


RESEARCH ARTICLE

CEO labor market and R&D investment in high-technology firms: an empirical study on the disciplinary effect of CEO labor market

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(Received 1 February 2021; revised 15 October 2021; accepted 31 January 2022; first published online 11 March 2022)

Abstract

Previous corporate governance research has paid little attention to the role of chief executive officer (CEO) labor markets in controlling CEO behaviors because the CEO labor market has been considered inefficient. With the increasing mobility of top executives across firms, however, the potential of CEO labor markets to serve as an external disciplining force has been growing. In this study, we argue that CEOs will be more pressured to engage in desirable behaviors as the CEO labor market becomes more efficient. Using a longitudinal sample of S&P 1500 firms in high-technology industries in United States from 2011 to 2019, we found that CEOs tend to increase R&D investment as CEO labor market supply increases. We also found that the tendency is greater when external CEO succession is more frequent in the market. Our results demonstrate that CEO labor markets have the potential to function as an effective external governance mechanism.

Key words: Agency theory; CEO labor market; corporate governance; R&D investment

At corporations where ownership and control are separated from each other, agency problems occur because chief executive officers (CEOs) tend to make decisions that primarily serve their own interests at the expense of shareholders (Eisenhardt, 1989; Fama & Jensen, 1983). In order to minimize these agency problems, shareholders rely on internal governance mechanisms (e.g., incentive pay and board of directors) or external governance mechanisms (e.g., M&A markets and CEO labor markets) (Fama, 1980; Walsh & Seward, 1990).

While governance researchers have paid a great deal of attention to the role of internal governance mechanisms in reducing agency problems (Bloom & Milkovich, 1998; Chakraborty, Sheikh, & Subramanian, 2007; Larraza-Kintana, Wiseman, Gomez-Mejia, & Welbourne, 2007; Walsh & Seward, 1990), studies on the role of external governance mechanisms, particularly studies on the role of external CEO labor markets (henceforth, ‘CEO labor markets’) have been scant¹.

¹As for external governance mechanisms, governance researchers have paid substantial attention to the role of the market for corporate control (Bloom & Milkovich, 1998; Chakraborty, Sheikh, & Subramanian, 2007; Larraza-Kintana et al., 2007; Walsh & Seward, 1990). Grossman and Hart (1980) and Shleifer and Vishny (1997), for example, emphasized that, if the market for corporate control is efficient, managers bear greater employment risk because, when their firm fails to maximize its value, the firm will be acquired by another firm and the managers will be replaced. Thus, managers have a strong incentive to work hard to maximize the firm’s value for their job security if the takeover market is efficient. The market for corporate

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The lack of research on this topic is rather surprising in that agency theorists have long argued that the CEO labor market has a great potential to be a powerful governance mechanism. Fama (1980), for instance, argued that if the CEO labor market functions efficiently, CEOs' self-interest-seeking behaviors will be effectively disciplined because the efficient CEO labor market would increase the sensitivity of CEOs' employment to their performance.

One reason for the lack of research on the role of CEO labor market is that the CEO labor market has been assumed to be inefficient (Ang, Lauterbach, & Vu, 2003; Finkelstein, Hambrick, & Cannella, 2009; Khurana, 2002a, 2002b; Zhang, 2008). First, firms were posited to have difficulty in finding a suitable candidate from the CEO labor market because talented individuals are in short supply in the market (Howard, 2001). Second, firms seeking to hire an external CEO might run a great risk due to high risk and low legitimacy associated with infrequent external CEO successions in the market. These two CEO labor market conditions – short supply of external CEO candidates and infrequent external CEO succession in the market – were believed to make the market inefficient and discouraged firms from hiring external CEOs. As such, firms tended to select their new CEO primarily from within the firm as opposed to outside the firm (Ocasio, 1999).

The number of externally hired CEOs, however, has been increasing (Ocasio, 1999; Zhang & Rajagopalan, 2003). Murphy and Zbojnik (2004), for example, found that while outside hires accounted for 15 and 17% of all CEO replacements in the 1970s and the 1980s, respectively, in the 1990s, 26.5% of new CEO openings were filled through external hires. Similarly, Khurana (2002a, p. 242) argued that 'at least one-third of all CEO successions in large, publicly-held corporations are outsider successions.' With the increasing mobility of top executives across firms, the potential of CEO labor markets to be an effective external force has been also on the rise.

In this study, we attempt to examine whether the CEO labor market can effectively discipline CEO behaviors. Specifically, we investigate if CEOs in high-tech industries increase R&D investment when CEO labor market becomes more efficient. Governance researchers have long argued that the level of firm investment in R&D signifies the degree of managerial risk taking that is fundamental to the calculus of agency problem. CEOs who are assumed to be risk-averse have a strong incentive to reduce R&D investment, while shareholders desire their CEO to increase R&D investment (Baysinger & Hoskisson, 1989; Hoskisson, Hitt, & Hill, 1993; Miller & Bromiley, 1990; Sanders & Hambrick, 2007; Wiseman & Gomez-Mejia, 1998). The cost of sub-optimal investment in R&D will be highest in high-technology firms because, in the high-technology industries, reduction in R&D investment will damage the firm's long-term competitiveness. If CEOs at high-technology firms reduce R&D investment, firms will soon fall behind the competition and struggle to survive (Balkin, Markman, & Gomez-Mejia, 2000). CEOs in high-technology firms are thus required to maintain a high level of R&D investment for continuous innovation. When CEOs in high-technology firms avoid high-risk/high-return investments, shareholders should devise internal governance mechanisms capable of discouraging such behaviors (Balkin, Markman, & Gomez-Mejia, 2000; Makri, Lane, & Gomez-Mejia, 2006; Siegel & Hambrick, 2005). For instance, boards at high-technology firms design CEO pay in such a way so as to promote CEOs' innovative behaviors (Balkin, Markman, & Gomez-Mejia, 2000; Makri, Lane, & Gomez-Mejia, 2006).

