooperating with innovative firms instead of outright acquiring such capabilities. Moreover, such directors consider only small acquisitions, primarily in response to competitive threats. Therefore, the dissertation points to a novel mechanism that underlies the firm's approach to outside knowledge—that is, whether the board is concerned with renewing knowledge capabilities or selecting an immediate response to technological disruption.

The findings also contribute to upper echelons theory by highlighting key differences in the role of output-oriented backgrounds. Prior studies have implicitly assumed that backgrounds in R&D/engineering and marketing functions lead to similar attention to innovation, growth, and entrepreneurship issues in the external environment (Cho & Hambrick, 2006; Tuggle et al., 2010). However, the findings show that technical experience leads to more recognition of external innovation resources and the contingencies that require adjusting innovation inputs, while marketing experience appears to have a limited impact. Thus, treating these two forms of

experience similarly might lead to underestimating directors' effect on innovation actions.

Furthermore, the results invite further examination of directors with scientific and engineering backgrounds. The role of such backgrounds in the upper echelons literature is certainly not new (e.g., Hitt & Tyler, 1991; Wiersema & Bantel, 1992). However, the specific contributions of such backgrounds at the director level and their impact on knowledge decisions warrant further examination. In this regard, this dissertation uncovers that such backgrounds enable directors to add value to the firm's access to technical talent. This finding is novel because the link between the board and human resources has received limited attention from the literature. Given that access to qualified technical talent (e.g., inventors) is a critical resource dependence in high technology industries (Agarwal et al., 2009; Keum, 2020), managing this dependence appears to be an important board function.

Finally, the dissertation makes unique contributions to the innovation literature. This literature is interested in examining the firm's choice between different knowledge sourcing strategies (Mawdsley & Somaya, 2016; Tzabbar et al., 2013). The findings add two insights to this stream of literature. First, having more technical expertise on the board leads to more R&D alliances and fewer large acquisitions. While prior studies have examined a host of industry and firm-level factors that predict the choice between alliances and acquisitions (Carayannopoulos & Auster, 2010; Hagadoorn & Duysters, 2002), the current findings point that governance factors are also relevant. Second, the findings explain the choice between inventor recruitment and startup acquisitions as modes for obtaining technical talent by showing that firms whose directors have technical experience utilize inventor recruitment to fix weaknesses in knowledge capabilities and acquire startups to respond to rivals' breakthroughs.

Future directions

Future research could extend the current work in several ways. First, future research could examine whether directors help the firm integrate and transform the sourced knowledge better. A key challenge in benefiting from external knowledge is exploiting it to foster future innovation (Cohen & Levinthal, 1990). Thus, a potential avenue of research is whether directors help institute strategies to maximize the returns on the firm's investments in outside knowledge. This can be done, for example, by examining how the firm combines sourced knowledge with existing knowledge to create new recombinations (Choi & McNamara, 2018). Second, future research could also directly measure the theorized attributes of ability and motivation and examine their mediating role. Although the pattern of results is consistent with some of the theorized mechanisms, a direct examination could better explain the unexpected findings and extend the current ones. Finally, future research could also examine whether directors' expertise complements or substitutes for the CEO's. Furthermore, such research could also examine whether a mix of board/CEO technical and marketing experience shapes knowledge sourcing. For example, it is plausible that having CEOs with marketing experience could improve the firm's ability to capitalize on the technical expertise of directors.

CONCLUSION

The composition of the board of directors predicts how firms source external knowledge. The most relevant directors to knowledge sourcing are those with technical backgrounds. Such directors increase inventor recruitment, R&D alliances but reduce technology acquisitions. Further, these relationships are contingent on the quality of the firm's knowledge and rivals' breakthrough innovations. Directors with marketing experience are also found to decrease technology acquisitions of established targets but have no impact on other sourcing modes.

APPENDIX

Table 1. Descriptive Statistics

Variables	Mean	Std. Dev.	Min.	Max.
1. Inventor recruitment	14.60	44.39	0.00	520.00
2. R&D alliances	0.24	0.86	0.00	14.00
3. R&D alliances with new partners	0.19	0.68	0.00	10.00
4. R&D alliances with repeat partners	0.05	0.38	0.00	10.00
5. Tech. acquisitions	1.03	1.98	0.00	27.00
6. Tech. acquisitions of startup targets	0.38	1.20	0.00	24.00
7. Tech. acquisitions of established targets	0.65	1.18	0.00	12.00
8. Directors with technical experience	0.25	0.23	0.00	1.25
9. Directors with marketing experience	0.22	0.21	0.00	1.13
10. Knowledge quality	-1.11	6.30	-28.97	84.06
11. Rivals' breakthroughs	0.46	1.55	0.00	24.00
12. Prior inventor recruitment	48.09	134.73	0.00	1384.00
13. Prior R&D alliances	0.46	2.48	0.00	43.00
14. Prior technology acquisitions	3.33	5.45	0.00	57.00
15. CEO technical experience	0.32	0.62	0.00	2.00
16. CEO marketing experience	0.44	0.73	0.00	2.00
17. Director age	61.92	4.02	49.20	78.50
18. Director education level	0.55	0.17	0.00	1.00
19. Director social ties	2134.53	1265.30	54.17	8509.91
20. Director throughput experience	0.45	0.17	0.00	1.00
21. Board independence	0.18	0.11	0.00	1.00
22. CEO duality	0.39	0.49	0.00	1.00
23. CEO compensation (L)	8.12	1.74	0.00	12.54
24. Director compensation (L)	5.18	0.99	0.00	8.75
25. CEO tenure	7.70	7.55	0.00	61.00
26. Firm size (L)	7.72	2.02	0.00	13.22
27. Firm debt (L)	4.79	3.38	0.00	12.06
28. Financial slack (L)	5.94	1.94	0.00	11.80
29. R&D intensity	0.13	0.50	0.00	17.48

***Notes**: N = 2952.* L: logged variable.

Table 2. Correlation Matrix

Variables	1	2	3	4	5	6	7	8	9	10	11
1. Inventor recruitment	1.00										
2. R&D alliances	0.24	1.00									
3. R&D alliances with new partners	0.21	0.91	1.00								
4. R&D alliances with repeat partners	0.19	0.66	0.28	1.00							
5. Tech. acquisitions	0.55	0.24	0.21	0.17	1.00						
6. Tech. acquisitions of startup targets	0.56	0.22	0.19	0.16	0.84	1.00					
7. Tech. acquisitions of established targets	0.35	0.17	0.16	0.12	0.83	0.39	1.00				
8. Directors with technical experience	0.11	0.18	0.16	0.13	0.05	0.07	0.01	1.00			
9. Directors with marketing experience	0.02	-0.03	-0.03	-0.01	0.00	0.04	-0.04	-0.11	1.00		
10. Knowledge quality	0.17	-0.02	-0.06	0.07	0.06	0.07	0.03	-0.08	0.09	1.00	
11. Rivals' breakthroughs	0.06	-0.01	0.01	-0.03	0.09	0.02	0.13	0.06	0.01	0.01	1.00
12. Prior inventor recruitment (L)	0.92	0.30	0.25	0.24	0.55	0.58	0.33	0.12	0.04	0.15	0.05
13. Prior R&D alliances (L)	0.29	0.65	0.58	0.46	0.26	0.23	0.20	0.15	-0.05	0.00	-0.01
14. Prior technology acquisitions (L)	0.57	0.30	0.26	0.23	0.67	0.59	0.53	0.05	-0.01	0.06	0.09
15. CEO technical experience	0.04	0.04	0.05	0.00	0.04	0.06	0.01	0.16	0.02	-0.02	0.03
16. CEO marketing experience	0.06	0.02	0.02	0.00	0.03	0.04	0.00	-0.08	0.09	-0.01	-0.04
17. Director age	-0.10	0.00	-0.01	0.01	-0.08	-0.12	-0.01	0.02	-0.21	-0.12	0.02
18. Director education level	0.04	0.05	0.06	0.00	0.02	0.00	0.04	0.08	-0.03	-0.03	0.03
19. Director social ties	0.57	0.36	0.32	0.26	0.46	0.44	0.32	0.21	0.05	0.06	0.06
20. Director throughput experience	-0.03	-0.02	-0.03	0.01	0.02	0.01	0.02	-0.11	0.13	-0.01	-0.03
21. Board independence	-0.03	-0.08	-0.07	-0.05	-0.01	0.01	-0.02	-0.09	-0.03	0.00	-0.03
22. CEO duality	0.03	0.08	0.05	0.09	0.04	0.01	0.06	0.08	-0.05	-0.03	0.01
23. CEO compensation (L)	0.02	0.17	0.16	0.09	0.09	0.01	0.14	0.03	-0.04	0.03	0.06
24. Director compensation (L)	0.14	0.11	0.10	0.07	0.13	0.10	0.12	0.12	-0.04	0.04	0.03
25. CEO tenure	-0.02	-0.06	-0.05	-0.05	0.01	0.01	0.01	0.08	-0.08	-0.02	0.01
26. Firm assets (L)	0.43	0.32	0.28	0.24	0.37	0.32	0.30	0.06	-0.08	0.09	0.07

Table 2 (cont'd)

27. Firm debt (L)	0.21	0.23	0.20	0.16	0.18	0.13	0.17	-0.02	-0.05	-0.01	0.08
28. Financial slack (L)	0.47	0.34	0.30	0.24	0.38	0.36	0.27	0.17	0.01	0.11	0.06
29. R&D intensity	-0.01	0.01	0.01	0.00	-0.02	-0.01	-0.03	0.14	-0.02	-0.03	-0.02
Variables	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
12. Prior inventor recruitment (L)	1.00										
13. Prior R&D alliances (L)	0.29	1.00									
14. Prior technology acquisitions (L)	0.63	0.33	1.00								
15. CEO technical experience	0.07	0.03	0.06	1.00							
16. CEO marketing experience	0.05	0.02	0.03	-0.02	1.00						
17. Director age	-0.09	-0.02	-0.08	-0.01	-0.11	1.00					
18. Director education level	0.06	0.03	0.02	0.05	0.00	-0.10	1.00				
19. Director social ties	0.62	0.36	0.56	0.09	0.05	-0.15	0.23	1.00			
20. Director throughput experience	0.01	-0.02	0.04	-0.05	0.06	-0.20	0.16	0.07	1.00		
21. Board independence	-0.05	-0.06	-0.02	-0.07	-0.04	-0.05	-0.16	-0.17	-0.13	1.00	
22. CEO duality	0.03	0.08	0.04	-0.08	-0.14	0.13	0.02	0.06	-0.06	-0.11	1.00
23. CEO compensation (L)	0.04	0.13	0.10	0.08	0.04	0.12	0.09	0.22	0.08	-0.35	0.08
24. Director compensation (L)	0.17	0.07	0.19	0.13	0.02	0.04	0.11	0.28	0.02	-0.35	-0.03
25. CEO tenure	-0.03	-0.06	0.02	-0.08	-0.14	0.24	-0.05	-0.12	-0.09	0.19	0.30
26. Firm assets (L)	0.49	0.28	0.47	0.04	-0.01	0.07	0.15	0.63	0.04	-0.29	0.11
27. Firm debt (L)	0.28	0.17	0.28	0.01	-0.01	0.14	0.17	0.44	0.14	-0.27	0.07
28. Financial slack (L)	0.52	0.29	0.45	0.11	0.03	-0.01	0.17	0.65	-0.03	-0.23	0.09
29. R&D intensity	-0.01	0.01	-0.02	0.05	0.01	-0.05	0.07	0.00	0.02	-0.04	-0.04
Variables	**23**	**24**	**25**	**26**	**27**	**28**					
23. CEO compensation (L)	1.00										
24. Director compensation (L)	0.57	1.00									
25. CEO tenure	-0.11	-0.14	1.00								
26. Firm assets (L)	0.56	0.51	-0.08	1.00							

