

FIRM-SPECIFIC KNOWLEDGE ASSETS AND EMPLOYMENT ARRANGEMENTS: EVIDENCE FROM CEO COMPENSATION DESIGN AND CEO DISMISSAL

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Research summary: We argue that firms with greater specificity in knowledge structure need to both encourage their CEOs to stay so that they make investments with a long-term perspective, and provide job securities to the CEOs so that they are less concerned about the risk of being dismissed. Accordingly, we found empirical evidence that specificity in firm knowledge assets is positively associated with the use of restricted stocks in CEO compensation design (indicating the effort of CEO retention) and negatively associated with CEO dismissal (indicating the job securities the firm committed to CEOs). Furthermore, firm diversification was found to mitigate the effect of firm-specific knowledge on both CEO compensation design and CEO dismissal, as CEOs are more removed from the deployment of knowledge resources in diversified firms.

Managerial summary: A firm's knowledge structure, that is, the extent to which its knowledge assets are firm-specific versus general, has implications for both CEO compensation design and CEO dismissal. In particular, we find that a firm with a high level of firm-specific knowledge has the incentive to retain its CEO through the use of restricted stocks in CEO compensation. Such a firm is also likely to provide job security for its CEO, leading to a lower likelihood of CEO dismissal. These arguments, however, are less likely to hold in diversified corporations as CEOs in such corporations are more removed from the deployment of knowledge assets. A key managerial implication is that CEO compensation and job security design should be made according to the nature of firm knowledge assets. Copyright © 2016 John Wiley & Sons, Ltd.

INTRODUCTION

According to the resource-based theory, a firm's resources, especially its knowledge resources, are fundamental determinants of the firm's economic performance (Barney, 1991; Peteraf, 1993; Wernerfelt, 1984). A firm's knowledge resources can

be broadly classified into firm-specific knowledge and general knowledge (Becker, 1975). Compared to general knowledge, firm-specific knowledge is often tailor-made for firm-specific situations, which makes it very difficult to be imitated and substituted by rivals (Helfat, 1994; Pennings, Lee, and Van, 1998). Moreover, as rents generated from firm-specific knowledge is likely to be shared between the firm and its key members (Becker, 1975; Hashimoto, 1981), firms are able to appropriate at least a proportion of the rents generated from firm-specific knowledge. Thus, the possession of unique and valuable firm-specific knowledge, instead of general knowledge, forms the basis

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for superior performance and long-term competitive advantage (Helfat, 1994; Kogut and Zander, 1992).

Also emphasized in the resource-based theory is the important role of top managers, especially the CEOs, in discovering and developing as well as deploying firm resources in order for the firm to achieve resource- or knowledge-based advantages (Castanias and Helfat, 1991, 2001; Finkelstein, Hambrick, and Cannella, 2009). Holding CEO capabilities as well as other managerial factors constant, we argue that a firm's knowledge structure—or the level of firm-specificity in the firm's knowledge assets—may affect the extent to which the firm needs the CEO to invest in firm-specific human capital. In particular, the accumulation and deployment of firm-specific knowledge assets often require top managers to engage in firm-specific effort by acquiring the corresponding specialized managerial skills. In addition, establishing stable CEO-employee relationship is especially critical in such firms as it helps facilitate mutual understanding and trust, and thereby, effectively motivate the key technical employees to exert effort in the deployment of firm-specific knowledge.

Given the importance of CEO's specialized human capital in deploying firm-specific knowledge, we argue that firms may resort to appropriate employment arrangements for CEOs, in order for them to be motivated to invest in specialized skills. In particular, we expect that a firm's knowledge structure would have implications for both key CEO compensation design and the likelihood of CEO dismissal. CEO compensation design, such as a greater use of restricted stocks, provides incentives for CEOs to stay in the firm (or discourage CEOs to voluntarily leave the firm) and to have a longer time horizon in making specialized human capital investments. Another way for the firms to motivate their CEOs is to retain them by providing the CEOs with greater job security, indicated by a lower likelihood of CEO dismissal *ex post*. Job security as a result of board retention efforts reduces the CEOs' risk of losing the value of their specific human capital investments, giving the CEOs the assurance of value capture from their specialized investments. Accordingly, we expect to observe a higher proportion of restricted stocks in CEO compensation for firms with a high degree of firm-specific knowledge assets. Moreover, such firms are more likely to have a lower CEO dismissal rate, even when the firm is experiencing poor financial performance.

To further untangle these arguments, we additionally examine the role of diversification in moderating the relationship between firm-specific knowledge and the use of restricted stocks in CEO compensation contracts and that between firm-specific knowledge and CEO dismissal. In highly diversified firms, CEOs are often far removed from the operational details and from the deployment of firm-specific knowledge resources. Thus, CEOs have less opportunity to acquire skills specialized to firm knowledge assets. It then follows that there is less need for the firm to provide incentives for its CEO to specialize. In contrast, in the case of focused or relatedly diversified firms, CEOs are more directly involved in knowledge assets deployment, which increases the need for the CEO to specialize. Thus, we expect that both the relationship between firm-specific knowledge and ratio of restricted stocks in compensation design and that between firm-specific knowledge and the intent of the board to retain the CEO (i.e., a lower likelihood of CEO dismissal) are stronger for less diversified firms.

This study intends to make several contributions. First, it contributes to the resource-based theory of the firm (e.g., Barney, 1991; Helfat and Peteraf, 2003; Peteraf, 1993) by providing a linkage between a firm's resources and top management employment arrangements. In particular, we develop the argument that a firm's knowledge resource structure affects firm employment arrangements in terms of both top managers' compensation design and job security. One important implication of the argument is that for a firm characterized with a high level of firm-specific knowledge, it is very important to provide incentives for their CEOs to stay in the firm through compensation design and to maintain leadership continuity through a lower CEO dismissal (Hoskisson *et al.*, 1999).

Second, relatedly, it contributes to the strategic leadership literature with a focus on the CEO compensation and CEO succession (Finkelstein *et al.*, 2009; Zajac and Westphal, 1996). By documenting the influence of firm knowledge structure on both compensation design and CEO career trajectory, our article provides fresh angles to understand the antecedents of CEO compensation and succession. Moreover, since we consider both CEO compensation and CEO succession as essential key elements of employment arrangements that provide incentives for CEOs to specialize, we are among the first studies to combine these two areas under one

unified framework. Toward this end, our article has also become one of the first studies that integrate prior research on resource-based view with strategic leadership literature.

Third, by examining how the level of corporate diversification influences the need for the CEO's investment in specialized skills, and thereby, moderates the key relationships argued, we further contribute to the literatures by introducing the role of firm structure and scope in firms' employment arrangements for their CEOs. We argue that for a given level of firm-specificity in knowledge assets, the opportunity for CEOs to invest in specialized skills may vary with the level of corporate diversification, which affects CEO responsibilities, and accordingly, their employment arrangements. While previous studies primarily focused on the direct effects of corporate diversification on various strategy and performance outcomes (e.g., Miller, 2006; Rumelt, 1982), our study provides insights into how corporate diversification may interact with a firm's knowledge structure to affect employment arrangements.

Last, this study also extends the arguments of agency theory and corporate governance, which falls short in discussing how firm resources may play a role in affecting the relationship between shareholders and top managers (e.g., Eisenhardt, 1989; Hillman and Dalziel, 2003; Westphal and Zajac, 1998). This study shows how incorporating a firm's knowledge structure into the analysis of managerial employment arrangements (i.e., restricted stock in CEO compensation and career stability in our article) may provide important implications for the agency relationships.