To examine the role that the CEO labor market plays in firm's R&D investment in high-technology industries, we focus on two CEO labor market conditions. First, we investigate whether the supply condition in CEO labor markets affects CEO's decisions regarding investment in R&D in high-technology firms. Second, we examine whether the rate of external CEO succession in the

control in the United States, however, became less efficient during the 1980s as a result of the enactment of anti-takeover laws in the majority of states and as a result of deinstitutionalization process of conglomerate form. For example, Davis, Diekmann, and Tinsley (1994) found that during the 1980s, the average entropy of Fortune 500 firms dropped from 1.0 to 0.67. Similarly, Comment and Jarrell (1995) found that the proportion of US businesses in single-business segments increased from 36.2% in 1978 to 63.9% in 1989.

market affects CEO's R&D investment decision at individual firms. We further investigate whether there is a complementary effect between these two CEO labor market conditions.

Theory and hypotheses

R&D investment in high-tech industries

According to agency theory, CEOs are hired professional managers who are responsible for maximizing shareholder value; however, CEOs, unlike shareholders who can diversify their investment risk in securities markets cannot diversify their risks regarding their employment and income (Morck, Shleifer, & Vishny, 1989). Accordingly, CEOs are assumed to be risk-averse. In particular, prior studies argue that CEOs tend to avoid R&D investments because R&D investments entail high uncertainty and long-term horizons and, thus, high risk (Rosenberg, 1996). Moreover, although R&D investment requires substantial levels of continuous effort from CEOs, it only pays off in the long term (Makri, Lane, & Gomez-Mejia, 2006). For these reasons, governance researchers argue that opportunistic CEOs tend to invest less in R&D unless their behaviors are effectively controlled by governance mechanisms (Baysinger & Hoskisson, 1989; Fong, 2010; Hoskisson, Hitt, & Hill, 1993; Miller & Bromiley, 1990; Sanders & Hambrick, 2007).

Although reduction in R&D investment may constitute agency problems, however, not all firms would require their CEO to maintain R&D investment to the same degree. For example, CEOs at firms in high-tech industries are required to invest more in R&D activities than those in low-tech industries because intensive R&D investment for innovation is more essential to firms' competitiveness and survival in high-tech than in low-tech industries (Balkin, Markman, & Gomez-Mejia, 2000; Hill & Snell, 1988). A high-technology firm 'invests significantly in R&D, is heavily dependent on new product formulations and designs, and is focused on achieving research-based breakthroughs' (Siegel & Hambrick, 2005, p. 260). Thus, CEOs' opportunistic behavior to reduce R&D investment is more problematic in high-tech than in low-tech industries. To capture this concern, we limit our focus to firms in high-tech industries where reduction in R&D investment by opportunistic CEOs may harm the competitiveness of the firm and, thus, shareholder values.

CEO labor market as an external governance mechanism

According to Fama (1980), an efficient CEO labor market has the potential to be an important governance mechanism because CEOs become more vulnerable to the disciplining force of CEO labor markets as the markets become more efficient. In an efficient CEO labor market, CEOs' performance is continuously evaluated and the updated information on CEO performance would result in changes in their employment contract or pay contract. Thus, CEOs bear a greater risk regarding firm performance if they compete in a more efficient CEO labor market than in less efficient one. CEOs who make decisions that do not help to enhance firm performance are more likely to be replaced by external CEO candidates if CEO labor market functions efficiently.

Governance researchers, however, argued that CEO labor markets may not properly function as an effective governance mechanism because of the supply inelasticity of the market's talented individuals who are capable of running large firms (Crystal, 1991; Khurana, 2002b). In addition to the short supply of potential candidates for CEO positions, information about these potential candidates is not readily available for firms that plan to replace their CEO, a situation that makes firms reluctant to consider external CEO succession (Ang, Lauterbach, & Vu, 2003; Khurana, 2002a, 2002b).

Khurana (2002a, 2002b) conducted extensive research on the role played by executive search firms in CEO labor markets. He argued that the 'CEO labor market is not a market in the ordinary sense. It is not even like the market for other executive positions' (Khurana, 2002b, p. 27). He further claimed that the efficiency of the CEO labor market suffers from three unique features of the market – that is, the small numbers of buyers and sellers, high risk to participants, and concerns about legitimacy. First, there are relatively few buyers (i.e., firms seeking to hire a

new CEO) and sellers (i.e., potential CEO candidates) in CEO labor markets, and buyers and sellers both lack a sufficient range of information regarding the opportunities that exist in the market. As such, transactions (i.e., external CEO succession) are discouraged. Second, both buyers and sellers in CEO labor markets bear substantial risks in participating in market transactions. The hiring firms, facing information asymmetry, are likely to make poor CEO succession decision (i.e., adverse selection) that is followed by frequent dismissal of newly appointed CEOs (Zhang, 2008). Candidates also run a great risk in participating in the market because most external CEO candidates are already employed and thus do not want their employing firm to know that they have any intention to leave. During the search process, therefore, both buyers and sellers in CEO labor markets want to maintain extreme confidentiality, which makes it more difficult for the two parties to obtain necessary information and to actively participate in market transactions. Third, both buyers and sellers in CEO labor markets have concerns about the legitimacy of the market. In a market that lacks legitimacy, buyers and sellers hesitate to participate in the market, whereas buyers and sellers tend to openly engage in transactions in a legitimate market. In sum, Khurana (2002a, 2002b) suggested that a CEO labor market is inefficient because of (1) the short supply of external CEO candidates and (2) high risk and low legitimacy associated with infrequent external CEO successions.

