

## DIRECT AND INTERACTION EFFECTS OF TOP MANAGEMENT TEAM AND BOARD COMPOSITIONS ON R&D INVESTMENT STRATEGY

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*This paper examines why firms differ in levels of R&D investment intensity by developing and testing a theory of direct and interaction effects of top management team and board outsider composition on R&D intensity. The theory is tested in a longitudinal sample of technology-intensive firms that completed an initial public offering. The results indicate that both top management team composition and board composition have direct and additive effects on R&D investment intensity. Also, monitoring by outsider directors does not constitute a universally effective governance mechanism with regard to a firm's R&D investment strategy. Firms opt for lower levels of R&D investment intensity when their outsider-rich board interacts with a team of managers who have high levels of (1) firm tenure, (2) shared team-specific experience, or (3) functional heterogeneity. When a firm's competitiveness relies on sustained R&D investments, it is important to note these interaction effects and make adjustments to promote a healthy dialogue between managers and the board. Adjustments could be made to the management team composition (e.g., initiating management turnover to reduce firm tenure) or to the bundle of governance mechanisms (e.g., partially substituting board monitoring with other mechanisms). Copyright © 2006 John Wiley & Sons, Ltd.*

In today's economy, firms are challenged to stay competitive and offer a continuous line of innovative products and services. In technologically intensive industries, investments in research and development (R&D) have been the primary source of product innovation and superior returns. R&D investments indicate the strategic importance of innovation for a firm (Branch, 1974; Hill and Snell, 1988) and constitute an important input for the development of intangible capital, differentiation, and product innovation (Chauvin and Hirschey, 1993; David, Hitt, and Gimeno, 2001;

Mosakowski, 1993). Because the development of R&D processes and routines is evolutionary (Nelson and Winter, 1982), early investments in R&D capability usually produce a superior absorptive capacity (Cohen and Levinthal, 1990; Lieberman, 1989). Lack of investments in R&D, on the other hand, may result in time compression diseconomies for a firm (Dierickx and Cool, 1989); that is, due to a weaker learning capacity, a firm may not be able to leapfrog the competitors with early investments in technological know-how.

Despite the key role of R&D investments in building and maintaining rent-producing innovative capabilities, firms differ in their commitment of financial resources to building innovation capabilities and new products. In fact, inter-firm differences in R&D investments persist even after controlling for the industry, firm size, and performance

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(Ettlie, 1998; Mosakowski, 1993). The continued presence of firm-level heterogeneity with respect to R&D investment strategy despite competition and imitative efforts remains a fundamental research topic in strategic management (Rumelt, Schendel, and Teece, 1994). Understanding *why firms differ* in R&D investment intensity (Nelson, 1991) also promises to illuminate the reasons for firm-level differences in dynamic innovation capabilities, and superior firm performance.<sup>1</sup>

Using insights from upper-echelons, resource-based, and agency theories, this paper develops and tests a theory of why firms differ in R&D investment intensity. These theoretical perspectives direct our attention to effects of top management team and board compositions on R&D investment intensity. The knowledge, confidence, and preferences of the top management team along with the incentives and stakes that managers have may shape a firm's commitment to R&D. Specifically, upper-echelon and resource-based perspectives emphasize the relevance to R&D investment choices of managers' firm-specific knowledge, collective confidence, and top management team diversity (e.g., Finkelstein and Hambrick, 1996; Penrose, 1959). Agency theory, on the other hand, stresses the role of an independent board of directors in disciplining managerial actions and mitigating the potential agency problem of underinvestment in R&D (Alchian and Demsetz, 1972; Baysinger, Kosnik, and Turk, 1991; Hansen and Hill, 1991).

Using multi-theoretical lenses, this paper examines whether both top management team and board independence have direct additive effects on firms' R&D intensity. This examination is superior to examining management and governance effects as separate systems of constructs because it allows us to understand whether management teams and board governance play unique roles in shaping a firm's R&D strategy. In addition, this paper theorizes about and tests complex interaction effects of the dynamics between the management team and the board on R&D intensity. These interaction effects demonstrate when conflicts between management teams and boards with specific compositions may undermine the effectiveness of board

monitoring as a governance mechanism. The theory developed here explains when unproductive conflicts and unhealthy dialogue between the team and the board result in reduced R&D investments. By investigating these potential behavioral and economic influences on R&D investment strategy, I follow in the footsteps of Barnard (1938), Finkelstein and Hambrick (1996), Mahoney (1995), and Penrose (1959) to search for the role of the *human element* in strategic choice.

## THEORY AND HYPOTHESES

### Top management team composition and R&D investment intensity

According to the upper-echelons perspective, firms' actions are reflections of their top-level managers (Hambrick and Mason, 1984). Differences in observable experiences and psychological attributes of managers influence their construed reality and lead to different executive behaviors and strategic choices (Finkelstein and Hambrick, 1996). Similarly, resource-based theory holds that firms' strategies develop and evolve as a result of the interactions between managers and firm's resources (Mahoney and Pandian, 1992; Wernerfelt, 1984). According to this theory, firms' entrepreneurial activities and strategic choices are also a function of managers' experience with each other at the upper ranks (Mahoney, 1995; Penrose, 1959). Both theories emphasize the attributes of top managers as a *team* because strategic decisions are often made and implemented through dynamic processes where managers interact, consult, and debate with each other.

The role of *top-level* managers in making strategic choice about R&D investments can be particularly relevant in young, entrepreneurial firms where the simplicity of the organization structure and communication channels in these firms allows top-level managers to interact with each other and with the firm's resources to influence R&D strategy. Whereas in large diversified firms, lower-level, divisional managers allocate their budget to various functions and projects (Chandler, 1991; Hoskisson and Hitt, 1988), in young, entrepreneurial firms, top-level executives decide the allocation of funds among different functions. However, even in young, entrepreneurial firms, which constitute the empirical context in this paper, top management team's influence on R&D

<sup>1</sup> R&D intensity refers to the degree at which a firm devotes its financial resources to research and development given its stock of resources (e.g., Dowling and McGee, 1994; Ettlie, 1998; Fryxell, 1990; Hill and Snell, 1988).

investments may differ according to the team's specific compositional characteristics. Insights from upper-echelons and resource-based perspectives suggest that top-level managers' firm tenure, shared team-specific experience, and functional heterogeneity may be closely linked to managerial preferences about R&D investments. Each of these three characteristics is discussed in more detail below.

#### *Managers' tenure in the firm*

During their tenure in the firm managers become knowledgeable about the firm's resources and develop a cognitive framework about the unique opportunities for the firm and what its strategy should be (Finkelstein and Hambrick, 1996; Penrose, 1959). According to the upper-echelons perspective, most managerial learning occurs during the first few years in the firm; then, after early success and initial learning, managers may commit psychologically to strategies they feel comfortable with (Finkelstein and Hambrick, 1996). With each passing year, managers may increasingly believe in the correctness of their view of the world. They may also receive less information, acquire task knowledge more slowly, and become more powerful. However, when long management tenure in the firm is associated with a passive decision making approach and resistance to changes to the firm's strategy, the firm's competitive position may become jeopardized in high-velocity industries, where timely adaptation and proactive decision making are essential (Bantel and Jackson, 1989; Boeker, 1997; Wiersema and Bantel, 1992). Resistance to change among tenured managers involves *reduced* willingness to take risks, which managers get away with when they are empowered with tenure in the firm.