THEORY AND HYPOTHESES DEVELOPMENT

Firm-specific versus general knowledge

In resource-based models of the firm, the basis for superior performance is possession of unique and valuable firm-specific resources (Barney, 1991). A resource is considered specific to a firm if its value to the firm exceeds its second-best use value in an alternative business setting. Among the pool of resources examined, a firm's knowledge assets are generally considered to be most critical for firm survival and long-run success (Helfat, 1994; Kogut and Zander, 1992, 1996).

In general, both firm-specific and general knowledge are considered critical for firm operations. Firms often have components of both firm-specific and general knowledge and they only differ in the degree of firm-specificity in firm knowledge assets, which falls on a continuum. A strategy toward a greater level of firm-specific knowledge is generally associated with higher risk, since the economic value of firm-specific knowledge is ultimately influenced by exogenous factors such as market conditions (Barney, 2001; Bowman and Ambrosini, 2000; Priem and Butler, 2001). As it is more difficult for firm-specific knowledge to find alternative settings where the knowledge can be applied, in case there is a misfit between firm-specific knowledge and consumer preferences and technologies, it can be detrimental for firm performance and survival (Anderson and Tushman, 1990, 2001; Sirmon, Hitt, and Ireland, 2007).

However, once firm-specific knowledge proves valuable in the market, it has a greater potential to generate superior economic performance for a firm than general knowledge does. Valuable firm-specific knowledge is difficult to be imitated by rivals as it is often related to the alteration and enhancement of existing technologies and operational processes, which are tailor-made for firm-specific situations (Ahuja and Katila, 2004; Helfat, 1994). For example, in the early stage of the printer industry, Epson applied Piezoelectric technology to develop its series of printers, while Hewlett-Packard centered on thermal ink jet technology for its product development. Since these two firms were major players in the industry that had dominant technology bases compared with many other firms, the series of innovative knowledge of the two firms developed based on their distinct technologies are considered highly firm-specific (Wang and Chen, 2010). Another example of firm-specific knowledge can be found in the petroleum industry. Due to the different geographical features of each reservoir in the petroleum industry, the innovation of new ways to extract additional crude oil from existing reservoirs is often not transferable across firms, and thus, has firm-specific components (Helfat, 1994).

In order to imitate a firm's firm-specific knowledge, other firms will have to obtain not only the knowledge per se, but also the bases, parameters, and other firm-specific features or the whole system on which the knowledge is built. Moreover, while rents generated from general knowledge is likely to

be appropriated by the key managers and employees who own or have control of such knowledge, rents generated from firm-specific knowledge is likely to be shared between the firm and its key members (Becker, 1975; Hashimoto, 1981). As a result, firms are able to appropriate at least a proportion of the rents generated from firm-specific knowledge. Therefore, compared with general knowledge, firm-specific knowledge is more likely to generate long-run superior economic performance for the firm (Barney, 1991; Ghemawat, 1986). Consistent with this argument, some previous studies have found that a higher level of self-citations of a firm's own patents, as an indicator of the level of firm specificity of knowledge, is associated with the greater economic value of the firm (Hall, Jaffe, and Trajtenberg, 2005; Wang and Chen, 2010; Wang, He, and Mahoney, 2009).

Firm-specific knowledge and CEO specialized skills

Because firm-specific knowledge tends to be “sticky”—there are significant costs associated with separating it from the firm that owns them, the decision to pursue a knowledge development strategy that emphasize firm-specific knowledge implies an irreversible commitment by the firm (Ghemawat and Del Sol, 1998). The cost associated with abandoning such firm-specific knowledge creates a tendency toward persistence or commitment in a company's strategy. Such a need for commitment can be shown in the firm's tendency to build long-term relationships with its key stakeholders, including its top managers.

More specifically, the deployment of firm-specific knowledge assets often require top managers to engage in a greater level of firm-specific effort by acquiring the corresponding specialized managerial skills.¹ First, developing and deploying firm-specific knowledge is often accompanied by a local search based on a firm's existing knowledge stock. A successful local search, in turn, requires skills specialized to each firm setting. Although top managers may not need to invest in as much specialized technical skills as R&D employees

do, they still need to have an understanding of the technical knowledge involved to not only “know the right questions to ask his subordinates,” but also know “how to evaluate the answers” (Castanias and Helfat, 1991; Katz, 1974). A similar line of argument can also be found from the perspective of the resource-based view of the firm, previous literature has argued that the effectiveness of firm knowledge investment is affected by top managers' skills in searching for superior opportunity set for the firm's knowledge assets (Kor and Mahoney, 2005; Penrose, 1959). The more firm-specific are the managers' skills, the more precisely can the managers assess the likelihood of success among multiple avenues of application of firm knowledge assets. Accordingly, top managers with specialized skills are better able to devote resources to those avenues that are most likely to achieve higher returns from their firms' unique knowledge base (Kor and Mahoney, 2005).

Therefore, when a firm has higher level of firm-specific knowledge assets, not only are the key technical employees involved in making corresponding specific human capital investments, but also the complementary managerial skills of its top managers are likely to increase in specificity. Consistent with this view, Gabarro (2010) suggests that the specific skills of employees and top managers are often highly correlated. The co-movement of developing firm-specific knowledge in all levels of employees not only facilitate strategy implementation, but also enable top managers to better evaluate their subordinates' performance and to build relationship with key technical employees.

Key technical employees are often directly involved in the process of deploying knowledge-based firm-specific assets. Their incentive in the knowledge development process is another critical issue that needs the firm to pay serious attention to (Wang *et al.*, 2009). In addition to an economic-based incentive mechanism, good employee relations are an important relationship-based employee governance mechanism that helps effectively motivate employees to exert efforts in the rent generation process of firm-specific knowledge. It then follows that firms with a high level of firm-specific knowledge often have a greater need for top managers to build close relations with key technical employees to obtain the mutual understanding and trust necessary to motivate such employees to successfully implement the firm's strategies (Wang

¹ What is central to our argument is the relative, instead of absolute, level of CEO specialized skills. Our key propositions will hold, as long as the need for CEOs to invest in specialized skills is *relatively* greater in firms with a high level of firm-specific knowledge than firms with a low firm-specific knowledge.

et al., 2009). Manager-employee relationship asset itself is likely to be specialized to the particular firm context (Williamson, 1985). In this case, specialized managerial skills can be interpreted as a relationship-specific investment, which is embedded in the particular firm context.

In sum, accumulating valuable firm-specific knowledge itself, even if guarded by intellectual property rights, is not enough to support a significant competitive advantage. In order to create a long-term competitive advantage, these firms require their top managers, especially its CEO, to invest in specialized skills, coupled with the management capability to effectively coordinate and combine firm-specific knowledge with other critical human resources. Without such specialized skills of CEOs, companies may accumulate a large stock firm-specific knowledge, but still not enjoy any sustainable performance advantages (Teece, Pisano, and Shuen, 1997).

The discussion above suggests that there is a greater requirement for a firm's CEO to invest in specialized human capital, if the firm implements a strategy toward the accumulation and deployment of firm-specific knowledge. Similar to other types of firm-specific investments, CEOs' specialized skills are imperfectly redeployable or are valued less in the external labor market than within the firm (Becker, 1975; Castanias and Helfat, 1991; Williamson, 1985). Thus, due to the concern for losing the value of their specialized human capital in the case of being dismissed, the CEOs are typically reluctant to make such investments *ex ante*. Indeed, previous research has found that CEOs with more firm-specific skills are likely to be paid less in the external market. For example, Custódio, Ferreira, and Matos (2013) found that there is a significant pay discount for CEOs who are specialists in the industries, compared to peer CEOs who are more generalists. Therefore, a firm with a high level of firm-specific knowledge has a greater need to induce its CEO to make specialized human capital investments, and therefore, has different employment arrangements with its CEO. Below we discuss two related elements of employment arrangements firms may adopt to induce CEO investments. The first is compensation design, such as the use of a higher proportion of restricted stocks, to encourage a CEO to stay and make long-time commitment to the firm, thereby reducing his or her likelihood of *voluntary* departure. The second is to directly reduce the risk associated with CEO

specialized investments by providing the CEOs with job security, which reflects the intent of the board to retain the CEO and is manifested as a lower level of *ex post* CEO dismissal, or *forced* departure.