We, however, argue that not all CEO labor markets will be equally inefficient. CEO labor market conditions will vary substantially across industries. Zhang and Rajagopalan (2003, p. 329) supports this view of CEO labor market by arguing that ‘supply and demand factors should be specific to a (CEO labor) market and hence, different managerial labor markets should reflect different supply and demand conditions.’ Similarly, managerial discretion literature argues that a CEO’s degree of discretion (i.e., latitude of action) will vary by industries and thus most CEO-related factors will also differ across industries (Finkelstein & Hambrick, 1990; Halebian & Finkelstein, 1993; Hambrick & Abrahamson, 1995; Hambrick & Finkelstein, 1987). In high-discretion industries, for example, CEOs can make greater impact on firm performance and therefore they receive a higher amount of compensation and higher incentive pay than CEOs in low-discretion industries. Although, because CEOs take greater responsibilities for firm performance in high-discretion industries, involuntary CEO turnover will be more frequent (i.e., higher employment risk for CEOs) and board of directors will make greater efforts to find the best CEO candidate, often from outside the firm (Hambrick & Finkelstein, 1987). These interindustry differences will make CEO labor markets heterogeneous rather than homogeneous. In a more attractive CEO labor market with high managerial discretion (Hambrick, 2005), there will be a larger pool of talented individuals who compete for CEO positions, increasing the efficiency of the market.

CEO labor market supply

According to Khurana (2002a, 2002b), CEO labor markets will become more efficient in exerting disciplining pressure on individual CEOs as the supply side of the market grows because firms will have a larger number of external CEO candidates in a well-supplied CEO labor market than in a short-supplied one.

Firms with a large pool of external CEO candidates do not need to retain their CEO when the CEO’s performance falls short of the firm’s expectations because these firms can find many alternative candidates available in the CEO labor market. Increases in the CEO labor market supply will, therefore, strengthen the likelihood that firms will make timely decisions regarding CEO replacement (Fredrickson, Hambrick, & Baumrin, 1988; Ungson & Steers, 1984). Extant studies find evidence that the size of the external CEO candidate pool is positively associated with the likelihood of external CEO succession (Zhang & Rajagopalan, 2003).

As such, if a CEO in a high-technology firm does not sufficiently invest in R&D activities the CEO is more likely to be replaced when the firm has a large supply of external CEO candidates than when it has a small supply of external CEO candidates. In the former context, firms can more easily find an external CEO candidate who is willing to take as much risk as shareholders

desire than in the latter context (Pfeffer & Moore, 1980). In sum, the larger the potential pool of the external CEO candidates, the stronger the disciplining force of the CEO labor market will be. In this circumstance, CEOs will perceive their position as less secure and thus will be disciplined to increase R&D investment. Thus, we hypothesize as follows:

Hypothesis 1: The level of CEO labor market supply will be positively associated with a firm's investments in R&D.

External CEO succession rate

Khurana (2002a, 2002b) also suggested that CEO labor markets will become more efficient as more firms hire their new CEO from the CEO labor market. If there is a strong market-level tendency to consider internal CEO candidates over external ones, high risk and low legitimacy problems will persist. Hence, individual firms will hesitate to hire their new CEO from the external CEO labor market. As a result, the CEO labor market is not likely to function as an effective governance mechanism. In contrast, if the number of firms in the market that hire external CEO increases, it will help reduce the high risk and low legitimacy problems associated with external CEO succession.

First, if more firms in the market hire their CEO from the external CEO labor markets, external CEO succession will become more legitimated in the market and thus firms will face less risk in selecting an external CEO. Ocasio (1999) argued that boards' CEO succession decisions follow institutionalized rules. According to Ocasio (1999, p. 391), in modern corporations, internal CEO succession was a 'formalized procedure for executive succession.' Firms, therefore, had shown a strong tendency to limit their attention to the internal candidates for their CEO position. In such circumstances where internal CEO succession is more legitimated, firms would run a risk when tapping into an external CEO labor market. However, as the number of firms that hire external CEO increases, external CEO succession will gain more legitimacy and firms will, therefore, exhibit an increasing tendency to hire an external CEO because they will face lower risk by adopting legitimized practices (Ahmadjian & Robinson, 2001; DiMaggio & Powell, 1983; Ocasio, 1999). Williamson and Cable (2003) found evidence that firms' executive selection decisions are affected by inter-organizational imitation. They found that when hiring top executives, firms imitate the hiring patterns which are adopted by a large number of other firms.

Second, increasing external CEO successions will reduce information problems that firms should experience in searching for external CEO candidates. In a CEO labor market where external succession is more frequent, information agents such as executive search firms and board networks will be more active in collecting and disseminating information on executive talents (Granovetter, 1985; Khurana, 2002b). The increasing availability of information will enable firms to make better-informed and timely decisions regarding CEO replacement, reducing the possibility of adverse selection, an inherent risk in external CEO succession. In such markets, firms will be able to replace their poorly performing CEO with an external CEO candidate with confidence.

Taken together, if the rate of external CEO succession increases in the market, this broader market-level tendency will increase the likelihood that individual firms will replace their CEO who makes inappropriate decisions such as a decrease in R&D investment in high-tech industries with external CEO candidate. Thus, we hypothesize as follows:

Hypothesis 2: The rate of external CEO succession in the CEO labor market will be positively associated with a firm's investment in R&D.

Interaction between the two CEO labor market conditions

Besides the main effects of the two CEO labor market conditions, we argue that there will be an interactive effect between the two conditions. Specifically, we argue that the disciplining force of well-supplied CEO labor markets will further increase as the rate of external CEO succession in the

market increases. In such a circumstance, firms will have a large pool of external CEO candidates and also bear a low risk in actually hiring external CEO. CEOs in such markets will therefore perceive higher job insecurity and greater pressure to take investment risks by increasing R&D investment. In contrast, even when a firm has a large number of external CEO candidates, if there is a strong tendency among other firms in the market to promote internal CEO candidates rather than hire external ones, the firm cannot readily select an external CEO because it is not legitimated and thus not well accepted in the market. In this situation, the large supply of external CEO candidates will have little impact on CEOs at individual firms. Therefore, we hypothesize as follows.