Table 2 (cont'd)

27. Firm debt (L)	0.45	0.33	-0.11	0.74	1.00	
28. Financial slack (L)	0.45	0.47	-0.08	0.86	0.53	1.00
29. R&D intensity	0.00	0.03	0.00	-0.09	-0.09	0.00

***Notes**: N* = 2,952. Correlations greater than |0.03| are significant at the 5% level. L: logged variable.

Table 3. Negative Binomial GEE Models Predicting Inventor Recruitment

Variables	(3-1)	(3-2)	(3-3)
	Controls	**Main effects**	**Interactions**
Directors with technical experience		0.124*	0.118*
		(0.058)	(0.056)
Directors with marketing experience		0.075	0.092+
		(0.056)	(0.055)
Knowledge quality		0.053	0.143***
		(0.038)	(0.033)
Rivals breakthroughs		-0.021	-0.016
		(0.020)	(0.017)
Directors with technical experience X Knowledge quality			-0.060**
			(0.023)
Directors with technical experience X Rivals breakthroughs			-0.062*
			(0.028)
Directors with marketing experience X Knowledge quality			-0.092
			(0.057)
Directors with marketing experience X Rivals breakthroughs			0.000
			(0.026)
Controls			
Prior inventor recruitment	0.383***	0.385***	0.369***
	(0.077)	(0.073)	(0.072)
Prior R&D alliances	0.034	0.038	0.035
	(0.031)	(0.031)	(0.027)
Prior technology acquisitions	-0.056	-0.053	-0.049
	(0.053)	(0.054)	(0.054)
CEO technical experience	0.103**	0.115**	0.124**
	(0.039)	(0.043)	(0.039)
CEO marketing experience	0.055	0.065+	0.067+
	(0.036)	(0.039)	(0.035)
Director age	-0.086	-0.053	-0.045
	(0.068)	(0.065)	(0.067)
Director education level	-0.072	-0.054	-0.060
	(0.061)	(0.062)	(0.061)
Director social ties	0.148+	0.117	0.130
	(0.077)	(0.075)	(0.080)
Director throughput experience	-0.053	-0.041	-0.042
	(0.068)	(0.068)	(0.066)
Board independence	-0.142*	-0.125+	-0.134*
	(0.067)	(0.068)	(0.065)
CEO duality	0.031	0.036	0.050
	(0.047)	(0.049)	(0.048)
CEO compensation (L)	0.027	0.011	0.023
	(0.064)	(0.063)	(0.058)

Table 3 (cont'd)

Director compensation (L)	0.191***	0.199***	0.185***
	(0.036)	(0.034)	(0.038)
CEO tenure	0.056	0.054	0.050
	(0.041)	(0.040)	(0.042)
Firm size (L)	0.567*	0.612**	0.633**
	(0.224)	(0.228)	(0.225)
Firm debt (L)	-0.043	-0.042	-0.038
	(0.066)	(0.064)	(0.061)
Financial slack (L)	0.215	0.203	0.199
	(0.173)	(0.175)	(0.173)
R&D intensity	0.040+	0.039	0.042+
	(0.024)	(0.024)	(0.023)
Constant	1.035***	0.936***	0.885***
	(0.257)	(0.265)	(0.259)

***Notes**:* 2,952 observations and 319 unique firms. All models include year and industry fixed effects and two dummies indicating whether the firm belongs to the mid or small-cap segments of the S&P1500 index. All predictors are standardized and lagged by one year. Robust standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05, + p<0. L: logged variable.

Table 4. Negative Binomial GEE Models Predicting R&D Alliances

Variables	(4-1)	(4-2)	(4-3)
	Controls	Main effects	Interactions
Directors with technical experience		0.160**	0.159**
		(0.053)	(0.057)
Directors with marketing experience		0.095	0.092
		(0.062)	(0.062)
Knowledge quality		0.008	0.021
		(0.035)	(0.060)
Rivals breakthroughs		-0.010	-0.043
		(0.056)	(0.058)
Directors with technical experience X Knowledge quality			-0.001
			(0.027)
Directors with technical experience X Rivals breakthroughs			0.066
			(0.045)
Directors with marketing experience X Knowledge quality			-0.081+
			(0.048)
Directors with marketing experience X Rivals breakthroughs			0.056
			(0.066)
Controls			
Prior inventor recruitment	0.127*	0.132*	0.142*
	(0.062)	(0.065)	(0.066)
Prior R&D alliances	0.296***	0.294***	0.296***
	(0.039)	(0.039)	(0.039)
Prior technology acquisitions	0.054	0.058	0.053
	(0.058)	(0.060)	(0.060)
CEO technical experience	0.093*	0.088*	0.090*
	(0.043)	(0.042)	(0.042)
CEO marketing experience	0.101+	0.109*	0.107*
	(0.053)	(0.053)	(0.053)
Director age	-0.047	-0.018	-0.022
	(0.071)	(0.079)	(0.079)
Director education level	0.034	0.056	0.065
	(0.065)	(0.065)	(0.064)
Director social ties	-0.031	-0.083	-0.096
	(0.080)	(0.087)	(0.089)
Director throughput experience	0.055	0.067	0.066
	(0.068)	(0.067)	(0.066)
Board independence	-0.032	-0.017	-0.015
	(0.079)	(0.077)	(0.079)
CEO duality	-0.005	-0.004	-0.008
	(0.057)	(0.060)	(0.061)
CEO compensation (L)	0.248***	0.271***	0.264***
	(0.074)	(0.076)	(0.074)

Table 4 (cont'd)

Director compensation (L)	0.001	-0.012	-0.013
	(0.084)	(0.081)	(0.081)
CEO tenure	0.036	0.029	0.031
	(0.058)	(0.058)	(0.059)
Firm size (L)	0.391+	0.465*	0.492*
	(0.235)	(0.236)	(0.243)
Firm debt (L)	0.020	0.030	0.030
	(0.102)	(0.103)	(0.102)
Financial slack (L)	0.121	0.059	0.061
	(0.161)	(0.168)	(0.168)
R&D intensity	-0.028	-0.054	-0.051
	(0.067)	(0.078)	(0.078)
Constant	-0.059	-0.165	-0.152
	(0.195)	(0.204)	(0.204)

***Notes**:* 2,952 observations and 319 unique firms. All models include year and industry fixed effects and two dummies indicating whether the firm belongs to the mid or small-cap segments of the S&P1500 index. All predictors are standardized and lagged by one year. Robust standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05, + p<0. L: logged variable.

Table 5. Negative Binomial GEE Models Predicting R&D Alliances with New Partners

Variables	(5-1)	(5-2)	(5-3)
	Controls	Main effects	Interactions
Directors with technical experience		0.153**	0.111+
		(0.059)	(0.062)
Directors with marketing experience		0.077	0.060
		(0.062)	(0.062)
Knowledge quality		-0.067	0.010
		(0.058)	(0.061)
Rivals breakthroughs		0.036	0.001
		(0.044)	(0.047)
Directors with technical experience X Knowledge quality			-0.071*
			(0.029)
Directors with technical experience X Rivals breakthroughs			0.062
			(0.044)
Directors with marketing experience X Knowledge quality			-0.097+
			(0.051)
Directors with marketing experience X Rivals breakthroughs			0.067
			(0.061)
Controls			
Prior inventor recruitment	0.139	0.155+	0.173*
	(0.088)	(0.085)	(0.086)
Prior R&D alliances	0.247***	0.251***	0.257***
	(0.041)	(0.040)	(0.041)
Prior technology acquisitions	-0.003	-0.010	-0.006
	(0.065)	(0.061)	(0.062)
CEO technical experience	0.110*	0.109*	0.115**
	(0.044)	(0.042)	(0.044)
CEO marketing experience	0.113*	0.124*	0.121*
	(0.057)	(0.057)	(0.058)
Director age	-0.062	-0.045	-0.038
	(0.078)	(0.083)	(0.082)
Director education level	0.069	0.083	0.096
	(0.072)	(0.070)	(0.068)
Director social ties	0.007	-0.051	-0.062
	(0.089)	(0.091)	(0.092)
Director throughput experience	-0.005	0.000	0.001
	(0.062)	(0.062)	(0.061)
Board independence	-0.068	-0.056	-0.048
	(0.081)	(0.080)	(0.080)
CEO duality	-0.058	-0.056	-0.051
	(0.060)	(0.061)	(0.063)
CEO compensation (L)	0.413***	0.443***	0.425***
	(0.125)	(0.132)	(0.128)

Table 5 (cont'd)

Director compensation (L)	-0.044	-0.044	-0.053
	(0.091)	(0.090)	(0.089)
CEO tenure	0.065	0.057	0.049
	(0.063)	(0.063)	(0.065)
Firm size (L)	0.134	0.203	0.196
	(0.224)	(0.222)	(0.229)
Firm debt (L)	0.079	0.078	0.081
	(0.109)	(0.109)	(0.107)
Financial slack (L)	0.208	0.167	0.173
	(0.159)	(0.160)	(0.161)
R&D intensity	-0.057	-0.081	-0.075
	(0.075)	(0.084)	(0.083)
Constant	-0.181	-0.361	-0.334
	(0.215)	(0.230)	(0.223)

***Notes**:* 2,952 observations and 319 unique firms. All models include year and industry fixed effects and two dummies indicating whether the firm belongs to the mid or small-cap segments of the S&P1500 index. All predictors are standardized and lagged by one year. Robust standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05, + p<0. L: logged variable.