Firm-specific knowledge and CEO compensation design

A typical mechanism that provides incentives for CEOs to make specialized investments is through some specific compensation design that is able to encourage CEO to stay longer in the firm and as a result to take a long-term strategic perspective. The deployment of firm-specific knowledge and investment in corresponding specialized skills are typically long term in nature. It takes time for managerial learning to become embedded in an organization, and to guide the subsequent learning and actions of other organizational members (Prietula and Simon, 1989). Thus, there are time compression diseconomies (Dierickx and Cool, 1989) for new leaders to accumulate firm-specific human capital. Therefore, when top managers make choices regarding firm-specific versus general skills, they have more incentives to invest in firm-specific skills (choosing the value enhancing long-term strategy) if the firm adopts compensation design that attracts the CEOs to stay longer in the firm and encourage the CEOs to make strategic decisions with a longer time horizon (Bebchuk and Grinstein, 2005; Buck *et al.*, 2003). In contrast, in the absence of such contracts, CEOs are more likely to choose short-term strategy, and correspondingly, acquire general skills because doing so will enable them to receive attractive outside offers.

Among various compensation components, restricted stocks are particularly helpful to achieve these purposes.² Restricted stocks, together with options and long-term incentive plans, are broadly considered as key components of long-term compensation designs. Restricted stock has recently become a popular alternative to stock options for executive compensation due to fewer issues related to valuation and income tax treatments (Damodaran, 2013; Deloitte, 2005; Hodge, Rajgopal, and Shevlin, 2009). Similar to options,

² Our additional analysis also discusses the use of long-term compensation (including stock options, restricted stocks, and long-term incentive plans) in the compensation design, which also helps to keep CEOs and encourage them to take a long-term perspective of their strategic choices. Results are very consistent with those of restricted stocks.

restricted stocks have a vesting date that requires the granted individuals to stay with the firm for a period before they can exercise their rights. But different from options which have expiration dates, restricted stocks do not expire (Hodge *et al.*, 2009). These features of restricted stocks allow it to function as an effective mechanism that facilitates CEO retention.³

First, as the value of restricted stocks is forfeited if CEOs leave their companies before the end of the vesting period, CEOs with restricted stocks as compensation are more likely to stay with a firm, especially if it represents a large proportion of their overall wealth. Thus, a direct effect of paying CEOs with restricted stocks is that the CEOs are less likely to actively search for other opportunities in external market and voluntarily leave the firm.

Second, the use of restricted stocks in CEO compensation also influences the extent to which the CEOs take a long-term perspective for firm strategy. Due to the claw back provision in the incentive design, CEOs cannot benefit immediately from short-term share price movement. In addition, the nature of no expiration date for restricted stocks could especially encourage CEOs to focus on the fundamentals of the firm or on the development of core capabilities, which have an enduring impact on firm success. Therefore, for a firm with a high level of knowledge specificity, restricted stocks help motivate CEOs to allocate their personal efforts to acquire firm-specific human capital and to build firm-specific relationship with key technological employees.

Furthermore, granting a CEO with a greater level of restricted stocks is likely to better align the firm's interest with that of the CEO (Shleifer and

Vishny, 1997). The board's insufficient knowledge of the CEO's effort in acquiring specialized skills may lead to an outcome control-based compensation incentive—as opposed to behavior monitoring control—to induce cooperative effort of the CEO (Eisenhardt, 1989; Ouchi, 1980). This is particularly so when resource compositions are characterized by high levels of firm-specific knowledge resources, where the behavior of the CEO in acquiring corresponding firm-specific skills is often more difficult to observe and measure.

In sum, when a firm has a high level of firm-specific knowledge, where the concern for CEO underinvestment is likely to be the greatest, the firm is more likely to use restricted stocks to provide incentives for the CEO to stay, to have a longer-term horizon, and accordingly, more likely to engage in firm-specific efforts. Therefore,

Hypothesis 1: The level of firm-specific knowledge is positively associated with the use of restricted stocks in CEO compensation.

Firm-specific knowledge and CEO dismissal

CEOs' incentives to engage in firm-specific efforts are not only influenced by their own intention to stay within their firm, as reflected in compensation through restricted stocks, but also influenced by the level of security they felt about their employment in the firm. This is because CEOs are concerned about the risk of losing the value of their specialized skills in case of being dismissed (Wang and Barney, 2006). Being specific to the current firm, such skills cannot be applied to an alternative business setting without losing at least some value. Accordingly, CEOs would be reluctant to make specific human capital investments, if the board does not have the intention to retain them, or the likelihood that they may be separated from the current firm setting is high. Similar concerns of managers or key employees about the risk associated with being separated from their firms have also been discussed in some previous studies (Laffont and Tirole, 1988; Schnitzer, 1995; Shleifer and Summers, 1988; Titman, 1984). For example, in the context of takeovers, target managers are likely to be dismissed and replaced by new ones (Walsh, 1988). As a result, an acquirer company appropriates the rents of target managers. Anticipating the dismissal and expropriation of their rents, the relationship-specific investments of the target managers will be too

³ The use of restricted stocks in CEO compensation may raise the concern that it may turn away "good quality" CEOs. The argument is that the vesting restrictions associated with restricted stocks could lead managers to value such stocks less, and thus, to be less likely to join firms offering restricted stocks in compensation. We do not think this is a serious concern because, in the open executive market, if good quality managers discounted the value of restricted stocks, they could negotiate for other ways to make up for the value loss, for example, by requesting a greater number of stocks, options, or simply more bonuses, and so on. Just like stock options and other incentive-based pay that have been widely adopted in practice, the concern is not about whether they attract lower quality individuals, but more about how managerial behaviors may be distorted by high-power incentives without proper governance structure (Sanders and Hambrick, 2007). In this regard, restricted stocks could be better than options as managers with heavy loads of options may be encouraged to take extremely risky decision to increase stock price volatility that is likely to increase the option valuation but reduce the firm value.

insignificant, which may offset the efficiency increase through the takeover (Schnitzer, 1995).

Thus, in the employment arrangement, another approach for motivating CEOs to make specialized skills investment is to show the firms' retention effort by increasing the CEOs' job security, so that they will be less concerned about separation from the current firm. Prior research on job (in)security at the employee level has documented that job insecurity was found to be significantly linked with both psychological distress, such as feelings of anxiety, depression, and irritability, as well as physical distress, such as fatigue, headaches, and insomnia (Cooper and Melhuish, 1980; Hartley *et al.*, 1991). In contrast, a sense of security positively influences individuals' job attitude, increasing their organizational commitments and reducing their withdrawal behaviors (Ashford, Lee, and Bobko, 1989; Davy, Kinicki, and Scheck, 1997; Sverke and Hellgren, 2002). For example, Foss and colleagues (Foss, 2003; Foss, Foss, and Vázquez, 2006) found that organizational commitment to a lower likelihood of project termination provides a greater sense of security to employees, leading to an increase in firm value through enhanced employee motivation and participation. Similarly, even at the apex of the organization, CEOs have stress and concern of being forced out, which will make their prior firm-specific investment less valuable (Hambrick, Finkelstein, and Mooney, 2005; Mannor *et al.*, 2016). Accordingly, to motivate CEOs to acquire specialized knowledge to create greater firm value, an effective way is to provide job security.

