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# INNOVATIVE KNOWLEDGE ASSETS AND ECONOMIC PERFORMANCE: THE ASYMMETRIC ROLES OF INCENTIVES AND MONITORING

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**We posit that a firm's resource configuration constitutes a critical context for various corporate governance mechanisms. Although innovative knowledge assets are generally a key determinant of a firm's economic performance, they also lead to greater information asymmetry among managers and owners and to the need to grant managers more discretion in making resource deployment decisions. This weakens the role of monitoring but increases the effectiveness of incentive mechanisms. Therefore, we hypothesize asymmetric moderating effects of monitoring- and incentive-based governance mechanisms on the relationship between innovative knowledge assets and economic performance. Our empirical analyses provide support for the key arguments.**

A contention of the resource-based view of firms is that heterogeneity in their resources and capabilities can best explain performance differences among firms (Barney, 1986, 1991; Dierickx & Cool, 1989; Mahoney & Pandian, 1992; Peteraf, 1993; Teece, Pisano, & Shuen, 1997; Wernerfelt, 1984). A key proposition of this view is that resources that are valuable, rare, and costly to imitate or substitute can be sources of sustainable competitive advantage (Barney, 1991). Among various types of firm resources, innovative knowledge assets, because of their novelty, tacitness, and firm specificity, are often regarded as possessing such strategic characteristics, thus offering the possibility of significant performance advantages (Coff, 1999; Grant, 1996; Kogut & Zander, 1992; McGrath, Tsai, Venkataraman, & MacMillan, 1996).

However, the same characteristics of innovative knowledge assets that often enable them to be sources of performance advantages can also lead to high levels of information asymmetry among managers and owners; as a result, the process of deploying these assets is potentially plagued with high

agency costs (i.e., costs resulting from misalignment of managers' and owners' interests). It then follows that corporate governance mechanisms, which are typically installed to channel managers' motivations toward the interests of a firm's owners, may critically affect the extent to which a firm's innovative knowledge can reach its full potential for value creation. Nevertheless, researchers in the areas of firm resources and innovation have generally assumed away the corporate governance issues associated with firms' accumulating and deploying innovative knowledge assets.

On the other hand, research on corporate governance has mainly focused on identifying mechanisms that help reduce the agency costs resulting from the conflict of interests among a firm's managers and its owners (Beatty & Zajac, 1994; Rediker & Seth, 1995; Zajac & Westphal, 1994). Many previous studies have directly examined the organizational consequences of these mechanisms, including their impact on firms' strategic choices (Amihud & Lev, 1981; Baysinger, Kosnik, & Turk, 1991; Sanders & Carpenter, 1998; Sanders & Hambrick, 2007) and economic performance (Core, Holthausen, & Larcker, 1999; Dalton, Daily, Ellstrand, & Johnson, 1998; Hermalin & Weisbach, 1998). Yet, despite the extensive literature in this area, little research has directly examined the relationship between corporate governance and firm resource configurations. This lacuna is also surprising because managers, as a firm's decision-making specialists, directly control the way in which firm resources are deployed. Inefficient use of firm resources should thus be a key indicator of agency problems (Fama, 1980; Jensen, 1986). The extent to

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which the “rent-generating” potential of a firm’s resources is fully realized will depend on the effectiveness of its corporate governance mechanisms in deterring unproductive resource deployment by managers. A firm’s resource configuration thus constitutes the fundamental context for evaluating its corporate governance, and unique challenges to corporate governance may arise from different resource configurations.

Therefore, in this study, we intend to bring these disjointed research streams together by examining the roles of corporate governance mechanisms in the efficient deployment of firm innovative knowledge assets. We emphasize that increased information asymmetry among a firm’s managers and its owners, as well as the need for greater managerial discretion, are prominent in the process of deploying these assets. How to effectively control the resource deployment process thus can be a significant challenge to corporate governance. Unless corporate governance mechanisms are tailored to a firm’s particular resource configuration, the performance advantages associated with innovative knowledge assets may not be fully realized.