Hypothesis 3: The positive relationship between the level of CEO labor market supply and a firm's investment in R&D will be stronger when the rate of external CEO succession in the CEO labor market is high than when it is low.

Method

Data and sample

We tested our hypotheses using a sample of high-technology manufacturing firms from the S&P 1500 firms in United States from 2011 to 2019. Following prior studies (Organisation for Economic Co-operation & Development (OECD), 2011; Quintana-Garcia and Elvira, 2017), we identified high-tech industries using OECD definition of high-tech industries: (1) aircraft and spacecraft, (2) pharmaceuticals, (3) office, accounting, and computer machinery, (4) radio, TV, and communications equipment, and (5) medical, precision, and optical instruments. OECD classification is appropriate for our study because it focuses on firms' input-side activities (i.e., R&D investment) as a major criterion to classify high-tech industries. Since OECD definition of high-tech industries is based on ISIC (International Standard Industrial Classification) codes, we matched the ISIC codes with four-digit SIC codes in Compustat using the concordance table provided by the United States Office of Management Budget, Statistics Canada, and Statistical Office of the European Communities. We then identified 2,000 firm-year observations that fall within the high-tech industry category. After removing firms that did not provide proper information, our final sample consisted of 1,534 firm-year observations.

We collected data on the CEO-related variables from ExecuComp service and each company's annual reports and proxy statements, which the companies report to the Securities and Exchange Commission. If neither an annual report nor a proxy statement provided appropriate information on CEO, we used Bloomberg' CEO profile information. Financial data were drawn from Compustat. Board structure data were taken from governance databases compiled by the Institutional Shareholder Services (ISS, formerly Risk Metrics).

Dependent variable

R&D investment

To test our hypotheses regarding CEO labor market and R&D investment, we measured *R&D investment* as the natural logarithm of R&D expenses. In prior corporate governance research, R&D investment has been widely used as a proxy for CEOs' risk-taking behaviors (Baysinger & Hoskisson, 1989; Bushee, 1998; Hoskisson, Hitt, & Hill, 1993; Lee & O'Neill, 1994; Miller & Bromiley, 1990). In an additional analysis not reported here, we used R&D intensity (i.e., R&D expenditures divided by total sales) to measure R&D investment. The results were identical.

Independent variables

CEO labor market supply

Following prior studies (e.g., Zhang & Rajagopalan, 2003), we argue that potential pool of external CEO candidates will be limited to top executives at other firms in the same industry because

industries substantially differ from one another in terms of technology and environment, thereby increasing the value of industry-specific knowledge and experiences that cannot be easily transferred between firms in different industries (Castanias & Helfat, 1991). Thus, intra-industry succession is less risky for both CEOs and firms than inter-industry succession, and top executives in different industries are less likely to be perceived as potential candidates (Harris & Helfat, 1997; Parrino, 1997). McCann and Hinkin (1984) analyzed executive transitions and found that most executive replacements indeed come from similar firms within the same industries as the hiring firms. Studying top executives in different industries, Palia (2000) also found significant pay differentials and low industry-to-industry migration, ascribing these findings to differential returns on human capital between industries.

Specifically, high-technology firms value industry-specific skills and experiences related to technology. Hence, CEOs in high-tech industries are required to have these industry-specific managerial skills and experiences to effectively maintain firms' innovation efforts, which makes intra-industry CEO succession more preferable than inter-industry CEO succession. Prior research found that CEOs in high-technology firms tend to have different demographic characteristics from those in low-technology firms (Barker & Mueller, 2002; Hambrick & D'Aveni, 1992; Peterson *et al.*, 2009), a finding that further suggests that high-technology firms will preferably seek CEO candidates from within the industry, not from outside the industry.

As such, we classified firms as belonging to the same CEO labor market if they share the same two-digit SIC code. Prior research found that two-digit SIC grouping better captures similarities and dissimilarities among firms than three- or four-digit SIC groupings (Clarke, 1989). For this reason, the two-digit SIC industry definition has been commonly used in prior studies that examine the effects of industry categorization on CEO compensation (e.g., Gibbons & Murphy, 1990; Porac, Wade, & Pollock, 1999) and CEO succession (e.g., Parrino, 1997). For example, Parrino (1997) identified 977 CEO succession events at US firms between 1969 and 1989. In total, 147 new CEOs were outsiders and only 26 new CEOs were from outside the same two-digit industry who had no apparent firm or industry experiences (at the two-digit SIC level). His result suggests that firms, when considering external CEO succession, primarily search for external CEO candidates from within the same two-digit SIC industry.

Prior studies suggest that the number of firms is a good proxy for the size of external CEO candidate pool (e.g., Fredrickson, Hambrick, & Baumrin, 1988; Zhang & Rajagopalan, 2003). In addition, Zhang and Rajagopalan (2003) argued that the actual pool of external CEO candidates is limited to top executives at similarly sized or larger firms in the industry (Zhang & Rajagopalan, 2003). Thus, following prior studies, we measured *CEO labor market supply* by counting the total number of firms whose sizes are similar or larger than the focal firm. The lowest limit on the size of the potential supplier of external CEO candidates for the focal firm was defined by the half of the focal firm's total sales. To account for skewness, we took the natural logarithm of the value.

External CEO succession rate

To examine whether a broader market-level tendency to hire external CEOs affects R&D investment at individual firms, we measured this tendency (*external CEO succession rate*) by using the proportion of firms in the same CEO labor market that have hired an external CEO in the past 5 years. When there had been no CEO succession event in the past 5 years, we examined the origin of the current CEO. CEOs were identified as external CEOs if their firm tenure prior to becoming a CEO was less than 2 years (Ocasio, 1999; Zhang & Rajagopalan, 2003).