Therefore, we expect that a firm with greater firm-specific knowledge, which requires a high level of CEO specialized skills investment, is more likely to benefit from, and have a greater need of, maintaining a higher level of job security for CEOs. Other things being equal, boards will have a stronger intention to retain CEOs, which can be reflected in a subsequently lower likelihood of the CEOs being forced out, *that is*, CEO dismissal. We therefore predict:

Hypothesis 2: The level of firm-specific knowledge is negatively associated with CEO dismissal.

Earlier research on CEO dismissal has often focused on the relationship between firm financial performance and the likelihood of CEO dismissal, and consistently found that CEOs of firms

experiencing poor performance are more likely to be dismissed (e.g., Coughlan and Schmidt, 1985; Denis and Kruse, 2000; Murphy, 1999; Weisbach, 1988). In these cases, the CEO is argued to hold responsibility for the poor firm performance (Crossland and Chen, 2013). But CEO dismissal could be a response to poor performance with a symbolic dimension containing the element of scapegoating, especially when the CEO has low discretion (Hambrick and Finkelstein, 1987). If the board shows strong intention to keep the CEO, CEO dismissal may not occur even in the case of poor performance. Therefore, extending our arguments above that firms with a high level of firm-specific knowledge are more likely to retain their CEOs through providing them with job security, we would expect that the likelihood of a CEO is dismissed under poor financial performance should be mitigated for firms with a high level of firm-specific knowledge.

Hypothesis 2a: The level of firm-specific knowledge weakens the negative relationship between firm financial performance and CEO dismissal.

The moderating role of corporate diversification

Our preceding argument is established on the premise that with an increase in firm-specific knowledge, the firm needs to provide incentives and employment arrangements for its CEO to invest in more specialized skills. However, for a given level of firm-specificity in knowledge assets, the opportunity for CEOs to invest in specialized skills may vary due to the differences across firms in terms of CEO responsibilities. We focus on one key factor of interest in the strategic management field—corporate diversification (Bettis and Hall, 1982; Hoskisson and Johnson, 1992; Wiersema and Bantel, 1992), and discuss how the level of diversification influences the need for the CEO's investment in specialized skills, and thereby, moderates the relationship between firm-specific knowledge and CEO dismissal.

Diversified firms tend to have more executive levels (Gomez-Mejia, Tosi, and Hinkin, 1987) and larger and more complex organizational structures (Aggarwal, 1981). For example, an M-form organization (Chandler, 1962; Williamson, 1975), which defines a set of management roles and relationships that emphasize delegation of authority to operating divisions, is a pervasive organizational structural form adopted by many large diversified companies.

Thus, in a highly diversified firm, management of operational details is often dedicated to division managers. CEOs, on the other hand, are more tuned to manage corporate level activities, such as coordination among divisions and portfolio management (Hill and Hoskisson, 1987; Hoskisson and Turk, 1990; Michel and Hambrick, 1992).

In contrast, in firms with low levels of diversification (focused or relatedly businesses), CEOs are typically more directly involved in firm or division operations and often manage the firm with a greater emphasis on strategic controls (Henderson and Fredrickson, 1996; Hill and Hoskisson, 1987; Hoskisson and Hitt, 1990). This also means that there is greater need for the CEOs to have a better understanding of the divisions' resources, operational details and strategies. In addition, in order to attain synergies among highly related businesses, the CEO must ensure coordination and cooperation between divisions by creating interdependent linkages among them (Hill and Hoskisson, 1987; Hoskisson, Johnson, and Moesel, 1994; Michel and Hambrick, 1992). Establishing and maintaining such company-wide resource exchanges result in an active role by CEOs in establishing relationships with key knowledge employees.

In sum, CEOs of less diversified firms have greater opportunity to acquire firm-specific skills, either directly specialized to firm knowledge assets, or indirectly specialized to the unique relationship with the firms' key employees. Accordingly, the need for a less diversified firm to use restricted stocks to encourage its CEO to stay is higher. In contrast, in a highly diversified firm where CEOs have fewer opportunities to acquire firm-specific skills, the firm is less likely to use such compensation design. Thus, in a highly diversified firm, the relation between firm-specific knowledge and long-term compensation will be weaker. Therefore, we predict:

Hypothesis 3: The positive relationship between firm-specific knowledge and CEO compensation with restricted stocks becomes weaker (stronger) with a higher (lower) level of firm diversification.

Similarly, a lower level of requirement for specialized skills of CEOs in a highly diversified firm further reduces the need for the firm to provide its CEO with job security, thus reducing the costs associated with making commitments as well as the costs of dismissing the CEO. Therefore, the

level of firm diversification will also affect the relationship between firm-specific knowledge and CEO dismissal. While there is a negative relationship between firm-specific knowledge and CEO dismissal, we posit that this relationship would be weakened by the level of firm diversification.

Hypothesis 4: The negative relationship between firm-specific knowledge and CEO dismissal becomes weaker (stronger) with a higher (lower) level of firm diversification.

DATA AND SAMPLE

Our initial sample selection was based on observations for all firms in the Execucomp database for the period from 1993 to 2001.⁴ A turnover event was identified if there was a change in a firm's CEO in a particular year based on Execucomp. The Factiva news database was then searched to obtain information on the exact announcement date of the succession and on whether it was a forced or a voluntary turnover (Jenter and Kanaan, 2015; Parrino, 1997).^{5,6} The data was then merged with the NBER patents file assembled by Hall, Jaffe, and Trajtenberg (2001), which was used to measure firm-specific knowledge. Board and CEO duality data were collected from Compact Disclosure. CEO compensation and CEO ownership data were extracted from the Execucomp, firm diversification data from Compustat's industrial segment file, and

⁴ Execucomp data began in 1992, and NBER patent citation data, which is the source of data for our key measure of firm-specific knowledge, was available between 1976 and 2006. Since both backward and forward citations are needed for our measure of firm-specific knowledge and truncation problems are serious for patent forward citations, we chose 2001 as the ending year of our sample, which provided us at least five years of forward citations.

⁵ The classification of turnovers into forced and voluntary follows Parrino (1997): All departures for which the press reports that the CEO is fired, is forced out, or retires/resigns due to pressure are classified as forced. All other departures for CEOs above and including age 60 are classified as voluntary. Departures for CEOs below age 60 are reviewed further and classified as forced if either the press does not report the reason as death, poor health, or the acceptance of another position (including being the chair of the board), or the press reports that the CEO is retiring, but does not announce the retirement at least six months before the succession. Finally, the cases classified as forced can be reclassified if the reports convincingly explain the departure as due to reasons that are unrelated to the firm's activities. This careful classification scheme is necessary since CEOs are rarely openly fired from their positions. CEO turnovers caused by mergers and spin-offs are excluded from the analysis.

⁶ We thank Professors Jenter and Kanaan for sharing their forced CEO turnover data.

analyst coverage information from IEBS database. Finally, Compustat and CRSP databases were used to construct accounting and stock return variables respectively. After merging the major data sets and deleting observations with missing values for the key variables, the final panel data set contained 972 firms and 4,390 firm-year observations for a sample period of 1993 through 2001.

Measurements

Restricted stock was defined as the value of restricted stock granted to the CEO during the year divided by the total annual compensation.

CEO dismissal was a dummy variable coded as 1 if there was a forced turnover in a firm's CEO in a particular year according to the classification procedure described earlier. Otherwise, this variable was coded as 0.