Firm-level corporate governance mechanisms mainly involve monitoring and incentives, corresponding respectively to the ideas of contract enforcement and interest inducement (Zajac & Westphal, 1994). Researchers usually view these two types of mechanisms as either substitutes or complements, implying that either monitoring or incentive alignment will bring benefits to principals, even though the presence of one mechanism may either enhance or override the effect of the other (Rediker & Seth, 1995; Tosi, Katz, & Gomez-Mejia, 1997; Zajac & Westphal, 1994). However, considering that firm resource configuration is a key corporate governance context, monitoring may not be effective in dealing with the governance challenges associated with innovative knowledge assets. Close monitoring by outsiders is not only ineffective for reducing the information asymmetry among managers and owners; it may even become counterproductive, as it will tend to constrain managerial discretion, which is necessary for the efficient deployment of a firm’s innovative knowledge assets. In contrast, high levels of information asymmetry among managers and owners are likely to increase the effectiveness of incentive alignment. Thus, the roles of the two broad governance mechanisms, monitoring and incentives, may be asymmetric in dealing with the agency concerns associated with deploying innovative knowledge assets.

This article is an attempt to make several contributions to the literature. First, by arguing that a firm’s resource configuration is a key context for

understanding the role of corporate governance, we expand the contingency view of corporate governance mechanisms, which has primarily focused on risk and strategic complexity as the key contingencies (Zajac & Westphal, 1994). Second, although different governance mechanisms are generally considered to be substitutes or complements (Rediker & Seth, 1995; Tosi et al., 1997; Zajac & Westphal, 1994), we emphasize their asymmetry here, providing an alternative view that has been overlooked in previous governance research. Third, this study is one of the first to examine how corporate governance and firm resources *jointly* affect a firm’s economic performance, an approach that scholars holding the resource-based view of the firm have suggested as highly necessary and promising (Gottschalg & Zollo, 2007; Makadok, 2003; Wang & Barney, 2006).

## BACKGROUND AND HYPOTHESES

### Innovative Knowledge Assets and Firm Economic Performance

According to the resource-based view of the firm, performance differences among firms can best be explained by differences in the value, rarity, inimitability, and nonsubstitutability of their resources (Barney, 1991). A central argument of the knowledge-based view of the firm, an extension of the resource-based view, is that differences in the knowledge bases and innovative capabilities of different firms are the main determinants of differences in their performance (Grant, 1996; Kogut & Zander, 1992). Among various types of firm knowledge, innovative knowledge assets, which may include information, know-how, and technologies that help a firm improve its product effectiveness and process efficiency, have the very characteristics of resources that are able to bring superior performance to a firm (Hoetker & Agarwal, 2007; McGrath et al., 1996).

Because the efficient operation of a firm requires congruence between the firm’s product and knowledge domains (Grant, 1996), a strong innovative knowledge base can increase a firm’s rent generation potential by strengthening its ability to take advantage of opportunities in product markets (Gopalakrishnan, 2000). Also, innovation in the form of a unique and superior combination of firm resources may introduce “creative destruction” to the competitive landscape and bring considerable benefits to the innovating firm (Schumpeter, 1934). Innovation can thus be a fundamental force that drives a firm’s exploitation and exploration in the

marketplace, resulting in positive economic performance for the firm (Griliches, 1990; Hall, 2000).

Usually, intensive investment in R&D can help a firm maintain an ample stock of innovative knowledge assets, which are often traceable, at least in part, through the firm's patenting history (Hoetker & Agarwal, 2007). Although rival firms may imitate certain codifiable but nonpatented innovative outputs, often much of a firm's innovative knowledge can be an "isolating mechanism" deterring rivals from appropriating economic returns through imitation (Mahoney & Pandian, 1992; Rumelt, 1984). The difficulty in imitating a firm's innovative knowledge is apparent from both the process of accumulating innovative knowledge and that of applying such knowledge toward productive use. First, the process of accumulating innovative knowledge is usually highly path (history) dependent and firm specific (Dierickx & Cool, 1989; Helfat, 1994). As a result, innovative knowledge is often tacit and idiosyncratic (Zander & Kogut, 1995). Most innovative knowledge assets are accumulated internally, over time, through routinized organizational mechanisms (Nelson & Winter, 1982) that help prevent value appropriation by potential imitators. Also, a continuous focus on accumulating innovative knowledge assets increases a firm's absorptive capacity, putting it in a better position to transform strategic inputs into valuable products or services (Cohen & Levinthal, 1990; Kor & Mahoney, 2005).