Control variables

Internal governance mechanisms

To properly examine the disciplining effect of the CEO labor market on individual CEOs, we need to control the effect of other governance mechanisms. Governance researchers have

extensively examined the effectiveness of various internal governance mechanisms in reducing agency problems. Prior studies have specified CEO incentive pay and board monitoring as key elements of internal governance mechanisms (Beatty & Zajac, 1994; Rutherford, Buchholtz, & Brown, 2007; Tosi, Katz, & Gomez-Mejia, 1997; Walsh & Seward, 1990).

According to agency theory, CEO incentive pay is a primary device that can mitigate agency problems between CEOs and shareholders (Barkema & Gomez-Mejia, 1998; Tosi, Werner, Katz, & Gomez-Mejia, 2000). CEO incentive pay helps align CEO interests with shareholder interests by tightly linking CEO income to shareholder wealth (Coughlan & Schmidt, 1985; Hoskisson, Hitt, Turk, & Tyler, 1989; Kerr & Bettis, 1987; Murphy, 1985; Walking & Long, 1984). Given that CEO incentive pay has the potential to induce desirable behaviors from CEOs, it has been argued that CEOs will increase R&D investment when a substantial portion of their pay is linked to long-term firm performance (Coles, Daniel, & Naveen, 2006). Thus, we measured *CEO incentive pay* by using the proportion of CEO long-term pay to CEO total pay. CEO long-term pay includes stock options, restricted stocks, and other long-term incentive plans (Carpenter, 2000).

Agency theory also posits that a board of directors is a central component of firms' overall efforts to control CEOs' self-serving behaviors (Fama & Jensen, 1983). Prior studies identified board independence as a key determinant of board vigilance and found evidence that a CEO's attempt to reduce R&D investment is less successful as the corresponding board becomes more independent from the CEO (Finkelstein, Hambrick, & Cannella, 2009). Board independence generally decreases as CEO's relative power over the board increases. Thus, following prior studies (Westphal & Zajac, 2001), we measured CEO-board relative power by using four measures: CEO duality, the proportion of directors appointed after the CEO, CEO's tenure relative to the average tenure of board members, and director ownership. We combined these four measures into a single index of *CEO-board relative power* using principal components analysis. In addition, we controlled *board size* and *outsider directors*, measured as the number of total directors and the number of outside directors on the board, respectively.

Other control variables

Our primary goal is to examine the role of external CEO labor market; however, 'reliance on internal labor markets for managerial succession is a central institutional characteristic of managerial capitalism in U.S. industrial corporations' (Ocasio, 1999, p. 390). Thus, an actively functioning internal CEO labor market will decrease the disciplining role of an external CEO labor market. To properly examine the role of external CEO labor market, it seems necessary to sort out the effects of internal CEO labor market on CEO behaviors. Because the most common form of formal internal CEO labor market is the designation of an heir apparent, we controlled for the effects of internal CEO labor market by using the *heir apparent* variable, which was coded '1' if there was any officer who held the title of president or chief operating officer and '0' otherwise (Vancil, 1987).

In addition, based on prior studies on R&D investment, we controlled for the following variables that might affect firm R&D investment: prior R&D investment, industry R&D investment, firm size, prior firm performance, liquidity, and CEO characteristics. Prior studies reported that prior R&D investment has a positive impact on current R&D investment (Hansen & Hill, 1991; Kim, Kim, & Lee, 2008). Thus, we included *prior R&D investment* by using a 1-year lagged dependent variable. Industry R&D investment also affects R&D investment (Baysinger, Kosnik, & Turk, 1991; Zona, 2016). Specifically, in high-technology industries where firms intensively compete on the basis of new technologies that require high-level of continuous R&D investment, how much other firms invest in R&D will affect the level of R&D investment at focal firm. Thus, we included *industry R&D investment*, measured as the average of a 1-year lagged R&D investment of all the other firms in the same industry. Previous studies found that firm size has a substantial effect on R&D investment (Baysinger & Hoskisson, 1989; Baysinger, Kosnik, & Turk, 1991; Hill & Snell, 1988). Therefore, we included the natural logarithm of *firm sales* to control the effect of firm size. Prior firm performance also affects R&D investment either positively

(Hundley, Jacobson, & Park, 1996) or negatively (Hitt, Hoskisson, Ireland, & Harrison, 1991). More importantly, CEO succession research found a robust relationship between poor firm performance and CEO replacement and also identified poor firm performance as a major determinant of external CEO succession (Finkelstein, Hambrick, & Cannella, 2009). Thus, we controlled for the effect of *prior firm performance* using a firm's return on assets lagged by 1 year. Liquidity affects the amount of internal capital that firms can invest in R&D activities. Hence, we measured liquidity by using a firm's *current ratio*, which is the ratio of a firm's current assets to the firm's current liabilities (Baysinger & Hoskisson, 1989). Several CEO characteristics that might affect R&D investment were also considered (Barker & Mueller, 2002; Chaganti & Sambharya, 1987; Thomas, Litschert, & Ramaswamy, 1991). For example, *CEO ownership* (%) was controlled. Agency theory suggests that substantial CEO ownership helps align CEO interests with shareholder interests and, therefore, predicts a positive relationship between CEO stock ownership and R&D investment (Fama & Jensen, 1983; Jensen & Meckling, 1976). However, behavioral agency theory suggests that CEO stock ownership will make the CEO more risk-averse and, therefore, predicts a negative relationship between CEO stock ownership and R&D investment (Sanders, 2001). It has been suggested that long-tenured CEOs might pursue less innovation (Barker & Mueller, 2002). Thus, *CEO tenure* was controlled as the number of years that the person has been a CEO. Research on CEO personality, particularly on CEO hubris, has shown a positive association between CEO hubris or CEO overconfidence and firm risk taking (Li & Tang, 2010). Thus, we measured CEO hubris by using *CEO-TMT (top management team) relative pay* as the ratio of CEO total pay relative to the total pay of second-highest-paid top executive. This measure has commonly been used as a measure of CEO hubris or CEO self-importance in prior studies (Hambrick & D'Aveni, 1992; Hayward & Hambrick, 1997; Henderson & Fredrickson, 2001). Because this variable was skewed we used the log-transformed variable in our analysis. When we used the ratio of CEO total pay relative to the average total pay of four other highest-paid top executives, the results were identical. Finally, we included dummy codes for each year.