Past empirical research focused primarily on how managers' tenure affects their willingness to change the firm's existing strategy (e.g., diversification) although this theory may also be applied to managers' willingness to take risks in other types of strategic actions such as making R&D investments which are risky and long-term oriented in nature (Barker and Mueller, 2002). Undertaking irreversible investments in R&D constitutes a risky endeavor because of uncertainties in achieving technical goals, commercialization, and appropriation (Mansfield, 1969; Scherer and Ross, 1990). Managers with less tenure in the firm may

be more willing to take risks and invest heavily in R&D because they are compelled to produce results and prove themselves as competent managers. Managers who are relatively new to the firm may lack legitimacy in the eyes of certain internal or external stakeholders and feel more pressure to produce new initiatives and directions (Miller, 1993). Bolder and aggressive investments in R&D increase the likelihood and speedy development of innovative products; thus, short-tenured managers who want to be affiliated with and praised for new product successes may push for an intense R&D strategy.

Long-tenured managers, on the other hand, may have a more risk-averse approach to R&D investments because they are less pressured to prove themselves. These managers can still glow in the success of past products, so they may prefer modest levels of R&D intensity, which may not lead to speedy innovation and high returns but may limit losses. Because of their high power in the firm and legitimacy among stakeholders, long-tenured managers often have the liberty to pursue the strategies they like even if they are not profit-maximizing choices (Cannella and Shen, 2001; Singh and Harianto, 1989; Zajac and Westphal, 1996). Thus, the R&D intensity of a firm decreases with the top-level managers' firm tenure, although this decrease in R&D intensity happens gradually. As their tenure progresses, managers slowly lower levels of R&D intensity to avoid high risk while maintaining some level of R&D productivity.

*Hypothesis 1: Managers' firm tenure is associated negatively with R&D investment intensity where the strength of the negative effect diminishes with tenure.*

#### *Managers' shared team-specific experience*

While managers' tenure in the firm indicates their knowledge of the firm's resources and capabilities, *shared* team-specific experience in the top management team refers to accumulated knowledge of each other's skills, limitations, and idiosyncratic habits (Barnard, 1938; Penrose, 1959). Shared team-specific experience is essential for managers functioning together because teamwork at the upper ranks involves taking risks on behalf of the firm, committing to certain strategic actions under uncertainty, and winning or losing as a team (Kor and Mahoney, 2000). Because each management

team is likely to be unique in its functioning, generic experience in teamwork cannot substitute for the experience of working with specific managers in a particular firm. Regarding the importance of managers' experience with one another, Penrose argues that:

An administrative group [management team] is something more than a collection of individuals; it is a collection of individuals who have had experience in working together, for only in this way can 'teamwork' be developed. Existing managerial personnel provide services that cannot be provided by personnel newly hired from outside the firm, not only because they make up the administrative organization which cannot be expanded except by their own actions, but also because the experience they gain from working within the firm and with each other enables them to provide services that are uniquely valuable for the operations of the particular group with which they are associated. ... Extensive planning requires the cooperation of many individuals and this *requires knowledge of each other*. (Penrose, 1959: 46–47, emphasis added)

Irreversible R&D investments constitute risks that require a sense of trust and common understanding among managers. Top management teams in which managers have high confidence in the ability and credibility of each other are more likely to initiate risky, but potentially profitable, investments, because managers are jointly prepared to tolerate uncertainties and to handle problems in implementation (Kor and Mahoney, 2000; Schoonhoven, Eisenhardt, and Lyman, 1990). A strong team orientation not only enables managers to cope well with the uncertainty associated with risky decisions (Bourgeois and Eisenhardt, 1988) but also encourages them to develop positive beliefs about the analyzability and predictability of the environment (Isabella and Waddock, 1994). As shared team-specific experience inoculates managers with collective confidence and optimism about the business environment, aspiration level and boldness of managerial decisions increase (Goodman and Leyden, 1991; Guzzo *et al.*, 1993). Therefore, firms invest more intensely in R&D when management teams have significant shared experience at the upper ranks.

*Hypothesis 2: Managers' shared team-specific experience is associated positively with R&D investment intensity.*

### *Functional background heterogeneity in the top management team*

Functional background heterogeneity refers to representation in the top management team of various business functions such as marketing, operations, and finance. A high degree of functional background heterogeneity in the top management team increases upper-level competition among departments for internal funds (Branch, 1974). Individual departments with distinct projects and budget requests can get their voices heard when they are represented at the executive level. The inclusion in the top management team of additional executives from different departments makes it harder to devote a firm's scarce funds to a particular function like R&D. Allocation of limited funds among departments can be a challenging issue particularly for entrepreneurial firms that are in the process of building or expanding functions besides R&D (e.g., production, marketing, distribution). As the financial interests represented by executives become diverse and conflicting, the possibility of reaching a consensus on an intense R&D investment policy dwindles (Evans and Dion, 1991; Hambrick, Cho, and Chen, 1996; Murray, 1989; Priem, 1990). The presence of multiple goals and coalitions in the top management team (Cyert and March, 1963) may mitigate the emergence of a dominant R&D logic and result in less concentrated allocation of funds. Thus, even though wide functional representation may expand the pool of skills and ideas in the top management team (Bantel and Jackson, 1989), competition among different functional managers for funds decreases the possibility of dedicating large sums to R&D.

*Hypothesis 3: Functional background heterogeneity in the top management team is associated negatively with R&D investment intensity.*

### **Board outsider composition and R&D investment intensity**

Agency theory (Fama and Jensen, 1983; Jensen and Meckling, 1976) points out the conflict of interest between owners and managers in public corporations. While increasing productivity to achieve the highest levels of profitability is often the main goal of owners (Alchian and Demsetz, 1972), agents, having a different utility function, may pursue their own interests such as growth maximization via diversification over profit

seeking to reduce the risks of their human capital (Amihud and Lev, 1981; Jensen and Meckling, 1976). As market frictions limit the ability of the market for corporate control to align the interests of shareholders and managers, additional mechanisms such as monitoring managerial actions by independent boards become essential to mitigate potential agency problems (Eisenhardt, 1989; Mahoney, 1992; Mahoney and Mahoney, 1993).