Second, the outcome of innovative knowledge can also prove difficult for other firms to imitate. Apart from protective mechanisms such as copyrights and patents, the idiosyncratic features of a firm make replication difficult if other firms do not have access to the asset configuration to which the innovative knowledge was applied (Helfat, 1994). Moreover, innovative knowledge assets can also provide superior insight and access with regard to firm-specific investment opportunities, as other firms may not have full information about the potential value of such investments (Alchian & Demsetz, 1972; McGrath et al., 1996).

In line with these arguments, previous empirical studies (DeCarolis & Deeds, 1999; D'Este, 2005; Geroski, Machin, & Van Reenen, 1993; Roberts & Amit, 2003) have generally demonstrated that variations among firms in their rates of accumulating new knowledge, and in their stocks of innovative knowledge assets, contribute to differences in the financial performance of these firms. For example, using a sample of U.S. biotechnology firms, DeCarolis and Deeds (1999) found that both stocks and flows of organizational knowledge had a positive impact on firm performance. Research has

shown similar positive effects of innovative inputs and outputs on performance in various other geographical and industrial settings, such as Australian retail banking (Roberts & Amit, 2003), Spanish pharmaceuticals (D'Este, 2005), and U.K. manufacturing (Geroski et al., 1993). Therefore, to facilitate further discussion on the role of corporate governance mechanisms in the deployment of firm innovative knowledge assets, we first submit the following baseline hypothesis:

*Hypothesis 1. Ceteris paribus, a firm's level of innovative knowledge assets is positively related to its economic performance.*

### **Governance Challenges for Innovative Firms and Possible Solutions**

Although a firm's knowledge base is often widely distributed through its entire workforce, the CEO and other top managers usually play a critical role in guiding the allocation, recombination, and exploitation of innovative resources (Castanias & Helfat, 1991, 2001; McGrath et al., 1996). "As resources devoted to innovation increase, the potential impact of the CEO on a firm's relative success or failure also increases" (Balkin, Markman, & Gomez-Mejia, 2000: 1119). Top managers' intimate experience with the firm's products and technologies is often highly valuable for managing the complexity and ambiguity associated with the deployment of innovative knowledge resources (Kor & Mahoney, 2005). Moreover, top managers' tacit knowledge of key employees' expertise and interests can help the firm match its limited financial and human resources more productively with its innovative knowledge base. As Coff explained,

He/she must organize and coordinate employees to generate rent in the context of causal ambiguity, social complexity, and tacit knowledge—a formidable task. The manager must develop systems that mitigate the information dilemmas associated with strategic resources. This includes identifying key complementary skills, making decisions under extreme ambiguity, and retaining people who are central to rent-generating capabilities. (1999: 123)

Therefore, although the detailed technical aspects of a firm's knowledge stock may be embodied in individual employees, transferring that knowledge into competitive advantage requires highly firm specific management skills and largely remains under the influence of top managers.

On the other hand, according to agency theory (Fama, 1980; Jensen & Meckling, 1976), in the absence of appropriate corporate governance mechanisms, managers may engage in actions that deviate

from the enhancement of firm value and shareholder wealth, diverting firm resources toward inefficient investments or away from investments that are needed (Seth, 2004). Examples include managers' pursuit of pet projects, overspending on advertising, suboptimal investment in product development, and shirking (Gomez-Mejia, Larrazakintana, & Makri, 2003). Thus, appropriate corporate governance mechanisms should channel managerial effort toward efficient deployment of resources. In this sense, corporate governance can be viewed as a "valve" installed to channel the flow of firm knowledge assets toward efficient deployments. Conversely, inappropriate governance mechanisms can hinder the efficient deployment of knowledge assets by misaligning managers' interests or by inappropriately constraining their decision making.

Two critical features of innovation-intensive firms are predominantly relevant to the erection of appropriate corporate governance mechanisms: (1) there is often a high degree of *information asymmetry* between owners and managers with regard to efficient ways to create value from a firm's resources, and (2) substantial *managerial discretion* is needed for making decisions about the deployment of innovative knowledge assets. Although the extent of information asymmetry and managerial discretion is generally not directly observable, these underlying concepts have important implications for understanding the effectiveness of various corporate governance mechanisms in firms with high levels of innovative knowledge assets.