Analysis

To test our hypotheses, we used generalized estimating equations (GEEs), which can analyze both within- and between-firm variations (Wade, Porac, Pollock, & Graffin, 2006). To test our hypotheses, we reported a control model and then a fully specified model(s) that include all control and theoretical variables. To address potential multicollinearity between main effects and interaction term, we centered the variables prior to calculating the interaction (Jaccard, Turrisi, & Wan, 1990).

Results

Table 1 presents descriptive statistics for the variables used in our analyses. The average of the number of similarly sized or larger firms was 67.48 and the variation was 49.06². A total of 16.67% of sample firms had hired an external CEO in the past 5 years or their current CEO was an outsider CEO. The average firm in the sample invested 743.15 million dollars, or 13.64% of their total revenue, which is far above the 5% benchmark for R&D intensity that prior studies have used to identify high-technology firms (Balkin, Markman, & Gomez-Mejia,

²The value of the CEO labor market supply condition did not change much over time during our research period. Analysis of variance test results show that most variation in the variable is cross-sectional (i.e., across different industries and across different firms within the same industry) rather than longitudinal. Although CEO labor market conditions remain stable over time, the cross-sectional variation in CEO labor market condition is large enough to explain why some high-technology firms invest more in R&D activities than other firms. In addition, our findings suggest that, if CEO labor market supply conditions change as a result of the entry of new firms or restructuring efforts at incumbent firms, although not observed in our sample firms, the market's disciplining effect on individual firms will change as well.

Table 1. Descriptive statistics for variables

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 R&D investment	4.82	2.00															
2 Prior R&D investment	4.74	1.99	.99														
3 Industry R&D investment _(t-1)	2.63	.41	.28	.28													
4 Firm sales	7.50	1.64	.72	.73	.02												
5 Prior firm performance	.06	.10	.07	.05	-.06	.12											
6 Current ratio	3.69	3.93	-.25	-.26	.02	-.40	.20										
7 CEO ownership	.02	.05	-.19	-.19	.03	-.27	.00	.11									
8 CEO tenure	8.89	7.31	-.11	-.12	.03	-.21	.08	.10	.49								
9 CEO-TMT relative pay	1.12	.36	.00	.00	-.02	.02	-.01	-.09	-.09	-.01							
10 Heir apparent	.51	.50	.07	.07	-.04	.17	-.05	-.10	.04	.06	-.14						
11 CEO incentive pay	.54	.25	.17	.17	.02	.10	-.03	-.06	-.19	-.16	.44	-.04					
12 CEO-board relative power	.00	1.00	-.05	-.06	.02	-.11	.05	.06	.34	.79	.06	.06	-.14				
13 Board size	2.27	.20	.47	.48	-.03	.62	-.04	-.29	-.19	-.24	-.03	.14	.06	-.20			
14 Outside directors	2.07	.25	.46	.47	-.03	.61	-.02	-.25	-.35	-.28	.04	.09	.11	-.19	.90		
15 CEO labor market supply	3.87	.98	-.52	-.54	.12	-.87	-.08	.33	.23	.22	.04	-.16	-.03	.13	-.56	-.55	
16 External CEO succession rate	.17	.07	.08	.08	.25	.05	-.03	.01	-.03	-.07	-.03	.01	.06	-.01	.04	.06	-.18

Note: N=1,534; $p < .05$ for correlations in bold; two-tailed test.

2000). In addition, 54.33% of CEO pay was tied to firms' long-term performance, and the average CEO tenure was 8.89 years.

Table 2 presents our GEE models that we used to examine our hypotheses regarding the role of the CEO labor market in R&D investment. Model 1 reports results for control variables.

In model 2, we tested hypothesis 1, wherein we predicted that CEOs in a well-supplied CEO labor market are more likely to increase R&D investment. The coefficient for the CEO labor market supply variable was significant in the expected direction ($\beta = .027, p < .05$). This result provides support for hypothesis 1. Our results indicate that CEOs will be more disciplined to increase R&D investment when their firms are operating in a well-supplied CEO labor market than in a short-supplied CEO labor market.

In model 3, we tested hypothesis 2, which predicts that the rate of external CEO succession in the market will increase R&D investment at individual firms. Hypothesis 2 was not supported. It can be argued that a CEO might feel rather pressured to increase R&D investment in a CEO labor market where the external CEO succession rate is low because incumbent CEOs will have difficulty in finding alternative job opportunities in such a market. This argument points to a U-shaped relationship between the two variables; however, in an additional analysis, we found no evidence to support this argument.