A firm's R&D investment decisions can be subject to agency problems due to the high levels of risks involved in sunk-cost investments. In particular, managers may be reluctant to make R&D investments that will pay off in the long term rather than in the short term (Alchian and Demsetz, 1972; Baysinger *et al.*, 1991; Eisenhardt, 1989; Fama and Jensen, 1983). Shareholders investing in R&D-intensive industries welcome the high-risk, high-return opportunities because they can protect themselves from high exposure to risk from high-technology stocks by holding diversified stock portfolios. Managers, on the other hand, bear high employment risk because poor investment outcomes can endanger the firm's financial health and their employment. Unlike shareholders, managers may more directly experience potential consequences of risky R&D investments on their employment and finances. Therefore, they may prefer to take fewer investment risks than what would be optimal for shareholders (Walsh and Seward, 1990). These managers may prefer to channel funds to activities that can deliver returns with more certainty, even if that means a lower rate of return. Managers who wish to build empires and maximize their compensation would rather invest heavily in marketing and distribution functions and acquisition activities because they boost sales and firm size more rapidly. Also, this tendency may be amplified among entrepreneurial firms, where there is scarcity of resources and elevated bankruptcy risk. These conditions expose managers to an even higher level of employment risk, which they may attempt to manage by limiting investments in risky and long-term R&D projects.

However, in technology-intensive industries, low levels of R&D may hurt a firm's competitive advantage because, in the absence of consistent efforts to keep the innovation pipeline full, a firm's dynamic innovation capability may erode away in as little as a year or two (Kor and Mahoney, 2005; Mosakowski, 1993). While high levels of R&D investments will not guarantee high

returns, they are usually necessary for intangible capital development, differentiation, and product innovation (Chauvin and Hirschey, 1993; David *et al.*, 2001; Mosakowski, 1993). Indeed, empirical research shows that firms with high investments in R&D, on average, outperform in sales, market share, and profits those with low investments (Branch, 1974; Chauvin and Hirschey, 1993; Dowling and McGee, 1994; Ettl, 1998; Fryxell, 1990; Hill and Snell, 1988; Mosakowski, 1993; Ravenscraft and Scherer, 1982).

This potential agency problem of under-investing in R&D may be mitigated by corporate governance mechanisms (Baysinger *et al.*, 1991). Specifically, boards can become a powerful internal monitoring mechanism to encourage value-maximizing decisions when they are independent of the CEO's influence (Morck, Shleifer, and Vishny, 1989). Board independence can be greatly improved by separating the CEO and board chairperson duties, and by including independent outside members in the board, who are more likely to question the decisions made by the CEO and other executives. Research shows that separation of CEO and board chairperson duties and the inclusion of more outsiders on board have a positive impact on board actions and firm performance (Daily and Dalton, 1994; Hill and Snell, 1988; Pi and Timme, 1993; Rechner and Dalton, 1991). When boards are under the influence of CEOs and other executives, firms are more likely to limit the level of investments in long-term R&D projects that may not deliver returns quickly. An independent board, however, could remind managers that developing and maintaining innovative capability is a priority of the firm.

A number of empirical studies indicate lack of support for the agency perspective predictions about the relationships between board monitoring and R&D spending/innovation. Baysinger *et al.* (1991) and Hill and Snell (1988) find a positive relationship between the ratio of insider directors and R&D expenditures per employee, and Zahra (1996) finds that the ratio of outsiders is negatively related to corporate entrepreneurship as perceived by executives. Hoskisson *et al.* (2002), on the other hand, do not find a relationship between the ratio of outsiders on the board and internal innovation. Despite the lack of empirical support for the agency view, it may be early to conclude about the role of boards of directors because the number of empirical studies that illuminate

the relationship between the outsider ratio and the R&D *investment intensity* is still small. R&D investment intensity is different from innovation and entrepreneurship, which are more about the outcomes of R&D investments. This study aims to generate much needed further empirical evidence and, instead of examining board and governance effects as a single system of constructs that influence R&D investments, it performs a *simultaneous* examination of top management team and board monitoring effects on R&D investment intensity.

*Hypothesis 4a: After controlling for the top management team effects, separation of CEO and chair duties will be positively related to R&D investment the intensity.*

*Hypothesis 4b: After controlling for the top management team effects, the ratio of outsiders on the board will be positively related to R&D investment intensity.*

### **Interaction effects of top management team and board compositions on R&D investment intensity**

The effectiveness of the board in performing its monitoring and advisory functions may also be driven by the nature of inter-group dynamics between the board and the top management team. A healthy dialogue between the team and the board can contribute to the quality of the strategic decisions, whereas conflicts and power struggles can create negative dynamics and an inappropriate decision-making environment. Conflicts and power struggles may occur when boards and management teams have specific compositions. Golden and Zajac (2001), for example, show that board demographics and the dynamics within the board affect strategic change of hospitals. The current study, however, gives attention to both top management team and board compositions. Rather than dynamics within the board, this paper investigates how the interactions *between* the management team and the board may influence the governance role of the board outsiders with respect to R&D investments.

The first interaction effect concerns situations where highly tenured executives work with an outsider-rich board, which may result in the emergence of two groups with opposing views on

R&D strategy. Managers with high firm tenure may be reluctant to invest heavily in R&D as these investments may pay off in the long term, whereas the board of directors, guarding the interests of shareholders, may advocate a high R&D intensity with expectations of superior returns. The polarized views of managers and outsider directors may result in conflicts and hostility in management-board interactions. Especially, when *both* the top management team and the board are powerful because managers are long tenured in the firm and the board is rich with outsiders representing the shareholders' interests, rival factions may develop at the upper ranks (Pearce and Zahra, 1991). Rising tensions and the polarization of views may weaken the communication between the board and the team (Sundaramurthy and Lewis, 2003), leaving outsiders with a bigger information disadvantage. In response to outsider directors' attempts to promote R&D investments, managers may withhold information (Walsh and Seward, 1990) and engage in interpersonal tactics (e.g., persuasion) to control these investments (Westphal, 1998). In fact, research shows that managers engage in interpersonal tactics *especially when* the board is structured to reduce their power (Westphal, 1998). Managers may use their superior firm-specific knowledge to justify to the board their preference in moving some of the R&D funds to other functions and investments which may be inherently less risky. Also, tenure-driven strong managerial power limits the board's ability to control managerial actions (Pearce and Zahra, 1991; Shen, 2003). The board may want to promote potentially profitable, but risky, R&D investments; however, tenured managers who have become increasingly powerful and entrenched in the firm may be able to constrict the board's efforts at the expense of shareholders' interests (Cannella and Shen, 2001; Singh and Harianto, 1989; Zajac and Westphal, 1996). Entrenched managers make themselves nonsubstitutable by building a corporate strategy that matches their unique skills and by establishing strong relationships with internal and external stakeholders (Walsh and Seward, 1990). By increasing their value for the firm, these managers can get away with suboptimal investments. Thus, as management teams with high firm tenure interact and negotiate with outsider-rich boards, firm's R&D investment intensity will be compromised.