Information asymmetry is usually considered a key source of agency problems. Managerial opportunism is more likely when a principal has little reliable information with which to evaluate an agent's motivation and ability to serve the principal's interests, as well as the appropriateness of the agent's decisions (Eisenhardt, 1985; Ouchi, 1980). The owners, as outsiders to the resource deployment process, normally do not have the firm-specific information and skills that top managers have, including their intimate experience with a firm's products and technologies and their knowledge of key employees' expertise and interests (Kor & Mahoney, 2005). Although, in general, owners can use various signals or "surveillance mechanisms" (Eisenhardt, 1985), such as the intensity of R&D activity, product launches, and short-term financial consequences, to evaluate managers' decisions and performance, for firms with high levels of innovative knowledge, such signals are likely to be rather noisy (Balkin et al., 2000; Gomez-Mejia et al., 2003). The same tacitness, path dependency, and firm specificity that make innovative knowledge a

promising source of superior performance can also challenge firm owners in interpreting these typical signals.

Information asymmetry also increases the need for managerial discretion in innovation-intensive firms. In the management literature, managerial discretion refers to the "latitude of actions" that allows managers to choose from a wide range of strategic options in deploying firm resources (Hambrick & Finkelstein, 1987; Shen & Cho, 2005). Such discretion is particularly important in firms with high levels of innovative knowledge assets because of the ambiguity in decision making prevalent in such firms. As Hambrick explained, managerial discretion is likely to be important "when means-ends ambiguity is great, that is, when there are multiple plausible alternatives" (2005: 119). This describes innovation-intensive firms, in which it is often necessary for top managers to have substantial flexibility and power in decision making.

But from the agency-theoretic perspective, such greater latitude in decision making also gives managers more freedom to pursue self-interested agendas (Gomez-Mejia et al., 2003; Jensen & Meckling, 1976; Shen & Cho, 2005). Therefore, the challenge is to grant managers sufficient discretion to make strategic decisions that facilitate the efficient deployment of a firm's innovative knowledge while limiting their motivation to pursue self-interested goals at the owners' expense. Solutions normally rely on two fundamental mechanisms of corporate governance: monitoring and incentives (Rediker & Seth, 1995; Tosi et al., 1997; Zajac & Westphal, 1994). In the sections that follow, we develop the argument that incentives are often the more suitable mechanism in an innovative environment, where overreliance on monitoring may hinder the full exploitation of a firm's innovative knowledge assets.

***Innovative knowledge assets and monitoring.*** Monitoring refers to "observation of an agent's effort or outcomes that is accomplished through supervision, accounting controls, and other devices" (Tosi et al., 1997: 588). Monitors oversee the activities of top managers to ensure they behave in a way that is consistent with the interest of the owners. But monitoring is not without costs, because monitors must collect, process, and analyze the information they need. Indeed, monitoring costs can be prohibitively high if the monitors have great difficulty in observing specific decision-making and implementation processes and, moreover, in interpreting what they observe.

Success in monitoring thus depends on the information characteristics of the specific management task that is to be monitored (Coff, 1999). Information asymmetry becomes particularly acute

when the task involves deploying a firm's innovative knowledge. The firm-specific and ambiguous nature of strategy formulation and implementation in such a context challenges monitors to find clear signals or indicators that can reliably assess management's effort and performance (Baysinger & Hoskisson, 1990). Furthermore, not only will monitoring be more expensive and less effective in highly innovative firms, but also, close monitoring may do more harm than good. Monitoring in innovation-intensive firms is inevitably based on limited information, poor assessment of managerial behavior, or myopic financial criteria. These limitations can make monitoring into counterproductive interference that negatively affects the quality of managers' decisions (Burkart, Gromb, & Panunzi, 1997). In such situations, excessive monitoring may inhibit managers from exercising the discretion necessary for effective strategy formulation and implementation. Therefore, instead of monitoring managers closely, it is sometimes preferable to grant them much discretion in making resource deployment decisions (Hambrick & Finkelstein, 1987).

In modern corporations, it is primarily the boards of directors (Demsetz & Lehn, 1985) and large shareholders (Rediker & Seth, 1995; Zajac & Westphal, 1994) who monitor the top managers. In the case of a board of directors, nonexecutive outsider representation is generally considered a key force for effective monitoring, mainly because "outside directors" have fewer conflicts of interest than "inside directors" and may be better able to objectively assess managers' strategy and performance (Fama, 1980). However, such monitoring may be less effective in a highly innovative firm because of the high information asymmetry between the top managers and outsiders and the prohibitive cost of outsiders reducing such asymmetry. Having more insiders on the board, on the other hand, can preserve some of the managerial discretion necessary for optimum value creation from knowledge assets (Hambrick & Finkelstein, 1987). In addition, more insiders can help reduce the information asymmetry among top managers and the board (Aguilera, 2005; Baysinger & Hoskisson, 1990). As Baysinger and Hoskisson pointed out, "Insiders, because they are participants in the decision processes, have access to information that is relevant to assessing managerial competence and the strategic desirability of initiatives, regardless of their short-run or long-run performance outcomes" (1990: 77).