Table 6. Negative Binomial GEE Models Predicting R&D Alliances with Repeat Partners

Variables	(6-1)	(6-2)	(6-3)
	Controls	Main effects	Interactions
Directors with technical experience		0.131	0.253+
		(0.147)	(0.148)
Directors with marketing experience		0.279	0.220
		(0.175)	(0.203)
Knowledge quality		0.121***	-0.241*
		(0.035)	(0.121)
Rivals breakthroughs		-1.371***	-1.643***
		(0.343)	(0.489)
Directors with technical experience X Knowledge quality			0.190**
			(0.058)
Directors with technical experience X Rivals breakthroughs			0.062
			(0.282)
Directors with marketing experience X Knowledge quality			0.035
			(0.090)
Directors with marketing experience X Rivals breakthroughs			-0.437
			(0.419)
Controls			
Prior inventor recruitment	0.117	0.103	0.113
	(0.082)	(0.077)	(0.079)
Prior R&D alliances	0.220***	0.245***	0.251***
	(0.043)	(0.048)	(0.050)
Prior technology acquisitions	0.028	0.097	0.065
	(0.100)	(0.110)	(0.122)
CEO technical experience	0.036	0.013	-0.001
	(0.124)	(0.120)	(0.133)
CEO marketing experience	-0.058	-0.151	-0.111
	(0.147)	(0.123)	(0.128)
Director age	-0.092	0.039	0.028
	(0.213)	(0.222)	(0.218)
Director education level	-0.148	0.002	-0.010
	(0.188)	(0.160)	(0.165)
Director social ties	-0.109	-0.059	-0.129
	(0.159)	(0.190)	(0.200)
Director throughput experience	0.497*	0.485*	0.434+
	(0.242)	(0.225)	(0.225)
Board independence	0.333	0.304	0.303
	(0.229)	(0.201)	(0.204)
CEO duality	0.191	0.189	0.161
	(0.133)	(0.139)	(0.144)
CEO compensation (L)	-0.089	-0.010	0.014
	(0.106)	(0.100)	(0.105)

Table 6 (cont'd)

Director compensation (L)	0.100	0.110	0.122
	(0.185)	(0.174)	(0.184)
CEO tenure	-0.158	-0.182	-0.139
	(0.167)	(0.160)	(0.157)
Firm size (L)	2.312***	2.372***	2.449***
	(0.647)	(0.677)	(0.664)
Firm debt (L)	-0.173	-0.137	-0.147
	(0.134)	(0.137)	(0.136)
Financial slack (L)	-0.538	-0.823	-0.787
	(0.574)	(0.566)	(0.549)
R&D intensity	0.091	0.092	0.111
	(0.105)	(0.087)	(0.073)
Constant	-2.793***	-3.141***	-3.456***
	(0.578)	(0.664)	(0.707)

Notes: 2,952 observations and 319 unique firms. All models include year and industry fixed effects and two dummies indicating whether the firm belongs to the mid or small-cap segments of the S&P1500 index. All predictors are standardized and lagged by one year. Robust standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05, + p<0. L: logged variable.

Table 7. Negative Binomial GEE Models Predicting Technology Acquisitions

Variables	(7-1)	(7-2)	(7-3)
	Controls	Main effects	Interactions
Directors with technical experience		-0.759*	-0.812*
		(0.337)	(0.336)
Directors with marketing experience		-0.085	-0.096
		(0.061)	(0.059)
Knowledge quality		-0.049	-0.078*
		(0.035)	(0.031)
Rivals breakthroughs		0.059*	0.067**
		(0.024)	(0.025)
Directors with technical experience X Knowledge quality			0.014
			(0.021)
Directors with technical experience X Rivals breakthroughs			-0.015
			(0.027)
Directors with marketing experience X Knowledge quality			0.055**
			(0.019)
Directors with marketing experience X Rivals breakthroughs			-0.070*
			(0.032)
Controls			
Prior inventor recruitment	0.102**	0.112***	0.105**
	(0.034)	(0.034)	(0.034)
Prior R&D alliances	-0.008	0.013	0.015
	(0.013)	(0.015)	(0.016)
Prior technology acquisitions	0.245***	0.215***	0.215***
	(0.044)	(0.044)	(0.044)
CEO technical experience	0.047	0.112**	0.114**
	(0.033)	(0.042)	(0.041)
CEO marketing experience	0.034	-0.023	-0.017
	(0.031)	(0.040)	(0.041)
Director age	-0.028	-0.064	-0.062
	(0.047)	(0.048)	(0.047)
Director education level	-0.024	-0.039	-0.037
	(0.049)	(0.049)	(0.049)
Director social ties	0.073	0.316*	0.339**
	(0.065)	(0.123)	(0.123)
Director throughput experience	0.034	-0.006	-0.009
	(0.040)	(0.045)	(0.045)
Board independence	-0.029	-0.075+	-0.071+
	(0.036)	(0.042)	(0.042)
CEO duality	0.015	0.013	0.009
	(0.034)	(0.034)	(0.034)
CEO compensation (L)	0.128***	0.124**	0.123**
	(0.038)	(0.039)	(0.038)

Table 7 (cont'd)

Director compensation (L)	-0.032	0.012	0.019
	(0.052)	(0.055)	(0.057)
CEO tenure	-0.020	0.073	0.082
	(0.035)	(0.053)	(0.054)
Firm size (L)	0.334**	0.094	0.069
	(0.121)	(0.163)	(0.162)
Firm debt (L)	-0.212***	-0.282***	-0.295***
	(0.044)	(0.052)	(0.052)
Financial slack (L)	0.136	0.356*	0.381**
	(0.097)	(0.140)	(0.139)
R&D intensity	-0.374**	-0.333*	-0.317*
	(0.138)	(0.139)	(0.136)
Tech. control function		0.759*	0.811*
		(0.336)	(0.334)
Constant	-0.354*	0.059	0.079
	(0.169)	(0.250)	(0.254)

***Notes**:* 2,952 observations and 319 unique firms. All models include year and industry fixed effects and two dummies indicating whether the firm belongs to the mid or small-cap segments of the S&P1500 index. All predictors are standardized and lagged by one year. Robust standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05, + p<0. L: logged variable.

Table 8. Negative Binomial GEE Models Predicting Technology Acquisitions of Startup Targets

Variables	(8-1)	(8-2)	(8-3)
	Controls	Main effects	Interactions
Directors with technical experience		-0.013	-0.018
		(0.059)	(0.058)
Directors with marketing experience		0.018	0.012
		(0.065)	(0.063)
Knowledge quality		-0.013	-0.024
		(0.034)	(0.038)
Rivals breakthroughs		0.034	0.023
		(0.030)	(0.032)
Directors with technical experience X Knowledge quality			0.007
			(0.025)
Directors with technical experience X Rivals breakthroughs			0.073*
			(0.036)
Directors with marketing experience X Knowledge quality			0.029
			(0.029)
Directors with marketing experience X Rivals breakthroughs			-0.064+
			(0.036)
Controls			
Prior inventor recruitment	0.049	0.052	0.038
	(0.043)	(0.043)	(0.042)
Prior R&D alliances	-0.012	-0.010	-0.012
	(0.017)	(0.018)	(0.018)
Prior technology acquisitions	0.293***	0.288***	0.296***
	(0.056)	(0.057)	(0.056)
CEO technical experience	0.072+	0.069	0.074+
	(0.043)	(0.042)	(0.042)
CEO marketing experience	0.120**	0.118**	0.129***
	(0.037)	(0.038)	(0.038)
Director age	-0.161*	-0.157**	-0.154**
	(0.066)	(0.060)	(0.059)
Director education level	-0.056	-0.056	-0.050
	(0.060)	(0.060)	(0.059)
Director social ties	0.078	0.082	0.086
	(0.083)	(0.085)	(0.085)
Director throughput experience	0.027	0.027	0.029
	(0.054)	(0.054)	(0.054)
Board independence	-0.047	-0.049	-0.037
	(0.062)	(0.062)	(0.061)
CEO duality	0.011	0.012	0.005
	(0.048)	(0.049)	(0.049)
CEO compensation (L)	0.076	0.073	0.072
	(0.051)	(0.050)	(0.049)

Table 8 (cont'd)

Director compensation (L)	-0.047	-0.044	-0.041
	(0.071)	(0.070)	(0.070)
CEO tenure	0.034	0.033	0.041
	(0.047)	(0.047)	(0.047)
Firm size (L)	0.483*	0.483*	0.489*
	(0.215)	(0.216)	(0.216)
Firm debt (L)	-0.247***	-0.249***	-0.255***
	(0.074)	(0.074)	(0.074)
Financial slack (L)	0.178	0.180	0.192
	(0.139)	(0.143)	(0.141)
R&D intensity	-0.051	-0.049	-0.039
	(0.062)	(0.060)	(0.054)
Constant	-1.778***	-1.755***	-1.765***
	(0.244)	(0.255)	(0.252)

***Notes**:* 2,952 observations and 319 unique firms. All models include year and industry fixed effects and two dummies indicating whether the firm belongs to the mid or small-cap segments of the S&P1500 index. All predictors are standardized and lagged by one year. Robust standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05, + p<0. L: logged variable.

Table 9. Negative Binomial GEE Models Predicting Technology Acquisitions of Established Targets

Variables	(9-1)	(9-2)	(9-3)
	Controls	Main effects	Interactions
Directors with technical experience		-0.975**	-1.041**
		(0.341)	(0.343)
Directors with marketing experience		-0.138*	-0.148*
		(0.059)	(0.058)
Knowledge quality		-0.052	-0.086*
		(0.042)	(0.042)
Rivals breakthroughs		0.064**	0.078**
		(0.024)	(0.026)
Directors with technical experience X Knowledge quality			0.023
			(0.025)
Directors with technical experience X Rivals breakthroughs			-0.041
			(0.031)
Directors with marketing experience X Knowledge quality			0.067*
			(0.026)
Directors with marketing experience X Rivals breakthroughs			-0.065+
			(0.036)
Controls			
Prior inventor recruitment	0.063+	0.077*	0.071+
	(0.038)	(0.038)	(0.039)
Prior R&D alliances	-0.016	0.008	0.012
	(0.018)	(0.019)	(0.019)
Prior technology acquisitions	0.264***	0.227***	0.222***
	(0.044)	(0.044)	(0.044)
CEO technical experience	0.027	0.113*	0.116**
	(0.037)	(0.045)	(0.044)
CEO marketing experience	-0.008	-0.082+	-0.077+
	(0.041)	(0.046)	(0.047)
Director age	0.029	-0.023	-0.023
	(0.047)	(0.050)	(0.050)
Director education level	-0.004	-0.025	-0.026
	(0.052)	(0.051)	(0.052)
Director social ties	0.064	0.377**	0.402**
	(0.074)	(0.131)	(0.133)
Director throughput experience	0.037	-0.012	-0.017
	(0.047)	(0.052)	(0.053)
Board independence	-0.010	-0.071	-0.070
	(0.039)	(0.044)	(0.044)
CEO duality	0.029	0.026	0.022
	(0.040)	(0.040)	(0.040)
CEO compensation (L)	0.164***	0.162***	0.159***
	(0.045)	(0.046)	(0.046)

Table 9 (cont'd)

Director compensation (L)	-0.029	0.024	0.034
	(0.061)	(0.064)	(0.066)
CEO tenure	-0.034	0.085	0.095
	(0.042)	(0.058)	(0.059)
Firm size (L)	0.283*	-0.027	-0.059
	(0.133)	(0.172)	(0.172)
Firm debt (L)	-0.180***	-0.270***	-0.283***
	(0.046)	(0.053)	(0.053)
Financial slack (L)	0.109	0.395**	0.424**
	(0.102)	(0.139)	(0.140)
R&D intensity	-0.528*	-0.467*	-0.453*
	(0.207)	(0.211)	(0.209)
Tech. control function		0.982**	1.050**
		(0.337)	(0.340)
Constant	-0.674***	-0.161	-0.130
	(0.192)	(0.271)	(0.278)

***Notes**:* 2,952 observations and 319 unique firms. All models include year and industry fixed effects and two dummies indicating whether the firm belongs to the mid or small-cap segments of the S&P1500 index. All predictors are standardized and lagged by one year. Robust standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05, + p<0. L: logged variable.