*Hypothesis 5: The interaction of length of managers' firm tenure and the ratio of outsiders on the board is negatively related to R&D investment intensity.*

As argued previously, shared experience in the top management team provides managers with in-depth knowledge of each other's abilities and idiosyncratic habits and strengthens the team's collective confidence (Eisenhardt and Schoonhoven, 1990; Penrose, 1959). However, the top management team's collective confidence also empowers managers to more easily pursue goals that serve their interests instead of those of shareholders. When a powerful and confident management team interacts with a board with a high percentage of outsider directors, certain conflicts become unavoidable (Pearce and Zahra, 1991). Even though these conflicts may concern agency issues such as executive compensation and excessive firm growth rather than R&D decisions, they may produce negative spillover effects on a firm's R&D investments. When the management team and the board do not get along and cannot maintain a healthy dialogue due to power struggles, the firm may abandon its dominant logic of developing and renewing innovative capabilities. In the midst of conflicts and power struggles, managers may not be able to keep their eyes on the ball and carry on a high R&D strategy to sustain the innovativeness of the firm. Therefore, bringing together managers with high levels of shared team-specific experience and a board with a high percentage of outsiders can constrain R&D investments.

*Hypothesis 6: The interaction of the level of shared team-specific experience among top-level managers and the ratio of outsiders on the board will be negatively related to R&D investment intensity.*

Finally, functional background heterogeneity in the top management team may also affect the dynamics between the team and the board. As argued before, R&D intensity may go down with representation of a higher number of functions and departments on the management team as each manager demands internal funds for his or her department, resulting in less concentrated distribution of funds. The negative effect of team's functional background heterogeneity on R&D investment intensity may be accentuated when a heterogeneous team

works with an outsider-rich board that prefers dedication of funds to R&D. This may happen because under pressure from the outsider-rich board to increase R&D spending, the non-R&D executives may form anti-R&D coalitions in the top management team (Polzer, Mannix, and Neale, 1998). Coalitions are formed under conditions of conflict, strong aspirations, and power imbalance (Thompson, 1967). As the ratio of outsiders on the board increases, causing a power imbalance in favor of the R&D function (Mannix, 1993), the non-R&D executives may collectively prevent significant funds from being allocated to R&D in order to channel them to their departments. Thus, combining high functional heterogeneity in the management team with high representation of outsiders on the board may produce a negative effect on a firm's R&D investment intensity.

*Hypothesis 7: The interaction of functional background heterogeneity in the top management team and the ratio of outsiders on the board will be negatively related to R&D investment intensity.*

## EMPIRICAL SETTING

### Sample

The empirical context of this paper is provided by technology-based entrepreneurial firms that completed an initial public offering (IPO) in the medical and surgical instruments industry (SIC = 3841–3845) in the United States during 1990–95. The sample consists of firms engaged in development and/or production of high-technology medical and surgical instruments such as cardiac pacemakers, defibrillators, angioplasty catheters, ultrasound imaging, and *in vitro* diagnostics products. High-technology IPO firms are considered entrepreneurial because of their engagement in new product and capability development and their access to public capital markets. The changes and challenges that accompany the post-IPO period present an opportunity for conducting a natural quasi-experiment in which we can examine the linkages between a firm's R&D investment intensity and top management team composition and board composition. This empirical setting also displays ample variance among firms with regards to top management team composition and corporate governance practices.

The sample includes 77 firms that went public between 1990 and 1995. The sample includes data on these firms from their initial public offering year through 1999. Since these firms went public in different years and not all of them continued to operate through 1999, the sample does not include an equal number of observations for each firm. The final sample includes a total of 408 observations from 77 firms. The longitudinal data on R&D investments, management, and governance are gathered from both initial registration statements (i.e., prospectuses) and proxy statements issued annually following the IPO. Data on firm performance and firm size are compiled from IPO prospectus and Compustat files.

### Variables

The dependent variable in this study is *R&D investment intensity*, which is typically calculated as the level of investments divided by the firm's sales, assets, or number of employees (e.g., Dowling and McGee, 1994; Ettl, 1998; Fryxell, 1990; Hill and Snell, 1988; Scherer, 1965). Here, R&D investments are standardized by total assets because some firms do not have sales in the early years of product development.

The top management team (TMT) is defined as all inside top-level executives including the chief executive officer, chief operating officer, business unit heads and vice presidents (Finkelstein and Hambrick, 1996). In this study, all inside executives listed in the management section of the prospectus are included. Top-level *managers' firm tenure* is calculated as the average number of years managers have spent in a particular firm (Hambrick *et al.*, 1996; Michel and Hambrick, 1992). *Shared team-specific management experience* is calculated as the sum of the shared experiences across all dyads on the team. This measure incorporates the shared team-specific experience of all current executives (Kor, 2003). *Functional background heterogeneity in the top management team* is calculated with a Herfindahl index [ $H = 1 - \sum p_i^2$ ], where  $p$  is the percentage of top management team members in each functional background category. The list of functional categories provided in Michel and Hambrick (1992) is used to code the various functional backgrounds. When coding managers' functional background, I used managers' current function (or department) at that time, as the heterogeneity construct in this paper tries to capture the

extent of executive-level representation of different business functions during a particular year. Executives' past positions may influence their willingness to approve funding for R&D; however, their *primary* interest should be to secure funding for their *current* department.<sup>2</sup>

*Separate CEO-chair* is measured with a dummy variable that takes the value of one if the CEO of the firm is *not* the board chair at the same time (Sundaramurthy, Mahoney, and Mahoney, 1997). The *ratio of outsiders* is calculated as the proportion of outside (i.e., non-executive) directors who were appointed before the current CEO took office (Sundaramurthy *et al.*, 1997; Wade, O'Reilly, and Chandratat, 1990; Zajac and Westphal, 1994). This measure excludes outside directors who may be appointed by the CEO during his/her tenure due to former personal or business ties. However, this measure does not exclude affiliated outside directors such as financiers and channel partners, with whom the firm may have business relationships. Affiliated outside directors are often sought by entrepreneurial firms as they help the firm access critical resources. For example, affiliated directors may use their board seats to closely monitor managers on behalf of institutional investors (e.g., venture capitalists) who funded firm's research efforts and operations. Likewise, directors from affiliated companies such as suppliers, distributors, and customers can provide the board with relevant industry knowledge that entrepreneurial firms need to survive and succeed. Because they have a stake in the success of the firm, these directors are also often well motivated to provide advice and counsel to managers (Hillman and Dalziel, 2003; Huff, 1982; Pfeffer and Salancik, 1978; Westphal, 1999). Thus, the current measure serves as an appropriate indicator of outside directors as a governance mechanism.

In the light of previous top management team (TMT) research and corporate governance research

<sup>2</sup> As one of the reviewers of this paper pointed out, by the time a manager becomes the CEO, he/she is likely to have served in multiple managerial positions in different functional areas, so it is not always clear how their managerial functional backgrounds may affect their commitment to R&D. Thus, it may be useful to control for the CEO's educational background, as CEOs with a scientific (i.e., research) background may be more inclined to dedicate resources to R&D (Barker and Mueller, 2002; Tyler and Steensma, 1998). However, when CEO educational background was controlled with a dummy variable (1 if the CEO had a PhD in science or engineering, 0 if not), the control variable was statistically insignificant, and regression results were unaffected.