For similar reasons, other forms of monitoring, such as that by large outside shareholders, who have conventionally been considered guardians of firm resources (Demsetz & Lehn, 1985; Hartzell & Starks, 2003), may also have little or even a nega-

tive impact on the deployment of innovative resources toward value creation. Although large outside shareholders have a strong interest in maximizing the value of their investments, their lack of firm-specific information with regard to the often-ambiguous process of creating value from innovative knowledge assets may limit their ability to play a constructive role. Thus, monitoring by large outside shareholders based on noisy signals may in fact result in much counterproductive interference.

Another structural arrangement often considered relevant to the actual degree of monitoring is CEO duality, which occurs when a firm's CEO also chairs its board of directors. Generally speaking, if a CEO is also chairperson, a board's monitoring role will be compromised, as it will be easier for the CEO to entrench other members of the board (Boyd, 1995; Finkelstein & D'Aveni, 1994). However, for firms with high levels of innovative knowledge, CEO duality may bring benefits, as such an arrangement eliminates from the leadership structure a potential source of unnecessary interference (Finkelstein & D'Aveni, 1994). The unity of command that is associated with unified leadership may thus become desirable, as the CEO-chairperson can more effectively implement assertive decisions based on his or her professional judgment of the most productive use of the firm's knowledge assets.

In summary, governance arrangements intended to facilitate monitoring, such as outsider representation on a board and the presence of large outside shareholders, may not be suitable for innovation-intensive firms. Such mechanisms are likely to be ineffective or even counterproductive for such firms. Similarly, separation of the CEO and chairperson positions (i.e., the opposite of CEO duality) is usually associated with a high degree of monitoring and thus is also expected to negatively influence the deployment of innovative knowledge assets. We therefore propose:

*Hypothesis 2. Monitoring governance mechanisms, including the presence of large outside shareholders, outsiders on a board, and separation of the CEO and chairperson positions, dampen the relationship between a firm's innovative knowledge assets and economic performance.*

**Innovative knowledge assets and incentives.** According to agency theory, incentive-based governance motivates managers to serve owners' interests by directly linking the managers' personal gains with a firm's performance. Appropriate financial incentives can forge a common economic bond between managers and shareholders (Jensen & Meckling, 1976), thus motivating managers to de-

vote their best efforts to improving a firm's short-term and long-term performance. Managerial equity ownership and managerial compensation contingent on firm performance are the two most prevalent examples of incentive-based corporate governance mechanisms (Beatty & Zajac, 1994; Zajac & Westphal, 1994). As discussed earlier, in firms with high levels of innovative knowledge assets, monitoring by external forces can prove to be ineffective or even counterproductive. Appropriate incentives are thus necessary to encourage managers to watch their own behavior in a way that benefits both themselves and their firm's owners (Balkin et al., 2000; Gomez-Mejia et al., 2003). Incentive-based mechanisms are therefore of greater importance in a governance context featuring high levels of innovative knowledge assets.

In addition, from the perspective of property rights (Demsetz, 1967; Libecap, 1989), linking managerial financial gain to firm performance—especially in the form of equity ownership rights—is particularly meaningful for innovating firms. Because innovation processes are highly firm specific and path dependent, firms often have heterogeneous stocks of innovative knowledge assets (Hoetker & Agarwal, 2007). This heterogeneity often requires top managers to make significant firm-specific human capital investments that have limited value in the general labor market (Castanias & Helfat, 1991; Zingales, 2000). In such situations, equity ownership rights represent residual rights of control, which can give managers some bargaining power with respect to the distribution of rents and motivate them to invest in developing firm-specific “human capital” in the most productive way (Grossman & Hart, 1986; Hart & Moore, 1990; Hartzell & Starks, 2003). Moreover, residual rights of control by top managers can increase the level of permissible managerial discretion, which can further facilitate rent generation from innovative knowledge assets.