Firm-specific knowledge was measured using patents and their citations. Patents represent an important component of a firm's knowledge assets and patent citations provide direct evidence of the path of knowledge flow and spillovers. Each patent's citations are typically evaluated carefully by patent examiners in order to avoid inappropriate citations and the exclusion of relevant citations. The data enable the tabulation of both citations that are made within the same firm (self-citations) and those made by other firms (external citations). If the amount of patents represents a firm's stock of knowledge resources, and patent citations represent the flow of the knowledge resources, then the frequency with which a firm's existing patents cite its own previous patents indicates the degree to which the firm's new knowledge is built on its own existing knowledge base. It can then be inferred that the higher the percentage of internal knowledge accumulation as represented by self-patent citations, the more likely that the firm's knowledge assets are firm specific. Accordingly, we built on previous studies (Hall *et al.*, 2005; Wang and Chen, 2010; Wang *et al.*, 2009) to generate a proxy for the level of firm-specific knowledge as follows:

$$\text{Firm-specific Knowledge} = \frac{\text{Share of backward self-citations}}{\text{over total citations made by the focal firm}} \times \frac{\text{the extent to which these self-cited patents are subsequently cited by the focal firm}}{\text{the extent to which these self-cited patents are subsequently cited by the focal firm}}$$

Specifically, the measure is the *share of self-citations made*, calculated by counting all citations made in a firm's new patents in a certain year that cited the firm's own previous patents, then dividing this number by the total number of citations made by all the firm's new patents in that year. It is further adjusted by a *weight*, the extent to which the self-cited patents are subsequently cited by the focal firm, which is the fraction of the total forward citations of these self-cited patents that are generated by the focal firm (versus by other firms). The weight is added to address the concern that, "even though a firm cites its own previous patents, if these previous patents are also widely cited by other firms (which makes the weight rather small), the degree of firm-specificity in knowledge ... should be discounted" (Wang *et al.*, 2009: 929).

We constructed two standard measures of *firm diversification*: (1) number of Business Segments, which was the number of different businesses in which the firm operates; (2) one minus Herfindahl index, which was calculated as the sum of squares of segment sales divided by the square of firm sales, thus a greater score suggests a higher level of diversification. To test the interaction effect between firm-specific knowledge and diversification, we mean-centered these variables to ease interpretation of results and address potential multicollinearity.

We also included two measures of firm financial performance. Our primary measure is prior year *industry-adjusted stock return* (Huson, Parrino, and Starks, 2001; Wiersema and Zhang, 2011), computed as the firm's stock return minus the median industry stock return. The median industry return is calculated using all CRSP firms in the focal firm's two-digit Standard Industrial Classification industry (excluding the focal firm). In addition, we also included return on asset (ROA) (similarly adjusted by industry) as it is a very commonly used accounting-based measure of firm financial performance.

In addition to the above key explanatory variables, we also included a series of control variables, including CEO characteristics, board characteristics, and firm-level variables such as R&D and firm size. Since previous studies found that the compensation design and the probability of CEO dismissal varied across *CEO tenure* and *age* (Finkelstein and Hambrick, 1989; Ocasio, 1994; Zhang and Rajagopalan, 2010), we also included these two variables in the regression to control their effects.

As the stock ownership of the firm's CEO might increase a CEO's power, and thus, influence the compensation design and decrease the probability of CEO dismissal (Denis, Denis, and Sarin, 1997; Finkelstein *et al.*, 2009; Huson *et al.*, 2001), we controlled for *CEO stock ownership*, measured as the fraction of stock shares held by the CEO. Similarly, we also included *CEO duality*, as a CEO who is also the board chair tends to have greater power. CEO duality was coded as a dummy variable equal to 1 if the CEO is the board chair, and 0 otherwise.

In addition to CEO characteristics, we also included two board level variables that may influence the CEO employment arrangements: board size and fraction of outside directors (Finkelstein *et al.*, 2009; Weisbach, 1988; Yermack, 1996). *Board size* was measured as the total number of directors on the board. *Outside directors* was measured as a ratio of nonexecutive directors on the board. We also controlled for the effect of *Analyst recommendation* as prior research suggested that it had a significant impact on CEO career trajectory (Wiersema and Zhang, 2011). In particular, Analyst recommendation was measured by the weighted average of all analyst recommendations of a firm. And the higher the score, the more it is oriented to "buy" recommendation. Last, we controlled for two firm level variables, *R&D intensity* and *Firm size*. Firm size was measured by the natural logarithm of annual sales of the firm (Huson *et al.*, 2001). R&D intensity of a firm was calculated as the annual R&D expenditure scaled by firm size (e.g., Griliches, 1981; Hall *et al.*, 2005).

RESULTS

Table 1 contains descriptive statistics and correlations for our sample. In line with previous studies, the mean value of the restricted stock was 0.035 (Murphy, 1999). The frequency of CEO dismissal was 2.3 percent of all firm-year observations in our sample, similar to what had been reported in previous studies (e.g., Jenter and Kanaan, 2015). Also in line of prior research, the average value of the firm-specific knowledge variable was 0.023. Similarly, the statistics of other variables were generally consistent with the literature (e.g., Jenter and Kanaan, 2015; Wiersema and Zhang, 2011). As expected, restricted stock was positively correlated with firm-specific knowledge, while

Table 1. Descriptive statistics and correlation matrix

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Restricted stock (ratio)	0.035	0.095														
2 CEO dismissal	0.023	0.148	0.03													
3 Firm-specific knowledge	0.023	0.040	0.06	-0.03												
4 Diversification 1 (number of business segment)	2.014	1.311	0.10	-0.03	0.03											
5 Diversification 2 (one minus Herfindahl index)	0.233	0.275	0.10	-0.03	0.04	0.87										
6 Industry-adjusted stock return	0.223	0.573	-0.06	-0.06	-0.01	-0.06	-0.07									
7 CEO age	56.221	7.541	0.04	-0.05	0.05	0.16	0.18	-0.12								
8 CEO tenure	8.135	8.057	-0.07	-0.07	0.02	-0.06	-0.06	-0.00	0.36							
9 CEO stock ownership	0.026	0.056	-0.08	-0.05	-0.05	-0.11	-0.11	0.03	0.12	0.37						
10 CEO duality	0.690	0.463	0.04	-0.05	0.05	0.10	0.11	-0.06	0.23	0.18	0.09					
11 Board size	9.064	3.320	0.17	0.00	0.08	0.36	0.33	-0.13	0.18	-0.08	-0.22	0.13				
12 Outside directors	0.716	0.186	0.09	0.02	0.04	0.15	0.14	-0.03	0.00	-0.12	-0.20	0.13	0.48			
13 Analyst recommendation	3.866	0.430	-0.08	-0.05	-0.05	-0.04	-0.05	0.35	-0.11	0.04	0.05	-0.08	-0.15	-0.06		
14 R&D intensity	0.060	0.087	-0.10	0.02	0.07	-0.24	-0.23	0.08	-0.24	-0.03	-0.01	-0.12	-0.30	-0.11	0.02	
15 Firm size	7.330	1.689	0.12	-0.04	0.11	0.26	0.19	0.17	0.07	-0.06	-0.14	0.15	0.42	0.14	0.11	-0.12

Correlations larger than 0.03 are significant at the level of $p < 0.05$.
N = 4,390.