(e.g., Bantel and Jackson, 1989; Hambrick *et al.*, 1996; Mahoney, Sundaramurthy, Mahoney, 1997), this study includes several control variables including TMT's average age, TMT size, firm tenure heterogeneity in the team, founders in the TMT, management stock ownership, institutional investor ownership, venture capital (VC) ownership, profitability, and firm size (i.e., total revenues). *Firm tenure heterogeneity* is calculated as the standard deviation of firm tenure of top executives (Hambrick *et al.*, 1996). *Founders in TMT* is measured with the ratio of founders in the TMT (i.e., number of founders in the TMT divided by TMT size). This variable controls for founders' presence in the top management team and their potential influence relative to the size of the team (Kor, 2003). *Management stock ownership* is calculated as the total percentage of common stock owned by the insider top executives of the firm (Mahoney *et al.*, 1997). *Institutional investor ownership percentage* is calculated as the total percentage of ownership by institutional investors including pension funds, mutual funds, insurance companies, investment firms, and other corporations (Mahoney *et al.*, 1997). *VC ownership* is measured with a dummy variable where values of 1 indicate stock ownership by venture capitalists. *Profitability* is measured with return on assets (Hill and Snell, 1988). Table 1 presents descriptive statistics and correlations among the variables in this study.

### Analysis

The hypotheses presented in this paper are tested using repeated observations (i.e., panel data) on the same set of cross-sectional units (Greene, 2000; Hsiao, 1996; Johnston and Dinardo, 1997). A random effects model is preferable to analyze the panel data because the alternative dummy approach is costly in degrees of freedom lost. However, it is crucial to do a Hausman test for orthogonality of the random effects before the individual effects can be treated as random. This test assesses the consistency of estimation results with dummy (fixed effects) and random effects models. In the event that two estimates do not differ systematically, random effects generalized least squares (GLS) regression is always preferable because it is a significantly more efficient estimation technique (Greene, 2000: 576). In this sample, the Hausman test indicates that estimation results

of dummy and random effects are consistent, and individual effects are uncorrelated with the other variables in the model. Therefore, the paper employs the more efficient random effects GLS estimation technique.

### RESULTS

Table 2 presents the coefficient estimates for the main and interaction effects of top management team and board compositions on R&D investment intensity. As the base model, the first model has all of the control variables. The second model includes both control and main variables. Interaction variables enter the regressions one at a time in the third, fourth, and fifth models. The first chi-square statistic indicates the overall significance of each model, and the second chi-square statistic provides a test of statistical significance for the added variables (i.e., change) in a particular model. For Models 3–5, the chi-square statistic for change compares each model to the main-effects model (i.e., Model 2). Centered values of variables are used for the estimation of interaction effect models (i.e., Models 3–5).

Hypothesis 1 argues that firm tenure of managers is associated negatively with R&D intensity, although the negative effect occurs at a diminishing rate. Model 2 indicates that the negative coefficient of managers' firm tenure and the positive coefficient of squared firm tenure are statistically significant. Given the small size of the coefficient of squared firm tenure, the model indicates a nonlinear negative relationship, where R&D investment intensity decreases with managers' firm tenure at a decreasing rate (which was also confirmed when the relationship was plotted). Thus, Hypothesis 1 is supported. In Hypothesis 2, it is predicted that the level of shared team-specific top management team experience of managers is associated positively with R&D investment intensity. The results provide support for this hypothesis. Hypothesis 3 posits a negative relationship between heterogeneity of functional background in the top management team and R&D investment intensity; however, findings do not support this hypothesis. Further, as predicted by Hypothesis 4a, the separation of CEO and chair duties is positively related to R&D investment intensity. Yet the results do not support Hypothesis 4b because the ratio of outsiders on the board does not have a

Table 1. Descriptive statistics and correlations

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Managers' firm tenure	5.83	3.24															
2. Shared team-specific experience	58.69	54.70	0.59														
3. Functional heterogeneity	0.71	0.16	0.02	0.33													
4. Separate CEO-chair	0.51	0.50	-0.04	-0.12	0.07												
5. Board outsiders ratio	0.27	0.29	-0.36	-0.24	0.03	0.28											
6. TMT average age	46.15	4.59	0.37	0.35	0.07	-0.11	-0.17										
7. TMT size	5.97	2.07	0.19	0.77	0.49	-0.09	-0.12	0.25									
8. TMT firm tenure heterogeneity	0.57	0.25	0.06	0.01	0.09	-0.04	-0.12	0.17	0.22								
9. Founders in TMT	0.17	0.21	-0.04	-0.29	-0.32	-0.01	-0.21	-0.05	-0.47	-0.25							
10. Management ownership %	0.16	0.18	0.18	-0.01	-0.09	-0.15	-0.40	0.20	-0.09	0.09	0.21						
11. Institutional investor ownership %	0.27	0.24	-0.23	-0.13	0.07	0.28	0.35	-0.19	0.00	-0.10	-0.10	-0.31					
12. VC ownership	0.39	0.49	-0.35	-0.20	0.13	0.29	0.33	-0.33	-0.09	-0.13	0.05	-0.24	0.49				
13. Firm age	9.70	6.64	0.52	0.36	0.00	0.01	0.00	0.00	0.06	0.01	0.27	0.00	0.00	-0.28	-0.21		
14. Profitability	-0.30	0.58	0.00	0.00	0.99	0.87	0.02	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00		
15. Firm size	0.07	0.20	0.00	0.00	0.35	0.80	0.15	0.05	0.33	0.81	0.13	0.23	0.00	0.00	0.00	0.20	
16. R&D investment intensity	0.21	0.27	-0.21	-0.15	-0.11	0.09	0.12	-0.13	-0.10	0.01	0.11	-0.04	0.31	0.67	0.00	0.00	0.00
			0.00	0.00	0.03	0.06	0.01	0.01	0.05	0.85	0.02	0.38	0.00	0.00	0.00	0.00	0.02

*p*-values are reported under correlation coefficients. *N* = 408. Firm size (revenues) are in billions of U.S. dollars.