Figure 1A. Hypothesized Relationships between Directors' Technical Experience and Knowledge Sourcing

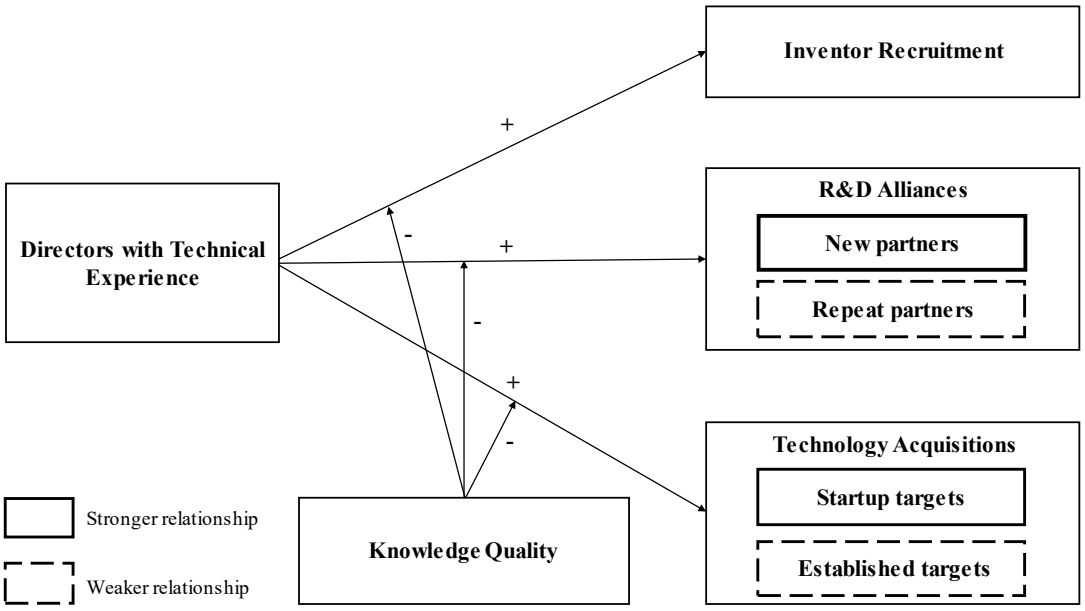


Figure 1B. Hypothesized Relationships between Directors' Marketing Experience and Knowledge Sourcing

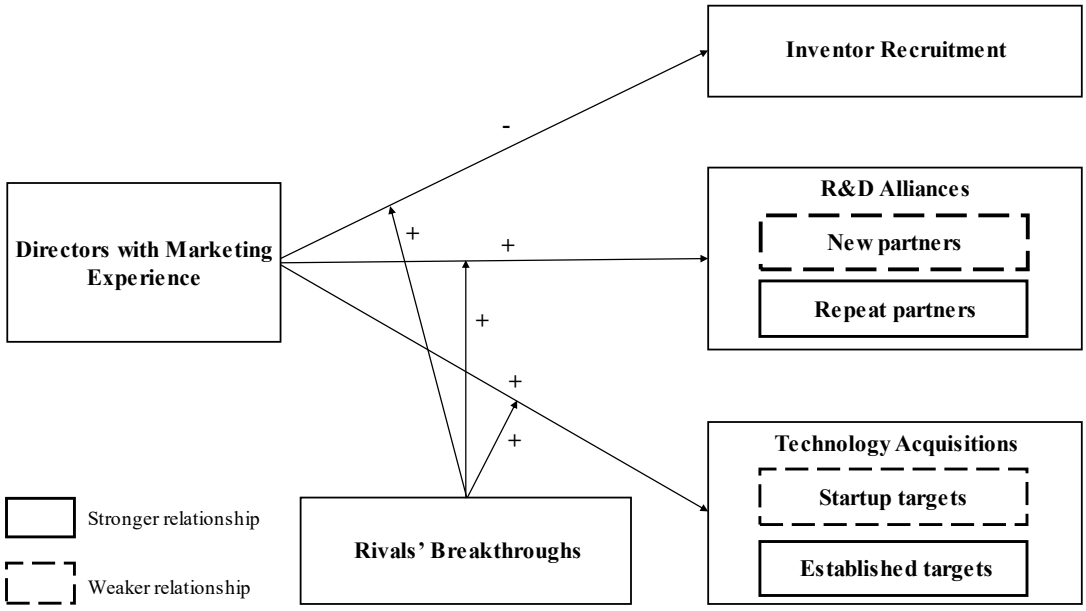


Figure 2. Interaction Plot of Directors with Technical Experience and Knowledge Quality on Inventor Recruitment[9]

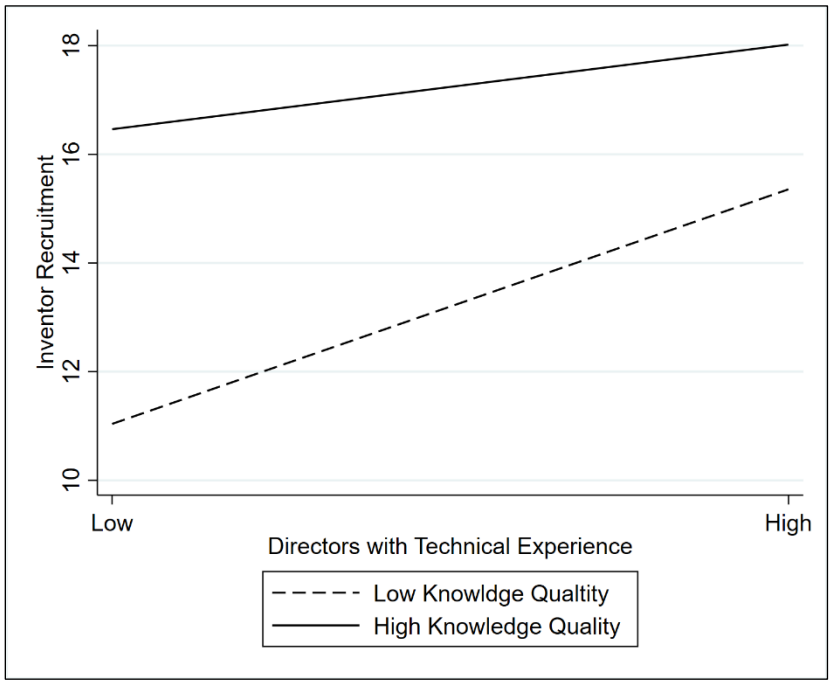
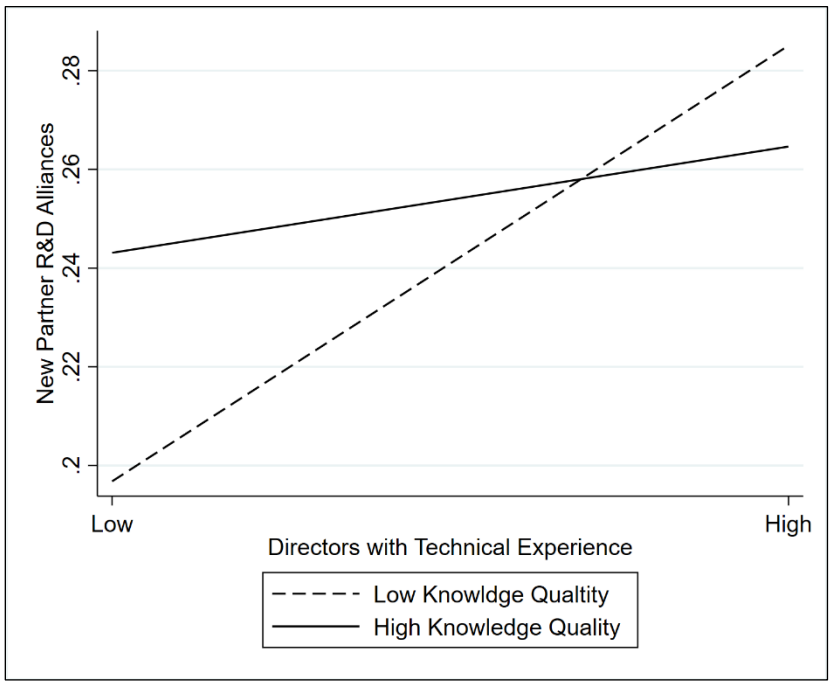


Figure 3. Interaction Plot of Directors with Technical Experience and Knowledge Quality on R&D Alliances with New Partners



[9] High (low) values are at one standard deviation above (below) the mean in all interaction figures.

Figure 4. Interaction Plot of Directors with Technical Experience and Knowledge Quality on R&D Alliances with Repeat Partners

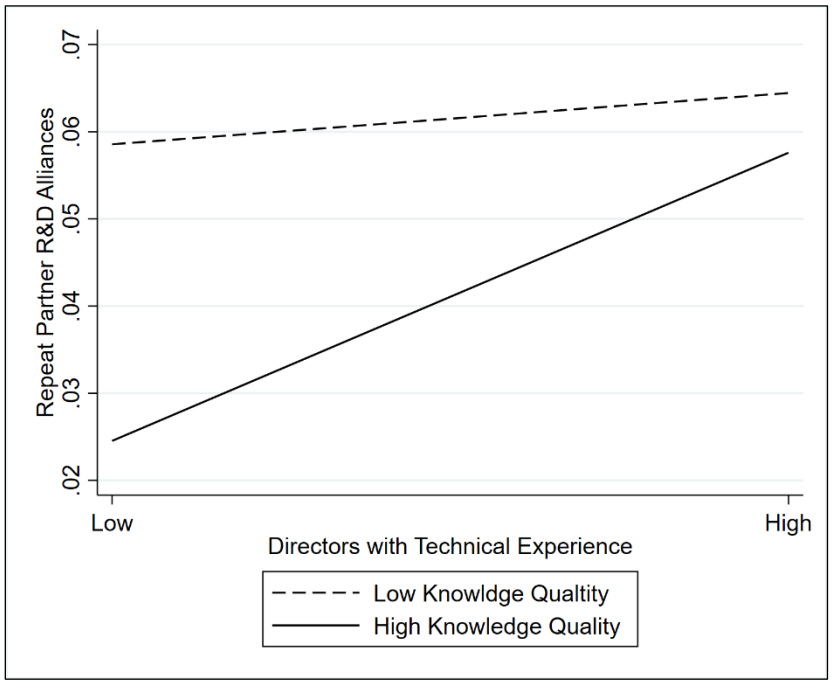


Figure 5. Interaction Plot of Directors with Marketing Experience and Rivals' Breakthroughs on Technology Acquisitions Established Targets

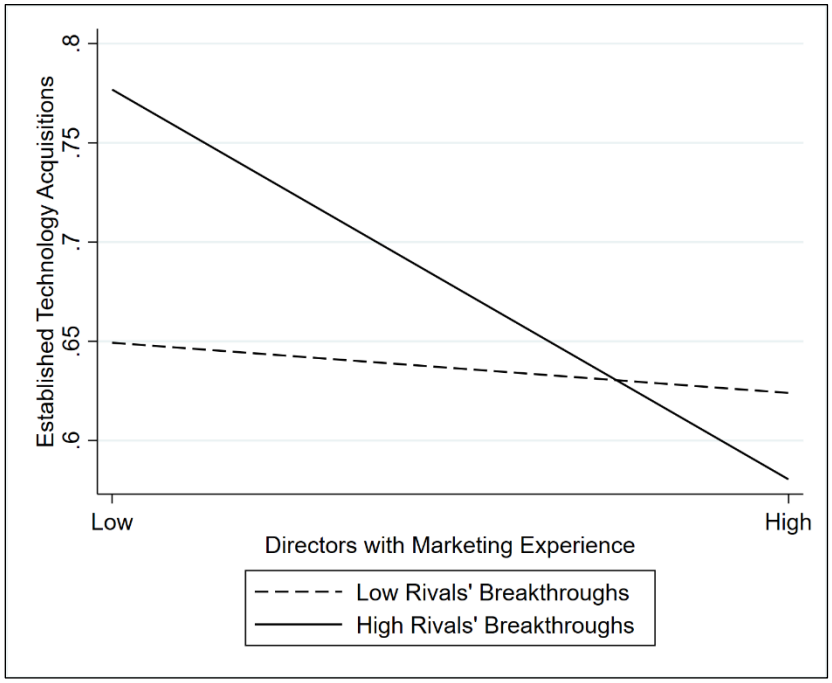


Figure 6. Interaction Plot of Directors with Technical Experience and Rivals' Breakthroughs on Inventor Recruitment