Table 2. OLS regression to predict the use of restricted stock in compensation design^{a,b,c,d}

	(1)	(2)	(3)	(4)	(5)	(6)
Industry-adjusted stock return	-0.004+ (0.002)	-0.004+ (0.002)	-0.004+ (0.002)	-0.004+ (0.002)	-0.004+ (0.002)	-0.004+ (0.002)
CEO age	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
CEO tenure	-0.000* (0.000)	-0.000* (0.000)	-0.000* (0.000)	-0.000** (0.000)	-0.000* (0.000)	-0.000* (0.000)
CEO stock ownership	-0.054** (0.019)	-0.051** (0.020)	-0.050* (0.019)	-0.048* (0.020)	-0.048* (0.019)	-0.047* (0.020)
CEO duality	0.001 (0.003)	0.000 (0.003)	0.000 (0.003)	0.000 (0.003)	0.000 (0.003)	0.000 (0.003)
Board size	0.002*** (0.001)	0.002*** (0.001)	0.002** (0.001)	0.002** (0.001)	0.002** (0.001)	0.002** (0.001)
Outside directors	0.007 (0.007)	0.007 (0.007)	0.007 (0.007)	0.006 (0.007)	0.007 (0.007)	0.007 (0.007)
Average analyst recommendation	-0.013*** (0.004)	-0.012** (0.004)	-0.012** (0.004)	-0.012*** (0.004)	-0.012** (0.004)	-0.012*** (0.004)
R&D intensity	-0.058*** (0.014)	-0.064*** (0.014)	-0.060*** (0.014)	-0.060*** (0.014)	-0.059*** (0.014)	-0.060*** (0.014)
Firm size	0.004*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.004*** (0.001)
Firm-specific knowledge		0.102** (0.039)	0.102** (0.040)	0.082* (0.040)	0.101* (0.040)	0.084* (0.039)
Diversification 1 (Number of business segment)			0.002 (0.001)	0.002 (0.001)		
Firm-specific knowledge * diversification 1				-0.068* (0.031)		
Diversification 2 (one minus Herfindahl index)					0.012* (0.006)	0.012* (0.006)
Firm-specific knowledge * diversification 2						-0.274+ (0.144)
Observations	4,390	4,390	4,390	4,390	4,390	4,390
R-squared	0.037	0.038	0.039	0.040	0.040	0.041

^a + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ level (two-tailed tests)

^b All models also include year dummies.

^c Robust standard errors are shown in parentheses.

^d Firm-specific knowledge and diversification variables are demeaned.

CEO dismissal was negatively correlated with firm-specific knowledge.

To test our hypotheses, we ran regressions with restricted stock and CEO dismissal as the dependent variables. Table 2 presents the results with restricted stock as the dependent variable. In Model (1), we included only control variables. Restricted stock was found to be significantly and negatively related to industry-adjusted stock return, CEO tenure, CEO stock ownership, analyst recommendation, and R&D intensity. In addition, bigger firms or firms with a bigger board size tended to grant more restricted stock to their CEOs.

We introduced firm-specific knowledge variable in Model (2). The coefficient of firm-specific knowledge was positive and significant ($\beta = 0.102$, $p < 0.01$), providing support

for our Hypothesis 1. In terms of economic significance, a one-standard-deviation increase in the firm-specific knowledge (0.04) led to an increase of 0.004 in restricted stock, representing more than 11 percent of the mean of restricted stock for our sample.

Models (3)–(6) showed the results with the two diversification measures added. In Models (3) and (5), we included the main effect of firm diversification measured by the number of business segments (Model [3]), and by one minus Herfindahl index (Model [5]), respectively. In Models (4) and (6), we added the interaction terms between measures of firm diversification and firm-specific knowledge, in order to test the moderating hypothesis (Hypothesis 3) that the positive effect of firm-specific knowledge on restricted stock would be weakened if the firm

Table 3. Logistic regression to predict the likelihood of CEO dismissal^{a,b,c,d}

	(1)	(2)	(3)	(4)	(5)	(6)
Industry-adjusted stock return	-0.814** (0.248)	-0.815*** (0.247)	-0.826*** (0.243)	-0.818*** (0.242)	-0.825*** (0.241)	-0.824*** (0.240)
CEO age	-0.028+ (0.015)	-0.026+ (0.015)	-0.023 (0.015)	-0.022 (0.015)	-0.021 (0.015)	-0.021 (0.015)
CEO tenure	-0.054* (0.024)	-0.053* (0.024)	-0.055* (0.024)	-0.054* (0.024)	-0.056* (0.024)	-0.055* (0.024)
CEO stock ownership	-14.816 (9.075)	-15.264 (9.308)	-15.814+ (9.315)	-15.997+ (9.356)	-15.736+ (9.197)	-15.896+ (9.232)
CEO duality	-0.485* (0.214)	-0.471* (0.215)	-0.453* (0.215)	-0.454* (0.215)	-0.445* (0.216)	-0.447* (0.217)
Board size	-0.008 (0.038)	-0.003 (0.038)	0.013 (0.039)	0.012 (0.039)	0.013 (0.038)	0.011 (0.038)
Outside directors	0.584 (0.601)	0.586 (0.605)	0.564 (0.623)	0.637 (0.624)	0.602 (0.625)	0.704 (0.628)
R&D intensity	0.803 (0.838)	1.086 (0.877)	0.745 (0.915)	0.773 (0.937)	0.694 (0.924)	0.748 (0.948)
Average analyst recommendation	-0.547* (0.243)	-0.553* (0.243)	-0.540* (0.243)	-0.529* (0.243)	-0.534* (0.243)	-0.517* (0.243)
Firm size	-0.068 (0.074)	-0.051 (0.075)	-0.037 (0.075)	-0.040 (0.076)	-0.046 (0.075)	-0.050 (0.075)
Firm-specific knowledge		-7.353* (3.654)	-6.949* (3.520)	-7.980* (3.683)	-6.696* (3.411)	-7.728* (3.660)
Diversification 1 (Number of business segment)			-0.208* (0.101)	-0.198* (0.101)		
Firm-specific knowledge * Diversification 1				4.524* (1.794)		
Diversification 2 (one minus Herfindahl index)					-1.061* (0.432)	-0.948* (0.446)
Firm-specific knowledge * diversification 2						26.140* (10.836)
Observations	4,390	4,390	4,390	4,390	4,390	4,390
Pseudo R-squared	0.0938	0.0984	0.103	0.107	0.105	0.109
Log likelihood	-428.9	-426.7	-424.4	-422.7	-423.7	-421.7
Wald chi-square	73.51	76.31	83.70	87.30	84.44	87.20

^a + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ level (two-tailed tests)

^b All models also include year dummies.

^c Robust standard errors are shown in parentheses.

^d Firm-specific knowledge and diversification variables are demeaned.

was more diversified. Consistent with Hypothesis 3, the coefficients of both interaction terms were negative and significant ($\beta = -0.068$, $p < 0.05$ in Model [4]; and $\beta = -0.274$, $p < 0.10$ in Model [6]).

We used results in Model (4) to illustrate the practical implication of the moderating effect of diversification. First, we computed the high and low values of number of business segment by adding and subtracting standard deviation from its mean, which were 1.311 and -1.311, respectively. At the high value of the variable (i.e., highly diversified companies), the effect of firm-specific knowledge on restricted stock was -0.007 ($=0.082 - 0.068 * 1.311$). This effect became 0.171 at the low value of the variable (i.e.,

relatively more focused firms). Similarly, the high and low values of one minus Herfindahl index were 0.275 and -0.275, respectively. The effect of firm-specific knowledge on restricted stock was 0.009 at the high value of the variable, and 0.159 at the low value.

To test Hypotheses 2 and 4, we used logit model with CEO dismissal as the dependent variable. Table 3 presents the main results. In Model (1), we included only control variables. CEO dismissal was significantly and negatively related to industry-adjusted stock return, analyst recommendation, CEO age, tenure, and CEO duality. These regression results were largely consistent with the prior literature.

Table 4. Moderating effects of firm-specific knowledge on the relationships between firm performance and CEO dismissal^{a,b}

	(1)	(2)	(3)	(4)
Firm-specific knowledge (FSK)	-7.353* (3.654)	-7.643* (3.692)	-6.923* (3.513)	-14.049* (5.796)
Industry-adjusted stock return	-0.815*** (0.247)	-0.927*** (0.258)		
FSK*industry-adjusted stock return		8.852* (4.310)		
Industry-adjusted ROA			-2.053+ (1.082)	-1.574 (1.093)
FSK*industry-adjusted ROA				64.963** (23.608)
Observations	4,390	4,390	4,390	4,390
Pseudo R-squared	0.0984	0.100	0.0869	0.0929
Log likelihood	-426.7	-412.1	-418.2	-415.5
Wald chi-square	76.31	85.59	72.31	79.59

^a Control variables (same as those in Table 3) are included but not reported to save space.