Table 2. Random effects GLS regression of R&amp;D investment intensity

	Model 1	Model 2	Model 3	Model 4	Model 5
Managers' firm tenure		-0.032** (-2.80)	-0.025* (-2.15)	-0.026* (-2.21)	-0.030** (-2.70)
Managers' firm tenure squared		0.001+ (1.81)	0.000 (0.65)	0.001 (1.12)	0.001+ (1.76)
Shared team-specific experience		0.001+ (1.94)	0.001+ (1.76)	0.001+ (2.43)	0.001+ (1.73)
Functional background heterogeneity		-0.087 (-1.22)	-0.092 (-1.29)	-0.091 (-1.28)	-0.081 (-1.15)
Separate CEO-chair		0.043+ (1.76)	0.047+ (1.89)	0.047+ (1.93)	0.039 (1.59)
Board outsiders ratio		0.000 (0.00)	-0.037 (-0.83)	0.083 (1.47)	0.002 (0.06)
Firm tenure × Outsider ratio			-0.035* (-2.14)		
Shared team experience × Outsider ratio				-0.002* (-2.22)	
Functional heterogeneity × Outsider ratio					-0.367+ (-1.73)
TMT average age	-0.004 (-1.59)	-0.004 (-1.50)	-0.004 (-1.43)	-0.003 (-1.39)	-0.004 (-1.52)
TMT size	-0.004 (-0.74)	-0.015 (-1.47)	-0.014 (-1.34)	-0.010 (-0.99)	-0.013 (-1.28)
TMT firm tenure heterogeneity	0.049 (1.22)	0.065 (1.46)	0.065 (1.46)	0.065 (1.47)	0.121 (2.01)
Founders in TMT	0.103+ (1.76)	0.114+ (1.88)	0.118+ (1.93)	0.121* (2.00)	0.067* (1.50)
Management stock ownership %	0.070 (1.13)	0.082 (1.30)	0.084 (1.31)	0.086 (1.35)	0.071 (1.12)
Institutional investor ownership %	0.154*** (3.51)	0.135** (3.04)	0.121** (2.70)	0.124** (2.78)	0.126** (2.83)
VC ownership	0.041+ (1.80)	0.028 (1.19)	0.022 (0.95)	0.026 (1.11)	0.025 (1.05)
Firm age	0.000 (-0.05)	0.001 (0.52)	0.002 (0.69)	0.001 (0.47)	0.001 (0.32)
Profitability	-0.064* (-2.26)	-0.061* (-2.16)	-0.062* (-2.20)	-0.061* (-2.17)	-0.063* (-2.23)
Profitability squared	0.126*** (10.91)	0.127*** (11.03)	0.128*** (11.16)	0.127*** (11.08)	0.126*** (10.96)
Firm size	0.000 (0.76)	0.000 (0.82)	0.000 (0.64)	0.000 (0.74)	0.000 (0.74)
Intercept	0.236* (2.02)	0.444** (3.28)	-0.010 (-0.73)	0.026 (1.54)	0.002 (0.16)
R <sup>2</sup>	0.63	0.64	0.65	0.64	0.64
Wald $\chi^2$	681.64***	712.00***	721.27***	723.56***	718.70***
$\chi^2$ change in model		3.07+	4.59*	4.91*	3.01+

+  $p < 0.10$ ; \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .  $N = 408$ . Firm size (revenues) are in millions of U.S. dollars. Z-scores are given in parentheses under coefficient estimates.

significant association with R&D investment intensity.

Further, Model 3 provides empirical evidence in support of Hypothesis 5. The R&D investment of the firm decreases as managers' firm tenure and the ratio of outsiders on the board increase simultaneously. Model 4 indicates that

the higher the firm tenure of managers and the ratio of outsiders in the board, the lower the R&D investment intensity. This finding is consistent with the prediction of Hypothesis 6. Finally, Hypothesis 7 is also corroborated. As Model 5 indicates, the interaction of heterogeneity of functional background in the top management team

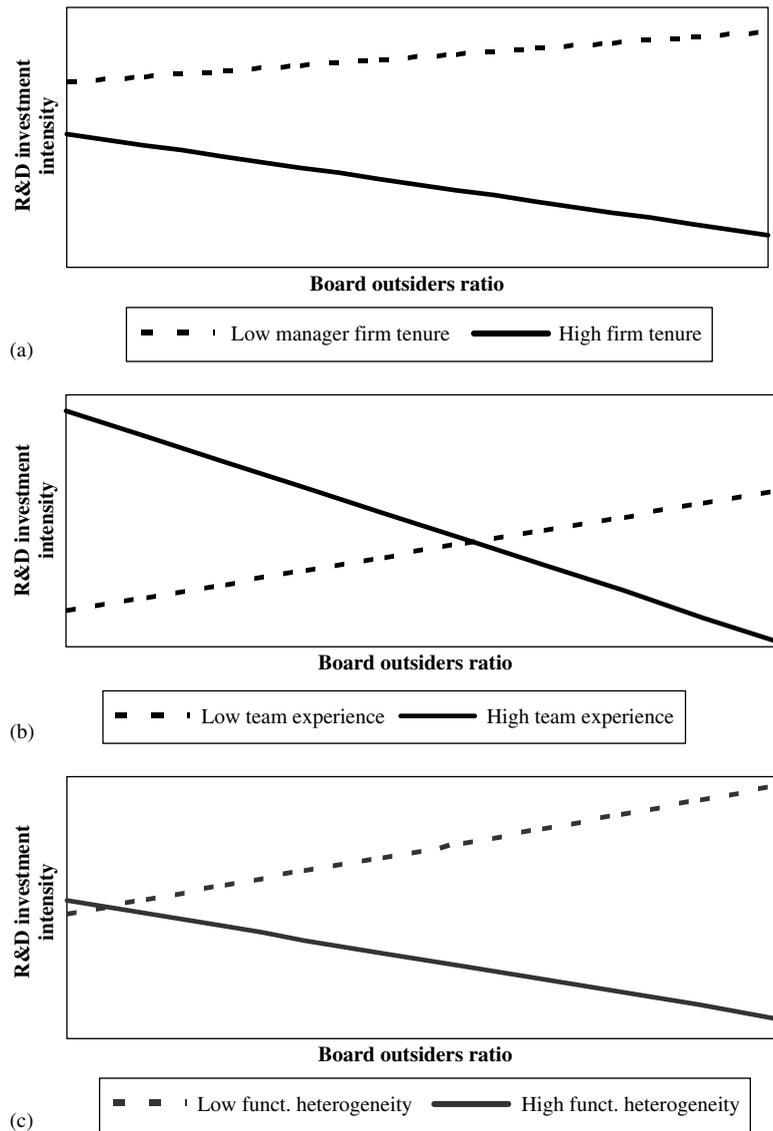


Figure 1. (a) Interaction effect of managers' firm tenure and board outsider ratio. (b) Interaction effect of managers' shared team experience and board outsider ratio. (c) Interaction effect of functional heterogeneity in TMT and board outsider ratio

and the ratio of outsiders on the board is negatively associated with R&D investment intensity. These interaction effects are illustrated in Figure 1.

Regarding control variables, findings show that founders in TMT, VC ownership, and institutional investor ownership percentage are positively related to R&D investment intensity. Profitability is related to R&D investment intensity in a curvilinear shape, initially decreasing and then increasing with profitability.

## DISCUSSION

This paper inquires about *why firms differ* in R&D investment intensity and demonstrates whether top management team and corporate governance effects are additive in shaping R&D investments. This paper also reveals when conflicts between management teams and boards with specific compositions may undermine the effectiveness of board monitoring as a governance mechanism and result in lower R&D investment intensity.