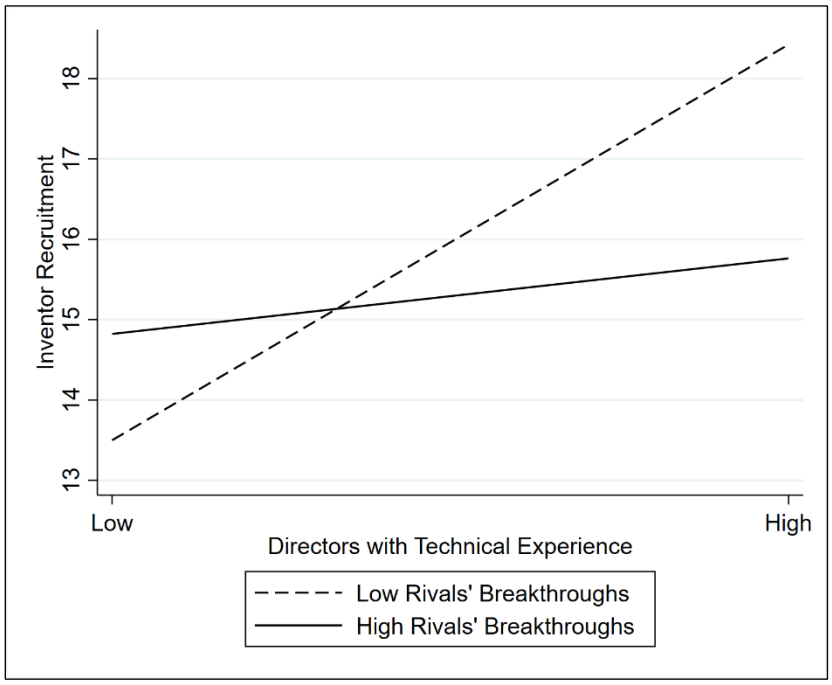


Figure 7. Interaction Plot of Directors with Technical Experience and Rivals' Breakthroughs on Technology Acquisitions of Startup Targets

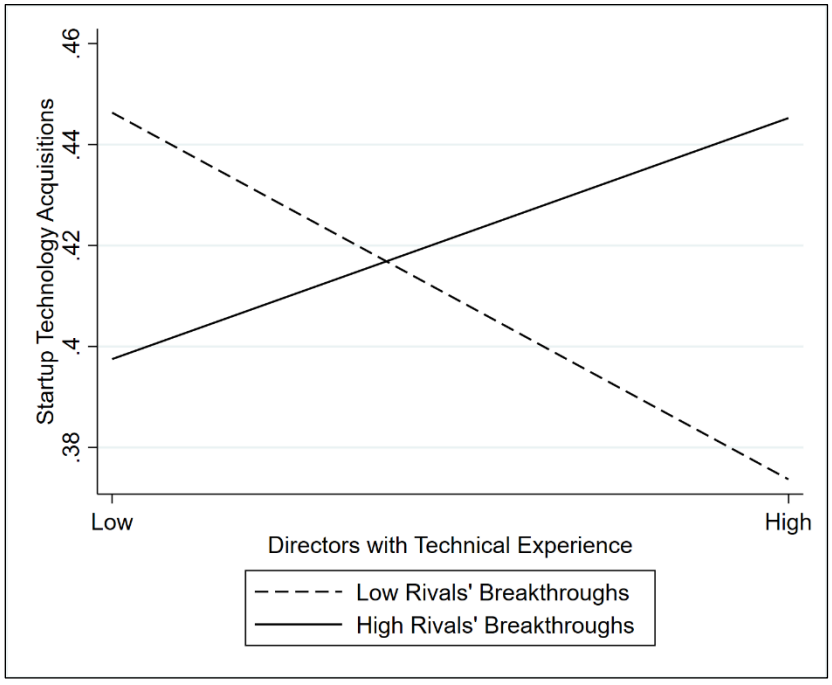
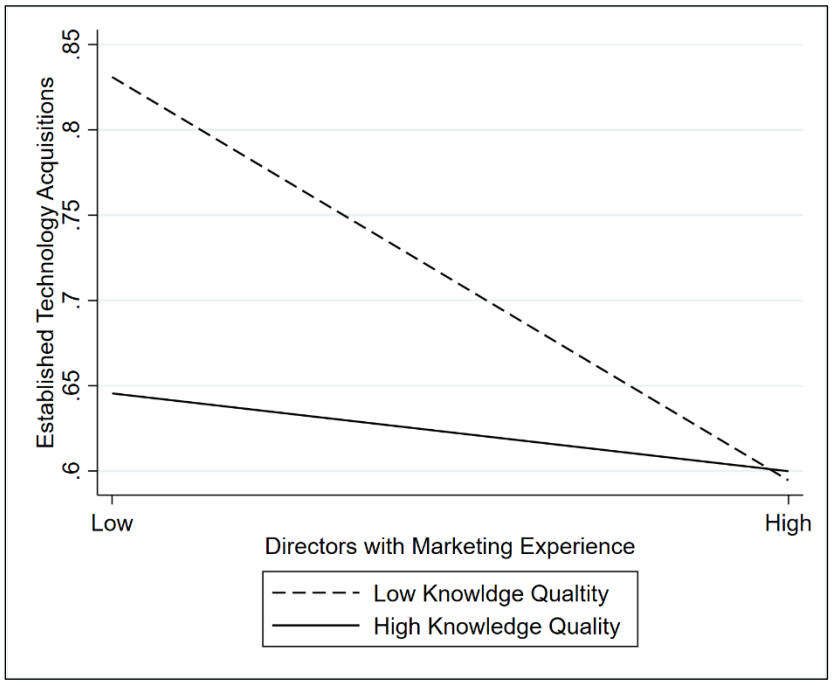


Figure 8: Interaction Plot of Directors with Marketing Experience and Knowledge Quality on Technology Acquisitions of Established Targets



REFERENCES

REFERENCES

Adams, R. B., & Ferreira, D. 2007. A theory of friendly boards. ***The Journal of Finance***, 62(1): 217-250.

Agarwal, R., Ganco, M., & Ziedonis, R. H. 2009. Reputations for toughness in patent enforcement: Implications for knowledge spillovers via inventor mobility. ***Strategic Management Journal***, 30(13): 1349-1374.

Aggarwal, V. A. 2020. Resource congestion in alliance networks: How a firm's partners' partners influence the benefits of collaboration. ***Strategic Management Journal***, 41(4): 627-655.

Aggarwal, V. A., & Hsu, D. H. 2014. Entrepreneurial exits and innovation. ***Management Science***, 60(4): 867-887.

Ahuja, G., & Katila, R. 2001. Technological acquisitions and the innovation performance of acquiring firms: A longitudinal study. ***Strategic Management Journal***, 22(3): 197-220.

Ahuja, G., Lampert, C. M., & Tandon, V. 2008. Moving beyond Schumpeter: management research on the determinants of technological innovation. ***Academy of Management Annals***, 2(1): 1-98.

Akcigit, U., Baslandze, S., & Stantcheva, S. 2016. Taxation and the international mobility of inventors. ***American Economic Review***, 106(10): 2930-2981.

Al-Laham, A., Amburgey, T. L., & Bates, K. 2008. The dynamics of research alliances: Examining the effect of alliance experience and partner characteristics on the speed of alliance entry in the biotech industry. ***British Journal of Management***, 19(4): 343-364.

Almeida, P., & Kogut, B. 1999. Localization of knowledge and the mobility of engineers in regional networks. ***Management Science***, 45(7): 905-917.

Amabile, T. M. (1993). Motivational synergy: Toward new conceptualizations of intrinsic and extrinsic motivation in the workplace. ***Human Resource Management Review***, 3(3): 185-201.

Amabile, T. M. 1988. A model of creativity and innovation in organizations. ***Research in Organizational Behavior***, 10(1): 123-167.

Amabile, T., & Gryskiewicz, S. S. 1987. ***Creativity in the R&D laboratory***. Center for Creative Leadership.

Angrist, J. D., & Pischke, J.S. 2009. ***Mostly harmless econometrics: An empiricist's companion***: Princeton University Press.

Arora, A., & Gambardella, A. 1990. Complementarity and external linkages: the strategies of the large firms in biotechnology. ***The Journal of Industrial Economics***, 38(4): 361-379.

Arora, A., Belenzon, S., & Patacconi, A. 2018. The decline of science in corporate R&D. ***Strategic Management Journal***, 39(1): 3-32.

Austin, J. T., & Vancouver, J. B. 1996. Goal constructs in psychology: Structure, process, and content. ***Psychological Bulletin***, 120(3): 338.

Balkin, D. B., Markman, G. D., & Gomez-Mejia, L. R. 2000. Is CEO pay in high-technology firms related to innovation? ***Academy of Management Journal***, 43(6): 1118-1129.

Ballinger, G. A. 2004. Using generalized estimating equations for longitudinal data analysis. ***Organizational Research Methods***, 7(2): 127-150.

Balsmeier, B., Buchwald, A., & Stiebale, J. 2014. Outside directors on the board and innovative firm performance. ***Research Policy***, 43(10): 1800-1815.

Balsmeier, B., Fleming, L., & Manso, G. 2017. Independent boards and innovation. ***Journal of Financial Economics***, 123(3): 536-557.

Barker, V. L., & Mueller, G. C. 2002. CEO characteristics and firm R&D spending. ***Management Science***, 48(6): 782-801.

Barney, J. 1991. Firm resources and sustained competitive advantage. ***Journal of Management***, 17(1): 99-120.

Becker, M. C., & Lillemark, M. 2006. Marketing/R&D integration in the pharmaceutical industry. ***Research Policy***, 35(1): 105-120.

Beckman, C. M., Haunschild, P. R., & Phillips, D. J. 2004. Friends or strangers? Firm-specific uncertainty, market uncertainty, and network partner selection. ***Organization Science***, 15(3): 259-275.

Benson, D., & Ziedonis, R. H. 2009. Corporate venture capital as a window on new technologies: Implications for the performance of corporate investors when acquiring startups. ***Organization Science***, 20(2): 329-351.

Beyer, J. M., Chattopadhyay, P., George, E., Glick, W. H., Ogilvie, D. T., & Pugliese, D. 1997. The selective perception of managers revisited. ***Academy of Management Journal***, 40(3): 716-737.

Bluedorn, AC. 2002. ***The Human organization of time: Temporal realities and experience***. Stanford University Press: Stanford, CA.