^b *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$

We introduced firm-specific knowledge variable in Model (2). The coefficient of firm-specific knowledge was negative and significant ($\beta = -7.535$, $p < 0.05$). We further examined the marginal effect of firm-specific knowledge on the probability of CEO dismissal at the mean value of all variable. The marginal value was -0.082 , which was significant at $p < 0.05$. In addition, we found that the predicted probability of CEO dismissal decreased by 0.35 percent (which was a 15% decrease from the average dismissal rate of 2.3%) when firm-specific knowledge increased by one standard deviation around the mean (at the mean value of all other variables).⁷ Indeed, this effect was greater than that of CEO age, CEO duality, and analyst recommendation. Overall, these results were consistent with Hypothesis 2, which states that firm-specific knowledge is negatively associated with CEO dismissal.

Hypothesis 2a suggests that firm-specific knowledge may negatively affect the performance-CEO dismissal sensitivity. The test results for this hypothesis are shown in Table 4. Specifically, Model (2) reported that the interaction between firm-specific knowledge and stock return-based performance measure was positive and significant, suggesting that although market performance was negatively related to CEO dismissal (i.e., poor performance increases the likelihood of CEO dismissal), such an effect was weakened if the firm had high level of

firm-specific knowledge. This was in line with our argument. In addition, when industry-adjusted ROA was used as an alternative performance measure in Models (3) and (4), we also found similar results supporting Hypothesis 2a.

Models (3)–(6) in Table 3 show the results with the two diversification measures added to test Hypothesis 4. In Models (3) and (5), we included the main effect of firm diversification measured by the number of business segments (Model [3]) and by one minus Herfindahl index (Model [5]), respectively. Both coefficients were negative and significant ($p < 0.05$ in both cases), a result consistent with Berry *et al.* (2006). In Models (4) and (6), we added the interaction terms between measures of firm diversification and firm-specific knowledge in order to test the moderating hypothesis that the negative effect of firm-specific knowledge on CEO dismissal would be weakened if the firm was more diversified. Consistent with our Hypothesis 4, the coefficients of both interaction terms were positive and significant ($\beta = 4.524$, $p < 0.05$ in Model [4]; and $\beta = 26.140$, $p < 0.05$ in Model [5]).

Several scholars recommended a set of best practices to test and interpret the interaction effect in logistic regressions (Hoetker, 2007; Wiersema and Bowen, 2009). Using the statistical procedures and the STATA codes suggested by Wiersema and Bowen (2009), we examined the effect of the firm-specific knowledge on the probability of CEO dismissal for low and high levels of firm diversification (Table 5). We found that in both measures

⁷ The analysis is implemented using STATA ado program *prchange*.

Table 5. Moderating effect analysis of firm diversification on the marginal effect of firm-specific knowledge on the probability of CEO dismissal^{a,b}

Firm diversification (# of business segments)	Marginal effect of firm-specific knowledge	z-Statistics	Firm diversification (one minus Herfindahl index)	Marginal effect of firm-specific knowledge	z-Statistics
Low	-0.355	-2.66**	Low	-0.376	-2.76**
High	-0.029	-0.41	High	-0.003	0.072

^a +*p* < 0.10, **p* < 0.05, ***p* < 0.01, ****p* < 0.001 (two-tailed tests)

^b The high(low) value of firm diversification is its value one standard deviation above (below) its sample mean.

of firm diversifications, the negative effect of the firm-specific knowledge on the probability of CEO dismissal was greater when the level of firm diversification was low (marginal effect = -0.355 and -0.376, respectively, *p* < 0.01 in both cases) than when it was high (marginal effect = -0.029 and -0.003, respectively, n.s. in both cases). This again supported Hypothesis 4.

Robustness tests and supplementary analyses

We did several additional analyses to ensure that our results were robust. First, extending the existing arguments, we could expect that the level of firm-specific knowledge not only influences CEO employment arrangements, it may also influence how a new CEO is selected. Our theory would suggest that firms with higher firm-specific knowledge are more likely to hire CEO internally (insider succession) than externally (outsider succession). To empirically test this conjecture, we further decomposed CEO dismissal into two categories: CEO dismissal followed by inside succession and dismissal followed by outside succession (Parrino, 1997; Shen and Cannella, 2002). We used this method to simultaneously estimate the likelihood of outsider succession and that of insider succession against the base category of no dismissal. Specifically, the dependent variable takes the value of 0 for no dismissal, 1 for outside succession, and 2 for inside dismissal.⁸ Appendix shows that there is a significant negative relation (at the 5% level) between outside succession and firm-specific knowledge. On the other hand, there is an insignificant relation

between the likelihood of inside succession and firm-specific knowledge. We further conducted a likelihood-ratio test of the equality of the coefficients of firm-specific knowledge in Models (1) and (2). The null hypothesis that two coefficients are equal was rejected at the five percent significance level. These results suggested that firms with higher firm-specific knowledge were less likely to hire a new CEO externally, which was consistent with your expectation.

Moreover, we have conducted several complementary analyses.⁹ One of our current dependent variable is the use of restricted stocks in compensation design, which is intended to directly capture the motivation for the firm to retain a CEO. Although restricted stocks are generally considered to encourage long-term perspective and increase the incentives for CEOs to stay longer with the firm, some other related measures of compensation, such as long-term compensation, may also capture a similar incentive design with an intention to motivate CEOs to stay in a firm. Thus, as a robustness test, we have also run regressions using long-term compensation (which include stock options, restricted stocks, and long-term incentive plans, and other long-term compensation) as dependent variables. We found largely consistent results.

Another complementary analysis was associated with the measure of our key independent variable, firm specificity in knowledge assets. Our current measure is based on patent citation data, which has certain limitations. Thus, in additional robustness tests, we constructed an alternative measure of firm-specific knowledge following Hoberg and Phillips (2016), who developed an index of product

⁸ Such a method has the benefits of including all firm-year observations (given CEO dismissal is a relatively rare event) and allowing scholars to compare the effect of our interested variable (i.e., firm-specific knowledge) on two different types of successions while controlling its effect on the nondismissal event (Shen and Cannella, 2002).

⁹ To save space, we do not separately report the results for these additional tests. Detailed results for these tests are available from the authors on request.

similarity between firms.¹⁰ We took the inverse of the similarity index (which is denoted by Product Dissimilarity) as a measure of specificity in firm knowledge assets, with the assumption that a firm with products dissimilar to those of other firms is more likely to have a high level of firm-specificity in knowledge assets. It is worth noting that because the Product Dissimilarity variable was skewed, following the literature, we used its decile rank from 1 to 10 in the regressions. The main findings appeared to be somewhat weaker, but 32 were largely consistent with our main results.

In addition, our key arguments are based on the proposition that firms with greater firm-specific knowledge is associated with greater need for CEO specialized skills. Although the argument makes logical sense, CEO specialized skills is a construct that is not directly measured. Thus, it might be helpful to conduct some complementary analyses to confirm this assertion empirically. In particular, we examined the correlation between firm-specific knowledge and CEO organizational tenure, which has been used in some previous studies to proxy for CEO specialized skills. We found that the correlation was positive and significant ($p < 0.001$). Although we admit this is a rather crude analysis, it does seem to provide some (indirect) evidence consistent with our arguments.