### Direct effects of the top management team composition

The results indicate that R&D investment intensity is negatively and nonlinearly related to managers' tenure in the firm. Firms' R&D intensity decreases with top-level managers' firm tenure, although at a diminishing rate. This finding is consistent with the argument that managers who are relatively new to the firm and thus want to be affiliated with new product successes push for an intense R&D strategy to increase the likelihood and speedy development of innovative products. With tenure in the firm, however, managers become more powerful and reluctant to assume high investment risk that may pay off only in the long run. These powerful managers prefer modest levels of R&D investments, which will enable them to lower the investment risk while maintaining some level of R&D productivity. Overall, this finding suggests that when the top management team has high firm tenure, the firm's commitment to high levels of R&D investments may be jeopardized.<sup>3</sup>

The results also indicate that presence of founders in the top management team is associated with higher R&D investments. Even though founder presence was not a central variable in this study, it is interesting to see that founders' effect on R&D contrasts with the effect of tenured managers. Consistent with past research findings (e.g., Busenitz and Barney, 1997), managers and founders can be different in their goals, priorities, biases, and levels of confidence, which may lead to divergence between their preferences and strategic choices, including their orientation towards R&D investments. Unlike tenured managers who may falter from committing to a strong R&D strategy, founders may act as protectors of continued innovation efforts. Given their enthusiasm and optimism about firm's products and future prospects, coupled with their ownership rights (Nelson, 2003; Rubenson and Gupta, 1996), founder managers can be influential in sustaining firm's entrepreneurial drive and innovative activities.

<sup>3</sup> Despite their unwillingness to assume long-term investment risk, managers with experience in the firm can make well-informed decisions regarding allocation of the budgeted R&D resources among competing projects. When managers possess the tacit knowledge of the firm's unique technology capabilities and employee skills, they may better assess which opportunities emerging in the environment fit better with internal firm strengths and weaknesses (Kor and Mahoney, 2005).

In addition, empirical findings indicate that managers' shared team-specific experience is positively related to R&D investment intensity. Because risky investments require a sense of trust and common understanding within the top management team that comes from working together over time (Kor and Mahoney, 2000; Penrose, 1959), managers with shared team-specific experience cope well with the uncertainty associated with investing in R&D (Bourgeois and Eisenhardt, 1988). The results are consistent with the argument that previous team-specific experiences can increase managers' aspiration levels, reinforce the speed and boldness of their decisions, and induce collective confidence in pursuing risky investments (Goodman and Leyden, 1991; Guzzo *et al.*, 1993; Isabella and Waddock, 1994). Thus, the results suggest that a strong team orientation that involves shared team-specific management experience is desirable in securing high R&D investments.

### Direct effects of the board outsider composition

A firm's R&D investment decisions can be subject to agency problems due to the high levels of risk involved in R&D investments, which are largely sunk costs. Managers in R&D-intensive industries who are subject to employment risk might prefer a less risky R&D strategy (Alchian and Demsetz, 1972; Baysinger *et al.*, 1991). This potential agency problem of under-investment in R&D may be mitigated with specific corporate governance mechanisms.

This paper's findings indicate that separating the CEO and board chairperson duties is associated positively with R&D investment intensity, and this result is consistent with previous findings that the separation of CEO and board chairperson duties have a positive impact on board actions and selection of profit-maximizing strategies (e.g., Daily and Dalton, 1994; Pi and Timme, 1993; Rechner and Dalton, 1991; Sundaramurthy *et al.*, 1997). The hypothesized positive relationship between the ratio of outsiders on the board and R&D investment intensity, however, is not significant. This insignificance could be because of a lack of influence of board outsiders on a firm's R&D strategy although the results, at the very least, indicate that increased board independence in the form of separate CEO-chair positions is related to R&D intensity. The insignificance of board outsiders

could be due to high correlations among various governance mechanisms. For example, there is a significant positive correlation ( $r = 0.28$ ) between the ratio of outsiders and CEO–chair separation. The ratio of outsiders is also positively correlated with institutional investor ownership ( $r = 0.35$ ), suggesting that the use of outsider directors is common in the presence of institutional ownership. Further, a significant negative correlation between the ratio of outsiders and managers' stock ownership ( $r = -0.40$ ) indicates that monitoring by outsider directors serves as a *substitute* governance mechanism in place of managerial incentives (Beatty and Zajac, 1994; Rediker and Seth, 1995). These findings are consistent with previous evidence for substitution effects among governance mechanisms (e.g., Beatty and Zajac, 1994; Zajac and Westphal, 1994). Yet, an important implication of substitution effects is that they make it difficult to empirically tease out the individual effects of governance mechanisms on specific strategic choices, including the level of R&D investments (Rediker and Seth, 1995). Therefore, despite the apparent insignificance of board outsiders, it may not be appropriate to conclude that outsiders do not have an effect on R&D investment intensity.

The simultaneous examination of top management and board composition effects demonstrates that both top management team and corporate governance have *additive* effects on the R&D investment intensity of the firm. Firms dedicate a higher proportion of their resources to research and development when (1) managers are not long-tenured in the firm, but have shared TMT-specific experience, (2) when board independence is strengthened by separating CEO and chair duties, and at higher levels of (3) institutional ownership. These management team and governance effects are critical in R&D-intensive industries where loss of competitive advantage can occur quickly if innovative capabilities are not maintained by continuous R&D investments (Kor and Mahoney, 2005; Mosakowski, 1993).

### Interaction effects of top management team and board outsider compositions

This paper also explores the interaction effects of top management team and board outsider compositions on R&D investment because the board's effectiveness in monitoring and advisory functions may be driven not only by its independence but

also by the nature of inter-group dynamics between the board and the top management team. While a healthy dialogue between the team and the board may contribute to the quality of strategic decisions, conflicts and power struggles between the team and the board produce an inappropriate decision-making environment. The first negative interaction effect on R&D investment indicates that the effect of board monitoring via outsiders weakens as managers' firm tenure lengthens. With legitimacy and power, long-tenured managers feel less pressure to incur risky R&D investments that may pay off in the long term, whereas outsider directors advocate higher R&D investments with expectations of superior returns. Faced with this conflict and the threat of high outside director presence, managers are likely to withhold information (Walsh and Seward, 1990) and use interpersonal tactics (Westphal, 1998) to persuade the board about merits of alternative expenditures and investments. Given their tenure-driven strong managerial power and entrenchment in the firm, these managers can successfully withstand board's governance efforts and achieve compromises in R&D investments.

In addition, the results indicate that the interaction of the level of managers' shared TMT experience and the ratio of outsider directors on the board creates a negative effect on R&D investment. As the shared team-specific experience of managers strengthens the team's collective confidence (Eisenhardt and Schoonhoven, 1990; Penrose, 1959), empowered managers pursue goals that serve their interests more easily. Various conflicts between a confident management team and an outsider-rich board may hurt the firm's R&D strategy as the distracted managers focus their efforts on maintaining their power at the upper ranks rather than maintaining and renewing firm's innovation capabilities.