Blumberg, M., & Pringle, C. D. 1982. The missing opportunity in organizational research: Some implications for a theory of work performance. ***Academy of Management Review***, 7(4): 560-569.

Boivie, S., Bednar, M. K., Aguilera, R. V., & Andrus, J. L. 2016. Are boards designed to fail? The implausibility of effective board monitoring. ***Academy of Management Annals***, 10(1): 319-407.

Bozeman, B., & Corley, E. 2004. Scientists' collaboration strategies: implications for scientific and technical human capital. ***Research Policy***, 33(4): 599-616.

Brower, J., & Nath, P. 2018. Antecedents of market orientation: marketing CEOs, CMOs, and top management team marketing experience. ***Marketing Letters***, 29(4): 405-419.

Brown, S. L., & Eisenhardt, K. M. 1997. The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations. ***Administrative Science Quarterly***, 42(1): 1-34.

Bunderson, J. S. 2003. Recognizing and utilizing expertise in work groups: A status characteristics perspective. ***Administrative Science Quarterly***, 48(4): 557-591.

Capron, L., & Hulland, J. 1999. Redeployment of brands, sales forces, and general marketing management expertise following horizontal acquisitions: A resource-based view**.** ***Journal of Marketing***, 63(2): 41-54.

Capron, L., & Mitchell, W. 2009. Selection capability: How capability gaps and internal social frictions affect internal and external strategic renewal. ***Organization Science***, 20(2): 294-312.

Carayannopoulos, S., & Auster, E. R. 2010. External knowledge sourcing in biotechnology through acquisition versus alliance: A KBV approach. ***Research Policy***, 39(2): 254-267.

Carlson, K. D., & Wu, J. 2012. The illusion of statistical control: Control variable practice in management research. ***Organizational Research Methods***, 15(3): 413-435.

Cassiman, B., & Veugelers, R. 2006. In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. ***Management Science***, 52(1): 68-82.

Cassiman, B., Colombo, M. G., Garrone, P., & Veugelers, R. 2005. The impact of M&A on the R&D process: An empirical analysis of the role of technological-and market-relatedness. ***Research Policy***, 34(2): 195-220.

Certo, S. T. 2003. Influencing initial public offering investors with prestige: Signaling with board structures. ***Academy of Management Review***, 28(3): 432-446.

Certo, S. T., Withers, M. C., & Semadeni, M. 2017. A tale of two effects: Using longitudinal data to compare within-and between-firm effects. ***Strategic Management Journal***, 38(7): 1536-1556.

Chase, W. G., & Simon, H. A. 1973. The mind's eye in chess. In ***Visual information processing***, 215-281. Elsevier.

Chatterjee, S., J. S. Harrison. 2001. Corporate governance. In M. A. Hitt, R. E. Freeman, J. S. Harrison, (Eds.), ***The Blackwell handbook of strategic management***, 543–563. Oxford, UK: Blackwell.

Chen, G., Hambrick, D. C., & Pollock, T. G. 2008. Puttin'on the Ritz: Pre-IPO enlistment of prestigious affiliates as deadline-induced remediation. ***Academy of Management Journal***, 51(5): 954-975.

Chen, I.-J., Hsu, P.-H., Officer, M. S., & Wang, Y. 2020. The Oscar goes to…: High-tech firms' acquisitions in response to rivals' technology breakthroughs. ***Research Policy***, 49(7): 104078.

Chen, M. J., Lin, H. C., & Michel, J. G. 2010. Navigating in a hypercompetitive environment: The roles of action aggressiveness and TMT integration. ***Strategic Management Journal***, 31(13): 1410-1430.

Choi, S., & McNamara, G. 2018. Repeating a familiar pattern in a new way: The effect of exploitation and exploration on knowledge leverage behaviors in technology acquisitions. ***Strategic Management Journal***, 39(2): 356-378.

Christensen, C. M., & Bower, J. L. 1996. Customer power, strategic investment, and the failure of leading firms. ***Strategic Management Journal***, 17(3): 197-218.

Cockburn, I. M., & Henderson, R. M. 1998. Absorptive capacity, coauthoring behavior, and the organization of research in drug discovery. ***The Journal of Industrial Economics***, 46(2): 157-182.

Coff, R. W. 1999. How buyers cope with uncertainty when acquiring firms in knowledge-intensive industries: Caveat emptor. ***Organization Science***, 10(2): 144-161.

Cohen, J., Cohen, P., West, S.G., & Aiken, L.S. 2002. ***Applied multiple regression/correlation analysis for the behavioral sciences*** (3rd ed.). Routledge

Cohen, W. M., & Levinthal, D. A. 1990. Absorptive capacity: A new perspective on learning and innovation. ***Administrative Science Quarterly***, 35(1): 128-152.

Dalziel, T., Gentry, R. J., & Bowerman, M. 2011. An integrated agency–resource dependence view of the influence of directors' human and relational capital on firms' R&D spending. ***Journal of Management Studies***, 48(6): 1217-1242.

Danneels, E. 2011. Trying to become a different type of company: Dynamic capability at Smith Corona. ***Strategic Management Journal***, 32(1): 1-31.

Day, G. S. 2011. Closing the marketing capabilities gap. ***Journal of Marketing***, 75(4): 183-195.

Deloitte. 2019. ***The state of the deal: M&A trends 2019***. Retrieved from https://www2.deloitte.com/content/dam/Deloitte/us/Documents/mergers-acqisitions/us-mergers-acquisitions-trends-2019-report.pdf

Deutsch, Y., Keil, T., & Laamanen, T. 2011. A dual agency view of board compensation: The joint effects of outside director and CEO stock options on firm risk. ***Strategic Management Journal***, 32(2): 212-227.

Dhanaraj, C., Lyles, M. A., Steensma, H. K., & Tihanyi, L. 2004. Managing tacit and explicit knowledge transfer in IJVs: the role of relational embeddedness and the impact on performance. ***Journal of International Business Studies***, 35(5): 428-442.

Diefendorff, J. M., & Chandler, M. M. 2011. Motivating employees. In S. Zedeck (Ed.), ***APA handbook of industrial and organizational psychology***, 3: 65-135. Washington, D.C.: American Psychological Association.

Dosi, G. 1982. Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change. ***Research Policy***, 11(3): 147-162.

Dosi, G. 1988. Sources, procedures, and microeconomic effects of innovation. ***Journal of Economic Literature***, 1120-1171.

Dougherty, D. 1992. Interpretive barriers to successful product innovation in large firms. ***Organization Science***, 3(2): 179-202.

Eggers, J. 2016. Reversing course: Competing technologies, mistakes, and renewal in flat panel displays. ***Strategic Management Journal***, 37(8): 1578-1596.

Eggers, J. P., & Kaplan, S. 2009. Cognition and renewal: Comparing CEO and organizational effects on incumbent adaptation to technical change. ***Organization Science***, 20(2), 461-477.

Eggers, J. P., & Kaplan, S. 2013. Cognition and capabilities: A multi-level perspective. ***Academy of Management Annals***, 7(1): 295-340.

Eggers, J., & Park, K. F. 2018. Incumbent adaptation to technological change: The past, present, and future of research on heterogeneous incumbent response. ***Academy of Management Annals***, 12(1): 357-389.

Eisenhardt, K. M., & Martin, J. A. 2000. Dynamic capabilities: what are they? ***Strategic Management Journal***, 21(10-11): 1105-1121.

Eisenhardt, K. M., & Santos, F. M. 2002. Knowledge-based view: A new theory of strategy. In A. Pettigrew, H. Thomas, & R. Whittington (Eds.), ***Handbook of strategy and management***, 1: 139-164. London: Sage.

Epstein, S. 2003. Cognitive-experiential self-theory of personality. In M. J. Lerner (Ed.), **Comprehensive handbook of psychology**, 5: 159-184. Hoboken, NJ: Wiley.

Faleye, O., Hoitash, R., & Hoitash, U. 2011. The costs of intense board monitoring. ***Journal of Financial Economics***, 101(1): 160-181.

Fama, E. F., & Jensen, M. C. 1983. Separation of ownership and control. ***The Journal of law and Economics***, 26(2): 301-325.

Feldman, D. C. 1981. The multiple socialization of organization members. ***Academy of Management Review***, 6(2): 309-318.

Fey, C. F., & Birkinshaw, J. 2005. External sources of knowledge, governance mode, and R&D performance. ***Journal of Management***, 31(4): 597-621.

Finkelstein, S., Hambrick, D. C., & Cannella, A. A. 2009. ***Strategic leadership: Theory and research on executives, top management teams, and boards***. New York: Oxford University Press.

Finsaas, M. C., & Goldstein, B. L. 2021. Do simple slopes follow-up tests lead us astray? Advancements in the visualization and reporting of interactions. ***Psychological Methods***, 26(1): 38-60.

Fleming, L. 2001. Recombinant uncertainty in technological search. ***Management Science***, 47(1): 117-132.

Fleming, L., & Sorenson, O. 2004. Science as a map in technological search. ***Strategic Management Journal***, 25(8-9): 909-928.

Garcia-Pont, C., & Nohria, N. 2002. Local versus global mimetism: The dynamics of alliance formation in the automobile industry. ***Strategic Management Journal***, 23(4): 307-321.

Gavetti, G., Levinthal, D. A., & Rivkin, J. W. 2005. Strategy making in novel and complex worlds: The power of analogy. ***Strategic Management Journal***, 26(8): 691-712.

Ge, C., Huang, K. W., & Png, I. P. 2016. Engineer/scientist careers: Patents, online profiles, and misclassification bias. ***Strategic Management Journal***, 37(1): 232-253.

Germann, F., Ebbes, P., & Grewal, R. 2015. The chief marketing officer matters!. ***Journal of Marketing***, 79(3): 1-22.

Giarratana, M. S., Mariani, M., & Weller, I. 2018. Rewards for patents and inventor behaviors in industrial research and development. ***Academy of Management Journal***, 61(1): 264-292.

Gimeno, J. 2004. Competition within and between networks: The contingent effect of competitive embeddedness on alliance formation. ***Academy of Management Journal***, 47(6): 820-842.

Goerzen, A. 2007. Alliance networks and firm performance: The impact of repeated partnerships. ***Strategic Management Journal***, 28(5): 487-509.

Golden, B. R., & Zajac, E. J. 2001. When will boards influence strategy? Inclination× power= strategic change. ***Strategic Management Journal***, 22(12): 1087-1111.

Gomes-Casseres, B., Hagedoorn, J., & Jaffe, A. B. 2006. Do alliances promote knowledge flows? ***Journal of Financial Economics***, 80(1): 5-33.

Graebner, M. E., Eisenhardt, K. M., & Roundy, P. T. 2010. Success and failure in technology acquisitions: Lessons for buyers and sellers. ***Academy of Management Perspectives***, 24(3): 73-92.

Grant, R. M. 1996. Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. ***Organization Science***, 7(4): 375-387.

Griffith, D. A., & Lusch, R. F. 2007. Getting marketers to invest in firm-specific capital. ***Journal of Marketing***, 71(1): 129-145.

Griffin, A., & Hauser, J. R. 1996. Integrating R&D and marketing: A review and analysis of the literature. ***Journal of Product Innovation Management: An International Publication of the Product Development & Management Association***, 13(3): 191-215.