Finally, we have tried a few alternative empirical models to make sure that our key results were not sensitive to model specification. First, in our sample, the number of CEO dismissal cases was relatively small (99 out of 4,390 observations). Thus, to make sure that our main results were not biased as a result of low dismissal cases, we ran the analyses using alternative regression models that explicitly take into consideration of such cases. In particular, we followed King and Zeng's (2001) procedure to account for rare events (implemented by using STATA command "relogit") and

found results that are qualitatively similar to those reported in Table 3. In addition, we reran our analyses using the hazard rate model, another alternative to the logit model. In particular, we predicted the hazard rate of CEO dismissal using Cox proportional hazard regressions. The level of firm-specific knowledge was found to negatively related to CEO dismissal, and moreover, it weakened the negative relationship between firm financial performance and CEO dismissal. These results were quite consistent with the main ones using the logit model. To evaluate the economic magnitude of the results by exponentiating the reported coefficients, we found that a one-standard-deviation increase in firm-specific knowledge was associated with a 35 percent lower hazard rate of CEO dismissal during the next year.

DISCUSSION

This study examines the interrelationships between firm resources and top management employment arrangements, including CEO compensation design (i.e., restricted stocks) and CEO dismissal. We argue that a high level of firm-specific knowledge is associated with the firm's greater commitment to its existing strategy and practices. Due to a higher need for their CEOs to invest in specialized human capital, firms with a higher level of firm-specific knowledge are likely to encourage their CEOs to stay and provide job securities to the CEOs in order to motivate them to acquire specialized skills. Accordingly, we argue that firm-specific knowledge is positively associated with the firms' use of restricted stocks in their CEO compensation design and negatively associated with CEO dismissal. Furthermore, we predict and found empirical evidence that firm diversification mitigates the effect of firm-specific knowledge on both CEO compensation design and CEO dismissal as CEOs are more removed from the deployment of knowledge resources in diversified firms.

To our best knowledge, this study is the first one that integrates resource-based view of the firm with the strategic leadership literature on CEO compensation and CEO succession. By developing theoretical arguments and empirically testing the influence of level of firm-specific knowledge on CEO compensation contract design and the likelihood of CEO dismissal, it provides fresh angles to understand antecedents of CEO compensation and dynamics

¹⁰ In particular, combining web crawling and text parsing algorithms that process the text of product descriptions in 10-K annual filings, Hoberg and Phillips (2016) calculated firm-by-firm pairwise similarity scores as a Hotelling-like product location space to directly quantify a dynamic, firm-specific relation between any two firms in terms of product similarity. For a given firm i , a product similarity index is computed as follows. First, a minimum threshold is subtracted from each pairwise similarity score between firm i and all the other firms to obtain net pairwise similarity scores. Second, the resulting net similarity scores that are above zero are summed up. Finally, this sum plus one (self-similarity score for firm i) is multiplied by 100 to obtain the similarity index for firm i .

of CEO succession. Furthermore, by examining the moderating effect of corporate diversification, we further contribute to the literatures by introducing the role of firm structure and scope in firms' employment arrangements for their CEOs.

In addition to its contribution to the CEO compensation and succession literatures, the study provides new insights for the general arguments of agency theory. Agency theory emphasizes the conflicts between shareholders and top managers, and how providing appropriate incentives to top managers may help align interests among them. Although there are some discussion in the literature on the roles of CEO general versus specific human capital (e.g., Murphy and Zabojnik, 2007; Parrino, 1997), it does not address how firm resource structure may play a role in affecting the conflicts and interest alignment between shareholders and top managers. In particular, when there is a high level of firm-specific knowledge resources, shareholders are likely to grant top managers restricted stocks as part of the compensation package and offer managers greater job security.

This study also contributes to the resource-based theory of firm literature. While some recent efforts extend the theory by emphasizing the role of human factors in the processes of resource accumulation and rent generation (Coff, 1997, 1999; Wang *et al.*, 2009), they have primarily focused on the role of key firm employees. Relatively less attention has been paid to managerial incentives (with the exception of Castanias and Helfat, 1991, 2001). One important implication that can be drawn from this study is that firms with high levels of firm-specific knowledge are more likely to maintain continuity and commitment in all key aspects of firm strategies as shown with a compensation package that encourage CEOs to have a longer stay in the firm and lower CEO dismissal.

This study has some inherent limitations that require future research to advance its key arguments. First, although patent data provided rich information about the path of knowledge creation and flow, they only encompass one type of organizational knowledge. This leads to some inherent limitations that might raise questions about the validity of our measurement of firm-specific knowledge and constrain the interpretation of our results. For example, patent examiners' contribution to citations listed in issued patents could complicate interpretation of findings and raise the concern regarding the extent to which patent citations, in

general, and self-citations, particularly, accurately reflect firm knowledge flow (e.g., Alcacer and Gittelman, 2006; Alcácer, Gittelman, and Sampat, 2009). Although we have, as supplementary analysis, explored alternative measures of firm-specific knowledge at both firm- and industry-levels, they have their own disadvantages, and are thus not ideal proxies. Future research may consider using survey or other field data to explore organizational knowledge and firm-specificity more broadly by including other types of knowledge assets.

Second, there might be two mechanisms at work, and both may lead to a lower rate of CEO dismissal associated with firm-specific knowledge. The first, which is also our article's main argument, is that the board has a strong intention to make an *ex ante* commitment to a lower likelihood of CEO dismissal. On the other hand, once the CEO invests in specialized human capital, firms may find that the replacement cost is higher. In addition, a higher level of firm-specific knowledge may promote CEO entrenchment, further making herself less likely to be dismissed. Since the replacement cost and the entrenchment power effect have been well documented in the prior literature (Crossland and Chen, 2013; Shen and Cannella, 2002; Zhang, 2008), we do not theoretically emphasize their impact in our article. But we admit that both mechanisms may be at play and the current study does not fully distinguish them empirically, despite our efforts to control the effect of CEO power by including variables such as CEO tenure and CEO duality. However, our inclusion of the other dependent variable, CEO compensation with restricted stocks, to some extent mitigates such a concern as CEO compensation reflects more of an *ex ante* arrangement. Future studies may consider a different research design that helps to tease out these two mechanisms more directly. In addition, one implication of our key arguments and findings is that for firms with firm-specific knowledge, the decision to retain rather than dismiss their CEOs should positively affect their financial performances. While our study focuses on the antecedents of such a decision, future research may examine how firm-specific knowledge may affect the consequences of retaining versus dismissing CEOs in terms of firm performance outcomes.

Third, as the first study establishing a connection between firm-knowledge structure and CEO-employment arrangement (the extent of

compensation with restricted stocks and the likelihood of CEO dismissal), this study only looks at one contextual factor—the level of diversification—that moderates our proposed relationships. Future studies may examine other internal firm-level and external environmental factors that are expected to influence the effect of firm-specific knowledge on CEO compensation and dismissal. Another interesting area of research would be integrating the effect of managerial incentives with that of human biases in order to draw richer managerial implications. For example, studies could investigate how escalation of commitment by CEO and/or the board of directors affect CEO compensation and the likelihood of dismissal, and how such a bias may influence the role of firm-specific knowledge in CEO compensation and dismissal.

By pointing out the effects of firm-knowledge structure on CEO compensation and the likelihood of CEO dismissal, via its influence on managerial incentives to make firm-specific investments, this study reemphasizes the importance of strategic commitment and incorporating managerial incentives in resource-based strategic decision making. It is hoped that this study will constitute another step toward a better understanding of the effect of knowledge resources on strategic decision making.

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APPENDIX

Table A1. Succession type and FSK-dismissal relationship^{a,b}

Variables	CEO dismissal with outside succession	CEO dismissal with inside succession
Firm-specific knowledge	−4.783* (2.233)	−0.955 (1.785)
Industry-adjusted stock return	−1.218*** (0.305)	−0.187 (0.115)
Control variables	Included	Included
Observations	4390	4390
Pseudo R-squared	0.0811	0.0811
Log likelihood	−1710	−1710
Wald chi-square	226.8	226.8

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$

^bControl variables are not reported to save space.