In model 5, we examined whether the effect of a well-supplied CEO labor market on R&D investment becomes stronger as the rate of external CEO succession in the market increases. Hypothesis 3 was supported. Results show that CEOs in a well-supplied CEO labor market will tend to further increase R&D investment when external CEO succession is more frequent in the market and thus legitimated. In a CEO labor market where external CEO succession is more frequent (i.e., one standard deviation greater than the mean), if CEO labor market supply increases by 10%, CEOs are predicted to increase R&D investment by .55% ($p < .001$), which is approximately 4.12 million dollar increase at a firm with average R&D investment (i.e., 743.15 million dollars). In contrast, if external CEO succession is less frequent (i.e., one standard deviation less than the mean), the predicted increase in R&D investment for 10% increase in CEO labor market supply was only .27%, which is approximately 1.99 million dollar increase at a firm with average R&D investment. Furthermore, this relationship was not statistically significant at the 5% significance level ($p < .057$). These results indicate that the disciplining effect of CEO labor market supply is largely contingent on the rate of external CEO succession in the market.

Figure 1 plots the moderating effect of external CEO succession rate in the CEO labor market on the relationship between CEO labor market supply and R&D investment.

Discussion

In this study, we examined whether CEO labor markets have the potential to be an effective external governance mechanism in controlling CEO's self-serving behaviors. Using longitudinal panel data from S&P high-technology firms, we found that CEOs in high-tech industries are more disciplined to increase investment in R&D when their firm has a larger pool of potential external CEO candidates; however, market-level tendency to hire external CEOs did not affect R&D investment at individual firms. We also found that the interaction effect between *CEO labor market supply* and *external CEO succession rate* variables was statistically significant and positive. Our results indicate that the disciplining effect of CEO labor market supply is contingent on the external CEO succession rate in the market.

This study makes important contributions to the corporate governance research. First, we found evidence that CEO labor market has the potential to discipline CEO behaviors. If a firm operates in an efficient CEO labor market, even without the provision of costly internal governance mechanisms, the firm will likely achieve desirable behaviors from its CEO (Fama, 1980). In this regard, our study empirically demonstrates the validity of Fama's (1980) argument that 'market forces alone will frequently remove moral hazard problems because managers will be

Table 2. Results of GEE estimation of the effects of CEO labor markets on R&D investment

	(1)	(2)	(3)	(4)	(5)
Constant	.19** (.07)	.10 (.08)	.20** (.07)	.09 (.08)	.09 (.08)
Prior R&D investment	1.01*** (.01)	1.00*** (.01)	1.01*** (.01)	1.00*** (.01)	1.00*** (.01)
Industry R&D investment _(t-1)	-.01 (.02)	-.02 (.02)	-.01 (.02)	-.03 (.02)	-.03 (.02)
Firm sales	-.02** (.01)	-.00 (.01)	-.02** (.01)	.00 (.01)	.01 (.01)
Prior firm performance	.39*** (.06)	.38*** (.06)	.39*** (.06)	.38*** (.06)	.38*** (.06)
Current ratio	-.00 (.00)	-.00 (.00)	-.00 (.00)	-.00 (.00)	-.00 (.00)
CEO ownership	-.32* (.15)	-.30* (.16)	-.33* (.16)	-.31* (.15)	-.31* (.15)
CEO tenure	.00 (.00)	.00 (.00)	.00* (.00)	.00 (.00)	.00* (.00)
CEO-TMT relative pay	-.03 (.02)	-.04* (.02)	-.03 (.02)	-.04 (.02)	-.03 (.02)
Heir apparent	-.00 (.01)	-.00 (.01)	-.00 (.01)	-.01 (.01)	-.00 (.01)
CEO incentive pay	.07* (.03)	.07* (.03)	.07* (.03)	.06* (.03)	.06* (.03)
CEO-board relative power	-.00 (.01)	-.00 (.01)	-.00 (.01)	-.00 (.01)	-.01 (.01)
Board size	.01 (.01)	.01 (.01)	.02 (.01)	.02 (.01)	.01 (.01)
Outside directors	-.02 (.01)	-.01 (.01)	-.02* (.01)	-.02 (.01)	-.01 (.01)
CEO labor market supply		.03* (.01)		.04** (.01)	.04** (.01)
External CEO succession rate			.14 (.09)	.22* (.09)	.43*** (.12)
CEO labor market supply × External CEO succession rate					.21** (.07)
Wald chi-squared	102,300.51***	101,901.57***	101,978.19***	102,635.11***	103,236.69***

Note: N = 1,534; standard errors are in parentheses.
*p < .05, **p < .01, ***p < .001.



Figure 1. Moderation of external CEO succession rate between CEO labor market supply and R&D investment.

concerned about their reputations in the labour market. Thus, there will be no need to resolve incentive problems using explicit contracts, since markets already provide efficient implicit incentive contracts' (Holmstrom, 1999, p. 170).

In practice, however, CEO labor markets can hardly be perfectly efficient. CEO labor market alone, therefore, cannot fully eliminate agency problems at individual firms and, therefore, internal governance mechanisms should play an important role in controlling CEOs' self-interest-seeking behaviors. Nonetheless, because firms in more efficient CEO labor markets do not need to heavily rely on internal governance mechanisms, our study suggests that the potential contribution of internal governance mechanisms in reducing agency problems will be contingent upon the efficiency level of the CEO labor market to which firms belong.

Our study thus suggests that governance researchers should first consider how efficient a CEO labor market is when examining the effectiveness of internal governance mechanisms at individual firms. An efficient CEO labor market may substitute for internal governance mechanisms to some degree, reducing the marginal contribution of additional internal corporate governance mechanisms. According to the substitution argument, firms generally rely on multiple governance mechanisms to control CEO behaviors, and these multiple governance mechanisms substitute for each other. If any governance mechanism is already in place, additional mechanisms are less necessary because there are cost–benefit tradeoffs between governance mechanisms. The substitution argument thus maintains that the effectiveness of corporate governance mechanisms at individual firms should not be assessed by examining any single mechanism and that more meaningful results can be obtained when the interrelatedness among governance mechanisms is taken into account (Hill & Snell, 1988; Rediker & Seth, 1995; Zajac & Westphal, 1994).