Griffin, D., Li, K., & Xu, T. 2021. Board gender diversity and corporate innovation: International evidence. ***Journal of Financial and Quantitative Analysis***, 56(1): 123-154.

Gruber, M., Harhoff, D., & Hoisl, K. 2013. Knowledge recombination across technological boundaries: Scientists vs. engineers. ***Management Science***, 59(4): 837-851.

Gulati, R. 1995. Does familiarity breed trust? The implications of repeated ties for contractual choice in alliances. ***Academy of Management Journal***, 38(1): 85-112.

Gupta, A. K., Raj, S., & Wilemon, D. 1986. R&D and marketing managers in high-tech companies: Are they different? ***IEEE Transactions on Engineering Management***, (1): 25-32.

Hagedoorn, J., & Duysters, G. 2002. External sources of innovative capabilities: the preferences for strategic alliances or mergers and acquisitions. ***Journal of Management Studies***, 39(2): 167-188.

Hall, B. H., Jaffe, A., & Trajtenberg, M. 2005. Market value and patent citations. ***RAND Journal of Economics***, 36(1): 16-38.

Hambrick, D. C., & Mason, P. A. 1984. Upper echelons: The organization as a reflection of its top managers. ***Academy of Management Review***, 9(2): 193-206.

Hambrick, D. C., Misangyi, V. F., & Park, C. A. 2015. The quad model for identifying a corporate director's potential for effective monitoring: Toward a new theory of board sufficiency. ***Academy of Management Review***, 40(3): 323-344.

Hamel, G. 1991. Competition for competence and interpartner learning within international strategic alliances. ***Strategic Management Journal***, 12(S1): 83-103.

Haynes, K. T., & Hillman, A. 2010. The effect of board capital and CEO power on strategic change. ***Strategic Management Journal***, 31(11): 1145-1163.

Henderson, R. M., & Clark, K. B. 1990. Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms. ***Administrative Science Quarterly***, 35(1): 9-30.

Hewlett Packard Enterprise Company. 2016. ***Schedule 14A***. Retrieved from http://www.sec.gov/edgar.html

Hill, L. A., & Davis, G. 2017. The board's new innovation imperative. ***Harvard Business Review***, 95(6): 102-109.

Hillman, A. J., & Dalziel, T. 2003. Boards of directors and firm performance: Integrating agency and resource dependence perspectives. ***Academy of Management Review***, 28(3): 383-396.

Hillman, A. J., Nicholson, G., & Shropshire, C. 2008. Directors' multiple identities, identification, and board monitoring and resource provision. ***Organization Science***, 19(3): 441-456.

Hitt, M. A., & Tyler, B. B. 1991. Strategic decision models: Integrating different perspectives. ***Strategic Management Journal***, 12(5): 327-351.

Hoberg, G., & Phillips, G. 2010. Product market synergies and competition in mergers and acquisitions: A text-based analysis. ***The Review of Financial Studies***, 23(10): 3773-3811

Hombert, J., & Matray, A. 2017. The real effects of lending relationships on innovative firms and inventor mobility. ***The Review of Financial Studies***, 30(7): 2413-2445.

Howard, M. D., Withers, M. C., & Tihanyi, L. 2017. Knowledge dependence and the formation of director interlocks. ***Academy of Management Journal***, 60(5): 1986-2013.

Inkpen, A. C. 2000. Learning through joint ventures: a framework of knowledge acquisition. ***Journal of Management Studies***, 37(7): 1019-1044.

Inkpen, A. C., & Tsang, E. W. 2007. Learning and strategic alliances. ***Academy of Management Annals***, 1(1): 479-511.

Islam, E., & Zein, J. 2020. Inventor CEOs. ***Journal of Financial Economics***, 135(2): 505-527.

Jensen, M. C., & Meckling, W. H. 1976. Theory of the firm: Managerial behavior, agency costs and ownership structure. ***Journal of Financial Economics***, 3(4): 305-360.

Jung, H. J., & Lee, J. J. 2016. The quest for originality: A new typology of knowledge search and breakthrough inventions. ***Academy of Management Journal***, 59(5): 1725-1753.

Kale, P., Dyer, J. H., & Singh, H. 2002. Alliance capability, stock market response, and long-term alliance success: the role of the alliance function. ***Strategic Management Journal***, 23(8): 747-767.

Kale, P., Singh, H., & Perlmutter, H. 2000. Learning and protection of proprietary assets in strategic alliances: Building relational capital. ***Strategic Management Journal***, 21(3): 217-237.

Kanfer, R., & Chen, G. 2016. Motivation in organizational behavior: History, advances and prospects. ***Organizational Behavior and Human Decision Processes***, 136: 6-19.

Kang, J.-K., Liu, W.-L., Low, A., & Zhang, L. 2018. Friendly boards and innovation**.** ***Journal of Empirical Finance***, 45: 1-25.

Katila, R., Thatchenkery, S., Christensen, M. Q., & Zenios, S. 2017. Is there a doctor in the house? Expert product users, organizational roles, and innovation. ***Academy of Management Journal***, 60(6): 2415-2437.

Katsikeas, C. S., Morgan, N. A., Leonidou, L. C., & Hult, G. T. M. 2016. Assessing performance outcomes in marketing. ***Journal of Marketing***, 80(2): 1-20.

Katz, R., & Allen, T. J. 1982. Investigating the Not Invented Here (NIH) syndrome: A look at the performance, tenure, and communication patterns of 50 R & D Project Groups. ***R&D Managemen*t**, 12(1): 7-20.

Kessler, E. H., & Chakrabarti, A. K. 1996. Innovation speed: A conceptual model of context, antecedents, and outcomes. ***Academy of Management Review***, 21(4): 1143-1191.

Keum, D. D. 2020. Penalizing the underdogs? Employment protection and the competitive dynamics of firm innovation. ***Organization Science***, 31(5): 1072-1089.

Khanna, P., Jones, C. D., & Boivie, S. 2014. Director human capital, information processing demands, and board effectiveness. ***Journal of Management***, 40(2): 557-585.

Khanna, T. 1998. The scope of alliances. ***Organization Science***, 9(3): 340-355.

Khanna, T., Gulati, R., & Nohria, N. 1998. The dynamics of learning alliances: Competition, cooperation, and relative scope. ***Strategic Management Journal***, 19(3): 193-210.

Kiesler, S., & Sproull, L. 1982. Managerial response to changing environments: Perspectives on problem sensing from social cognition. ***Administrative Science Quarterly***, 27(4): 548-570.

Kim, C.-S., & Inkpen, A. C. 2005. Cross-border R&D alliances, absorptive capacity and technology learning. ***Journal of International Management***, 11(3): 313-329.

Kim, L. 1997. The dynamics of Samsung's technological learning in semiconductors. ***California Management Review***, 39(3): 86-100.

King, D. R., Slotegraaf, R. J., & Kesner, I. 2008. Performance implications of firm resource interactions in the acquisition of R&D-intensive firms. ***Organization Science***, 19(2): 327-340.

Klarner, P., Probst, G., & Useem, M. 2020. Opening the black box: Unpacking board involvement in innovation. ***Strategic Organization***, 18(4): 487-519.

Kline, S. J., & Rosenberg, N. 1986. An overview of innovation. In R. Landau & N. Rosenberg (Eds.), ***The positive sum strategy: Harnessing technology for economic growth***, 275–305. Washington, DC.: National Academy Press.

Kogan, L., Papanikolaou, D., Seru, A., & Stoffman, N. 2017. Technological innovation, resource allocation, and growth. ***The Quarterly Journal of Economics***, 132(2): 665-712.

Kogut, B. (1989). The stability of joint ventures: Reciprocity and competitive rivalry. ***The Journal of Industrial Economics***, 38(2): 183-198.

Kogut, B., & Zander, U. 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. ***Organization Science***, 3(3): 383-397.

Lacetera, N., Cockburn, I. M., & Henderson, R. 2004. Do firms change capabilities by hiring new people? A study of the adoption of science-based drug discovery. In J. A. C. Baum & A. M. McGahan (Eds.), ***Business strategy over the industry lifecycle***, 21: 133-159. Emerald Group Publishing Limited.

Lam, A. 2011. What motivates academic scientists to engage in research commercialization:'Gold','ribbon'or 'puzzle'?. ***Research Policy***, 40(10): 1354-1368.

Lane, P. J., & Lubatkin, M. 1998. Relative absorptive capacity and interorganizational learning. ***Strategic Management Journal***, 19(5): 461-477.

Laursen, K., & Salter, A. 2006. Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms. ***Strategic Management Journal***, 27(2): 131-150.

Lavie, D., & Rosenkopf, L. 2006. Balancing exploration and exploitation in alliance formation. ***Academy of Management Journal***, 49(4): 797-818.

Lavie, D., Kang, J., & Rosenkopf, L. 2011. Balance within and across domains: The performance implications of exploration and exploitation in alliances. ***Organization Science***, 22(6): 1517-1538.

Lawrence, P.R., & Lorsch, J.W. 1967. ***Organization and environment: Managing differentiation and integration***. Homewood, IL: Irwin.

Lee, J., & Kim, M. 2016. Market-driven technological innovation through acquisitions: The moderating effect of firm size. ***Journal of Management***, 42(7): 1934-1963.

Leonard-Barton, D. 1995. ***Wellsprings of knowledge***. Boston, MA: Harvard Business School Press.

Liebeskind, J. P., Oliver, A. L., Zucker, L., & Brewer, M. 1996. Social networks, learning, and flexibility: Sourcing scientific knowledge in new biotechnology firms. ***Organization Science***, 7(4): 428-443.

Lim, E. N. 2015. The role of reference point in CEO restricted stock and its impact on R&D intensity in high-technology firms. ***Strategic Management Journal***, 36(6): 872-889.

Locke, E. A., & Latham, G. P. 2002. Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. ***American Psychologist***, 57(9): 705.

Lorsch, J. W., & MacIver, E. 1989. ***Pawns or potentates: The reality of America's corporate boards***. Boston: Harvard Business School Press.

Lungeanu, R., & Zajac, E. J. 2019. Thinking broad and deep: Why some directors exert an outsized influence on strategic change. ***Organization Science***, 30(3): 489-508.

Maltz, E., & Kohli, A. K. 1996. Market intelligence dissemination across functional boundaries. ***Journal of Marketing Research***, 33(1): 47-61.

Mawdsley, J. K., & Somaya, D. 2016. Employee mobility and organizational outcomes: An integrative conceptual framework and research agenda. ***Journal of Management***, 42(1): 85-113.

McDonald, M. L., Westphal, J. D., & Graebner, M. E. 2008. What do they know? The effects of outside director acquisition experience on firm acquisition performance. ***Strategic Management Journal***, 29(11): 1155-1177.

Moeen, M., & Mitchell, W. 2020. How do pre-entrants to the industry incubation stage choose between alliances and acquisitions for technical capabilities and specialized complementary assets? ***Strategic Management Journal***, 41(8): 1450-1489.

Mowery, D. C., Oxley, J. E., & Silverman, B. S. 1996. Strategic alliances and interfirm knowledge transfer. ***Strategic Management Journal***, 17(S2): 77-91.

Nadkarni, S., & Chen, J. 2014. Bridging yesterday, today, and tomorrow: CEO temporal focus, environmental dynamism, and rate of new product introduction. ***Academy of Management Journal***, 57(6): 1810-1833.