The results are also consistent with the argument that as both levels of TMT functional heterogeneity and outsiders on board escalate, efforts of outsiders to persuade the top management team of higher R&D spending may result in organization of anti-R&D coalitions in the management team by non-R&D executives. By diverting funds away from R&D, non-R&D managers benefit collectively as more funds become available for their departments. As a result, functional heterogeneity in the management team reduces the effectiveness of outsider directors in promoting high R&D investment.

These interaction effects underscore for corporate governance research the importance of examining managerial attributes at the team level rather than merely at the CEO level. While past research often focused how CEO characteristics may impact the effectiveness of governance mechanisms (or adoption of desirable strategic choices), this study shows that managers' characteristics can *collectively* affect the CEO's ability to resist pressures from a powerful board. Even when surrounded by outsiders on the board, a CEO can be empowered with the support of other executives who are collectively confident and entrenched in the firm. CEOs can invite these executives to board meetings as 'experts' to build support for specific proposals and decisions. Also, studying managerial characteristics at the team level (e.g., functional heterogeneity) helps us understand the group dynamics within the board (e.g., emergence of conflicts and coalitions), which shapes the board's ability to control CEO's actions.

### Implications for corporate governance and strategic management

The results of this paper have certain implications for firms that operate in high-technology environments where the pace of innovation and imitation is high and continued investments in R&D are essential. This paper shows that management-specific contextual factors shape managers' willingness to undertake risky R&D investments. First, this paper demonstrates that, when long-tenured managers negatively affect firm's R&D investment intensity, an outsider-rich board may not be highly effective in securing R&D investments. In these situations, turnover in the top management team may be necessary to sustain a healthy stream of R&D inputs and innovative outputs.

Second, this study finds that while shared team-specific experience of managers in the top management team may be an asset in building the team's collective confidence and preparing managers for risky R&D investments, bringing together a team with long shared team-specific experience and an outsider-rich board may convert this asset into a liability. Excessive collective confidence in the team may create conflicts between managers and the board, resulting in negative spillover effects on R&D investment. The presence of a positive *direct* effect and a negative *interaction* effect suggests that medium levels of shared team-specific

experience may be ideal when a firm needs to sustain high levels of R&D. This combination not only provides the team with sufficient collective confidence to pursue risky R&D investments but also promotes a healthy dialogue between the management team and the board.

Third, a wide representation of many functional areas in the top management team makes it difficult to nurture and maintain a dominant R&D logic in the firm, especially when this management team has to work with an outsider-rich board. Firms may be better off carefully assessing the vitality of different business functions/departments for future success and allowing executive level representation only for functions that are highly important for the firm. This issue deserves close attention especially in entrepreneurial firms where there may be heightened competition for funds among different functions/departments.

At times, it may be difficult to make changes in the composition of the management team. For example, it may be hard to promote turnover in the management team because long-tenured managers' firm-specific knowledge could be uniquely valuable for the firm. In such cases, as an alternative approach, a firm may limit the number of outsiders on its board and rely more on other forms of governance such as separation of CEO and chair positions and stock ownership by managers. The presence of interaction effects of management team and board outsider compositions suggests that *promoting monitoring by outsider directors as a universally effective governance mechanism may not be appropriate*. In the presence of severe conflicts and unhealthy dialogue between the management team and the board, monitoring by outsider directors may have unintended negative effects on competitive advantage and shareholder wealth. The effectiveness of monitoring by outsiders depends on (1) the specific strategic choice and the conflicts this choice creates between managers and outsider directors, and (2) the management team and board compositions and how these compositional variables shape the dialogue and conflicts between the management team and the board. An important implication of this study is that firms and shareholders should be wary of situations where such conflicts occur and should either (1) initiate the necessary modifications in the management team composition or (2) partially substitute board monitoring with other corporate governance mechanisms. In substituting governance mechanisms,

however, it is important to consider the firm-specific factors (e.g., firm risk and strategy) and environmental factors that may influence the relative costs and benefits of particular mechanisms (Beatty and Zajac, 1994; Rediker and Seth, 1995; Zajac and Westphal, 1994).

### Limitations and future research

This study has a number of limitations. First, sampling is limited to a single industry, so findings may not generalize to other industries and competitive settings. Second, because most technology IPO firms are highly focused in a single or a small group of products, findings may also not generalize to diversified firms, where the degree of diversification and organization structure influence the R&D strategy (Hoskisson and Hitt, 1988; Hoskisson and Johnson, 1992). Third, the study relies on observable characteristics of the management team and board compositions, which are only proxy indicators of management power and of the potential conflicts that may occur within or between the management team and the board. Future studies can be enriched with different data-gathering techniques such as interviews and surveys that enable researchers to collect in-depth data about the nature and sources of conflicts at the upper ranks. Fourth, in this paper we controlled for executive's stock holdings, but not their stock options, which may also affect their predisposition toward accepting risk (Beatty and Zajac, 1994; Hoskisson *et al.*, 2002). Future research may benefit from a focus on how managers respond to different performance-based incentives when making high-risk decisions under uncertainty.

Future studies can further explore the specific conditions that may boost or diminish the effectiveness of corporate governance mechanisms in protecting firms' continued innovation efforts. For example, it may be interesting to examine whether top management team composition may moderate the relationship between managerial incentives and R&D investment strategy. Also, future research may explore how the nature of the dialogue and potential conflicts within or between the board and the management team may impact other important organizational outcomes such as strategic change. For example, Golden and Zajac (2001) show that board demographics and the dynamics within the board strongly affect strategic change.

### CONCLUSIONS

This paper develops and tests a theory of direct and interaction effects of top management team and board outsider composition on R&D investment intensity. The empirical examination offers three major conclusions. First, *both top management team composition and corporate governance have direct and additive effects on R&D investment intensity*. Long-tenured managers prefer not to commit a significant level of funds to R&D, while shared TMT-specific experience among managers prepares them for risky R&D investments under uncertainty. Corporate governance in such forms as separating CEO and chair positions and institutional investor stock ownership mitigates the potential agency problem of under-investment in R&D. Second, *monitoring by outsider directors does not constitute a universally effective governance mechanism with regard to a firm's R&D investment strategy*. Conflicts and an unhealthy dialogue between top management teams and boards could emerge due to specific compositional variables and lead to compromises in the level of R&D investment. Specifically, firms opt for lower levels of R&D investment when their outsider-rich board interacts with a team of managers who have high (1) firm tenure, (2) shared team-specific experience, or (3) functional heterogeneity. Third, when firms' competitiveness relies on continuous investments in R&D, it is crucial for firms to make necessary adjustments to promote a healthy dialogue between the management team and the board. In some cases, adjustments could be made more easily in the management team, and in other cases firms may consider making adjustments in the bundle of governance mechanisms and partially substituting board monitoring with other mechanisms. The solution to the puzzle of *why firms differ* in R&D investment intensity lies in how they achieve *balancing* the complex direct and interaction effects of top management team and board compositions on R&D investment intensity.

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