In this regard, our study provides one feasible explanation to the longstanding corporate governance problem around CEO pay. The lack of sensitivity of CEO pay to firm performance has been regarded as a manifestation of corporate governance failure and thus has been at the center of corporate governance research (Bebchuk & Fried, 2003, 2006). Our study, however, suggests that even effective boards may yield low sensitivity of CEO pay to firm performance when firms are operating in an efficient CEO labor market. In such market, boards can induce desirable CEO behaviors with less use of CEO incentive pay.

Second, our study contributes to the research stream that investigates the role of external governance contexts in firm-level outcomes. Prior governance research on this topic has narrowly focused on the role of inter-organizational networks formed by interlocking directors in

spreading governance mechanisms (Davis, 1991; Haunschild, 1993, 1994). With a few exceptions (e.g., Ocasio, 1999; Zhang & Rajagopalan, 2003), almost no research has examined the role of CEO labor markets in firm-level governance outcomes. With the increasing mobility of top executives across firms, however, it seems necessary to pay more attention to the role of CEO labor markets in corporate governance research. We hope our study triggers interests among governance researchers in the role of external contexts wherein individual firms are embedded, specifically CEO labor markets (Granovetter, 1985).

Our findings have important implications for boards of directors, shareholders, and policy-makers. First, our study suggests that it is generally desirable to design policies that can make the CEO labor market more efficient. This is because a policy that can encourage external CEO succession or eliminate barriers to external CEO succession will help reduce agency problems at individual firms. For example, a regulation that requires firms to report detailed information about their top executives to shareholders or a policy that facilitates the activities of executive search firms will help promote external CEO succession by reducing information problems in the CEO labor market and thereby will help reduce agency problems at individual firms. Our study also indicates that to design cost-effective internal incentive and monitoring mechanisms at individual firms, boards and shareholders need to pay close attention to the conditions of the CEO labor market that surrounds the firm because CEO labor market efficiency determines the monitoring potential of costly internal governance mechanisms.

Second, recognizing the positive potential of efficient CEO labor markets in protecting the wealth of shareholders at firms in the market, our study suggests that boards need to stimulate the market development by more actively hiring external CEO. One of the most robust findings in CEO succession literature is that firms tend to hire external CEO mostly when poor performance demands and justifies the hiring of external CEO (Finkelstein, Hambrick, & Cannella, 2009). Our study suggests that even when external CEO succession is yet legitimated in the market, boards need not to be reluctant to hire external CEO, because it will enable boards to select the best CEO from larger pool of qualified candidates and also help the boards to effectively control CEO behaviors by imposing a greater employment risk on the CEO. In addition, since firms tend to repeat their past experiences with insider succession or outsider succession (Ocasio, 1999) and firms imitate other firms' executive succession decision patterns (Williamson & Cable, 2003), small number of early external CEO succession cases will soon expedite the legitimation process in the market, reducing risks associated with external succession. It is also important to note that even without actually hiring external CEO, boards can heighten the employment risk for their CEO by paying a keen attention to external CEO candidates. By exposing firms to the external CEO labor market, boards should maintain the adequate level of employment risk as well as pay risks for their CEO, to more effectively and efficiently control CEO behaviors (Holmstrom, 1979). Therefore, it is important for boards to have an ongoing CEO succession plan that includes a short list of both internal and external CEO candidates.

Limitations and directions for future research

This research has several limitations. First, although we argued that CEOs in an efficient CEO labor market face greater employment risk, we did not directly measure how much employment risk CEOs actually perceive from the conditions of the market. CEOs in the same CEO labor market may perceive different degrees of employment risk, depending on individual and organizational characteristics such as personality, CEO power, and firm performance. Although we endeavored to control some of these factors, future research that collects data from extensive surveys or qualitative studies such as interviews will help remedy these measurement problems. Second, although we assumed that shareholders would prefer more investment in R&D, research has found that some investors are short-term oriented and therefore prefer their CEO to reduce R&D investment (Bushee, 1998). Although we tested our theory using data from high-technology

firms where R&D investment is essential, we were not able to consider shareholders' heterogeneous investment horizon in our empirical model.

Next, we defined CEO labor markets by industry categorization; however, actual CEO labor markets can be more narrowly or broadly formed. It is also highly likely that a firm hires its new CEO from outside the industry. In addition, we limited our sample to publicly traded firms. Although it can be risky, and thus less common, for listed firms to hire new CEO from private firms because of the lack of reliable performance data, it is still possible that publicly-traded firms hire their new CEO from private firms, or *vice versa*. Further research on the boundaries of CEO labor markets is required.

We found evidence that CEO labor markets have the potential to be an effective external corporate governance mechanism; however, more research on the role of CEO labor market is needed. A fruitful avenue for future research would be to further examine the relationship between CEO labor market conditions and other governance mechanisms. Prior studies on the joint effects of multiple governance mechanisms have not examined the joint effects between external and internal governance mechanisms. Also, it seems necessary to examine whether other forms of agency problems are also reduced in more efficient CEO labor markets. For example, it would be interesting to examine whether CEOs pursue unprofitable growth strategy less in CEO labor markets that are more efficient than in those that are less efficient. Finally, it would also be interesting to examine whether CEO pay is more tightly linked to firm performance or less tightly linked to firm performance in an efficient CEO labor market. Our study suggests that incentive pay scheme is less necessary for CEOs when the CEO labor market is efficient because of the disciplining power of the CEO labor market. In contrast, it can be also argued that CEO pay will be more tightly linked to firm performance in a more efficient CEO labor market because boards can better evaluate their CEO's performance. Future study on this topic will uncover the relationship.

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Cite this article: Seo J, Lee G, Park C (2023). CEO labor market and R&D investment in high-technology firms: an empirical study on the disciplinary effect of CEO labor market. *Journal of Management & Organization* 29, 30–47. <https://doi.org/10.1017/jmo.2022.5>