Nahapiet, J., & Ghoshal, S. 1998. Social capital, intellectual capital, and the organizational advantage. ***Academy of Management Review***, 23(2): 242-266.

Narver, J. C., & Slater, S. F. 1990. The effect of a market orientation on business profitability. ***Journal of Marketing***, 54(4): 20-35.

National Science Foundation. 2016. ***Science and engineering indicators 2016***. Retrieved from https://www.nsf.gov/statistics/2016/nsb20161/#/report

Nonaka, I. 1994. A dynamic theory of organizational knowledge creation. ***Organization Science***, *5*(1): 14-37.

Oxley, J. E., & Sampson, R. C. 2004. The scope and governance of international R&D alliances. ***Strategic Management Journal***, 25(8-9): 723-749.

Pangarkar, N., Yuan, L., & Hussain, S. 2017. Too much of a good thing? Alliance portfolio size and alliance expansion. ***European Management Journal***, 35(4): 477-485.

Park, S. H., & Zhou, D. 2005. Firm heterogeneity and competitive dynamics in alliance formation. ***Academy of Management Review***, 30(3): 531-554.

Paruchuri, S., Nerkar, A., & Hambrick, D. C. 2006. Acquisition integration and productivity losses in the technical core: Disruption of inventors in acquired companies. ***Organization Science***, 17(5): 545-562.

Paternoster, R., Brame, R., Mazerolle, P., & Piquero, A. 1998. Using the correct statistical test for the equality of regression coefficients. ***Criminology***, 36(4): 859-866.

Pfeffer, J., & Salancik, G. R. 2003. ***The external control of organizations: A resource dependence perspective***. Stanford, CA: Stanford University Press.

Pisano, G. 2006. Profiting from innovation and the intellectual property revolution. ***Research Policy***, 35(8): 1122-1130.

Poulsen, A. B., & Stegemoller, M. 2008. Moving from private to public ownership: selling out to public firms versus initial public offerings. ***Financial Management***, 37(1): 81-101.

Powell, W. W., Koput, K. W., & Smith-Doerr, L. 1996. Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. ***Administrative Science Quarterly***, 41(1): 116-145.

Puranam, P., & Srikanth, K. 2007. What they know vs. what they do: How acquirers leverage technology acquisitions. ***Strategic Management Journal***, 28(8): 805-825.

Puranam, P., Singh, H., & Zollo, M. 2003. A bird in the hand or two in the bush?: Integration trade-offs in technology-grafting acquisitions. ***European Management Journal***, 21(2): 179-184.

Puranam, P., Singh, H., & Zollo, M. 2006. Organizing for innovation: Managing the coordination-autonomy dilemma in technology acquisitions. ***Academy of Management Journal***, 49(2): 263-280.

Ranft, A. L., & Lord, M. D. 2000. Acquiring new knowledge: The role of retaining human capital in acquisitions of high-tech firms. ***The Journal of High Technology Management Research***, 11(2): 295-319.

Rosenkopf, L., & Almeida, P. 2003. Overcoming local search through alliances and mobility. ***Management Science***, 49(6): 751-766.

Rosenkopf, L., & Nerkar, A. 2001. Beyond local search: boundary-spanning, exploration, and impact in the optical disk industry. ***Strategic Management Journal***, 22(4): 287-306.

Rothaermel, F. T., & Boeker, W. 2008. Old technology meets new technology: Complementarities, similarities, and alliance formation. ***Strategic Management Journal***, 29(1): 47-77.

Sampson, R. C. 2007. R&D alliances and firm performance: The impact of technological diversity and alliance organization on innovation. ***Academy of Management Journal***, 50(2): 364-386.

Santos, F. M., & Eisenhardt, K. M. 2009. Constructing markets and shaping boundaries: Entrepreneurial power in nascent fields. ***Academy of Management Journal***, 52(4): 643-671.

Schilling, M. A. 1998. Technological lockout: An integrative model of the economic and strategic factors driving technology success and failure**.** ***Academy of Management Review***, 23(2): 267-284.

Schilling, M. A. 2015. Technology shocks, technological collaboration, and innovation outcomes**.** ***Organization Science***, 26(3): 668-686.

Schweizer, L. 2005. Organizational integration of acquired biotechnology companies into pharmaceutical companies: The need for a hybrid approach. ***Academy of Management Journal***, 48(6): 1051-1074.

Sears, J., & Hoetker, G. 2014. Technological overlap, technological capabilities, and resource recombination in technological acquisitions. ***Strategic Management Journal***, 35(1): 48-67.

Semadeni, M., Withers, M. C., & Certo, S. 2014. The perils of endogeneity and instrumental variables in strategy research: Understanding through simulations. ***Strategic Management Journal***, 35(7): 1070-1079.

Seru, A. 2014. Firm boundaries matter: Evidence from conglomerates and R&D activity. ***Journal of Financial Economics***, 111(2): 381-405.

Setor, T. K., & Joseph, D. 2017. Buying All the Bathwater Just to Get the Baby: Do Acqui-hires Create Value?. In ***Academy of Management Proceedings***, 2017(1): 12447. Briarcliff Manor, NY: Academy of Management.

Shane, H., & Klock, M. 1997. The relation between patent citations and Tobin's Q in the semiconductor industry. ***Review of Quantitative Finance and Accounting***, 9(2): 131-146.

Shane, S. 2000. Prior knowledge and the discovery of entrepreneurial opportunities. ***Organization Science***, 11(4): 448-469.

Shen, W. 2003. The dynamics of the CEO-board relationship: An evolutionary perspective. ***Academy of Management Review***, 28(3): 466-476.

Shropshire, C. 2010. The role of the interlocking director and board receptivity in the diffusion of practices. ***Academy of Management Review***, 35(2): 246-264.

Silverman, B. S., & Baum, J. A. 2002. Alliance-based competitive dynamics. ***Academy of Management Journal***, 45(4): 791-806.

Simon, H. A. 1991. Bounded rationality and organizational learning. ***Organization Science***, 2(1): 125-134.

Skilton, P. F., & Dooley, K. J. 2010. The effects of repeat collaboration on creative abrasion. ***Academy of Management Review***, 35(1): 118-134.

Smith, K. G., Grimm, C. M., Gannon, M. J., & Chen, M.-J. 1991. Organizational information processing, competitive responses, and performance in the US domestic airline industry. ***Academy of Management Journal***, 34(1): 60-85.

Song, J., Almeida, P., & Wu, G. 2003. Learning–by–hiring: When is mobility more likely to facilitate interfirm knowledge transfer? ***Management Science***, 49(4): 351-365.

Stern, S. 2004. Do scientists pay to be scientists? ***Management Science***, 50(6): 835-853.

Stock, J., Yogo, M., & Andrews, D. W. K. 2005. Testing for Weak Instruments in Linear IV Regression. In D. W. K. Andrews & J. Stock (Eds.), ***Identification and inference for econometric* models**, 80–108. New York: Cambridge University Press.

Sujan, H., Weitz, B. A., & Kumar, N. 1994. Learning orientation, working smart, and effective selling. ***Journal of Marketing***, 58(3): 39-52.

Sundaramurthy, C., Pukthuanthong, K., & Kor, Y. 2014. Positive and negative synergies between the CEO's and the corporate board's human and social capital: A study of biotechnology firms. ***Strategic Management Journal***, 35(6): 845-868.

Teece, D. J. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. ***Research Policy***, 15(6): 285-305.

Teece, D. J. 2010. Technological innovation and the theory of the firm: the role of enterprise-level knowledge, complementarities, and (dynamic) capabilities. In B. H. Hall & N. Rosenberg (Eds.), ***Handbook of the economics of innovation***,1: 679-730. Elsevier.

Teece, D. J., Pisano, G., & Shuen, A. 1997. Dynamic capabilities and strategic management. ***Strategic Management Journal***, 18(7): 509-533.

Thomas, A. S., Litschert, R. J., & Ramaswamy, K. 1991. The performance impact of strategy-manager coalignment: An empirical examination. ***Strategic Management Journal***, 12(7): 509-522.

Trajtenberg, M. 1990. A penny for your quotes: patent citations and the value of innovations. ***The Rand Journal of Economics***, 21(1): 172-187.

Tripsas, M., & Gavetti, G. 2000. Capabilities, cognition, and inertia: Evidence from digital imaging. ***Strategic Management Journal***, 21(10-11): 1147-1161.

Tuggle, C. S., Schnatterly, K., & Johnson, R. A. 2010. Attention patterns in the boardroom: How board composition and processes affect discussion of entrepreneurial issues. ***Academy of Management Journal***, 53(3): 550-571.

Tushman, M. L., & Anderson, P. 1986. Technological discontinuities and organizational environments. ***Administrative Science Quarterly***, 31(3): 439-465.

Tzabbar, D. 2009. When does scientist recruitment affect technological repositioning? ***Academy of Management Journal***, 52(5): 873-896.

Tzabbar, D., Aharonson, B. S., & Amburgey, T. L. 2013. When does tapping external sources of knowledge result in knowledge integration? ***Research Policy***, 42(2): 481-494.

Verhoeven, D., Bakker, J., & Veugelers, R. 2016. Measuring technological novelty with patent-based indicators. ***Research Policy***, 45(3): 707-723.

Wagner, S., & Goossen, M. C. 2018. Knowing me, knowing you: Inventor mobility and the formation of technology-oriented alliances. ***Academy of Management Journal***, 61(6): 2026-2052.

Waller, M. J., Huber, G. P., & Glick, W. H. 1995. Functional background as a determinant of executives' selective perception. ***Academy of Management Journal***, 38(4): 943-974.

Walsh, J. P. 1995. Managerial and organizational cognition: Notes from a trip down memory lane. ***Organization Science***, 6(3): 280-321.

Westphal, J. D. 1999. Collaboration in the boardroom: Behavioral and performance consequences of CEO-board social ties. ***Academy of Management Journal***, 42(1): 7-24.

Whitler, K. A., Krause, R., & Lehmann, D. R. 2018. When and how board members with marketing experience facilitate firm growth. ***Journal of Marketing***, 82(5): 86-105.

Withers, M. C., Corley, K. G., & Hillman, A. J. 2012. Stay or leave: Director identities and voluntary exit from the board during organizational crisis. ***Organization Science***, 23(3): 835-850.

Wooldridge, J. M. 2015. Control function methods in applied econometrics**.** ***Journal of Human Resources***, 50(2): 420-445.

Yang, H., Zheng, Y., & Zaheer, A. 2015. Asymmetric learning capabilities and stock market returns. ***Academy of Management Journal***, 58(2): 356-374.

Younge, K. A., Tong, T. W., & Fleming, L. 2015. How anticipated employee mobility affects acquisition likelihood: Evidence from a natural experiment. ***Strategic Management Journal***, 36(5): 686-708.

Zheng, Y., & Yang, H. 2015. Does familiarity foster innovation? The impact of alliance partner repeatedness on breakthrough innovations. ***Journal of Management Studies***, 52(2): 213-230.

Zollo, M., & Singh, H. 2004. Deliberate learning in corporate acquisitions: post-acquisition strategies and integration capability in US bank mergers. ***Strategic Management Journal***, 25(13): 1233-1256.

Zollo, M., Reuer, J. J., & Singh, H. 2002. Interorganizational routines and performance in strategic alliances. ***Organization Science***, 13(6): 701-713.