We ought to note, however, that incentive-based governance also has its costs. Compensating managers using stock options, for example, may lead to excessive risk taking, as managers are more likely to bet firm resources into big losses, being motivated by unlimited upside profit but minimal downside potential for option holders (Sanders, 2001; Sanders & Hambrick, 2007). In addition, managers with performance-based pay and large share holdings may attempt to manipulate short-term performance measures and their firm's stock price to increase their own wealth at the expense of long-term shareholder benefits (Zahra, Priem, & Rasheed, 2005). These arguments suggest that incentive-based corporate governance does not perfectly solve all the agency problems in firms. Its use

should thus require great caution and complementary control. This need may also explain why, in general, firms often adopt monitoring and incentive-alignment mechanisms simultaneously.

However, because of the inefficacy of monitoring-based governance in these firms, as well as the greater need for them to enlist managers' firm-specific human capital investments, shareholders of highly innovative firms may still find it beneficial to rely heavily on incentive-based compensation contracts, despite their potential costs. In contexts with high levels of innovative knowledge assets, as the benefits of exploring wealth-creating opportunities are likely to be high for both a firm and its top managers, managers may be more motivated to respond to incentive-based governance by devoting themselves to the efficient deployment of these innovative assets (Gomez-Mejia et al., 2003). On the other hand, in less-innovative contexts, where such wealth-creating opportunities are less apparent, managers might be more likely to respond inappropriately to incentive-based pay schemes by, for example, taking on excessive risk in the case of stock option plans (Sanders & Hambrick, 2007). They may also be more likely to indulge in other forms of misconduct, such as accounting manipulation. Indeed, technology-oriented and innovative start-up companies often rely heavily on stock options as a form of compensation for their top managers (Kim & Nofsinger, 2007).

Because a CEO plays a key role among a firm's top managers, and because CEO compensation usually mirrors the incentives provided to managers and other employees (Balkin et al., 2000), it may be appropriate to focus on the incentives provided to CEOs when examining the effects of incentive-based governance. Considering both the benefits and potential costs of incentive-based governance mechanisms, we propose the following:

*Hypothesis 3. Incentive-based corporate governance mechanisms, including equity ownership by a firm's CEO and CEO contingency pay (i.e., the components of CEO compensation that are directly related to firm value) strengthen the relationship between a firm's innovative knowledge assets and its economic performance.*

## RESEARCH SETTING AND METHODS

### Data and Sample

We combined U.S. patent data and several Standard & Poor's COMPUSTAT data sets, including Industrial Annual, Executive Compensation, Blockholders, and IRRC's Directors data, to

test our hypotheses. To keep the industry backgrounds comparable while not losing too much generality, we included data on manufacturing firms with four-digit SIC codes ranging from 2000 to 3999 in the analysis. We focused on manufacturing firms because technology competition and patenting, which reflect the level of firm innovative knowledge assets, are more important in manufacturing than in service firms. Thus, we began our sample selection with the group of firms in manufacturing industries that were listed simultaneously in the COMPUSTAT Executive Compensation (ExecuCom), Blockholders, and IRRC board composition data sets. The former is a database on executive compensation covering 2,698 companies from 1992 to 2005. The latter two data sets contain standardized data about blockholders and board composition that start in 1996. To increase the final sample size, we additionally extracted blockholders and board composition data for the years 1994 and 1995 based on firms' proxy statements.

Hall, Jaffe, and Trajtenberg (2001) created a data file with detailed information on almost 3 million U.S. patents granted between 1963 and 1999 and on over 16 million citations of these patents granted between 1975 and 1999. We used this data set to construct our patent-based measures of firm innovative knowledge assets. Because our unit of analysis was the firm, we aggregated the patents and their citation counts to the firm level (Rosenkopf & Nerkar, 2001). In addition, we extracted R&D expenditure as well as other firm and industry information from COMPUSTAT's Industrial Annual data.

Since each data set spanned several years, we were able to construct a panel data set based on the overlapping periods. As a result, the total number of observations used for analysis was 736 for the data period 1994–99. When we used the lagged structure in the two-stage models, our final sample in the second-stage model, consisting of 215 firms and 546 firm-year observations, covered the period 1996–99. Of the 215 firms, 49 had four years of observations, and 73 had three years. The rest of the firms (93 of them) had observations for either one or two years.

## Measurements

**Firm economic performance.** Following the lead of previous studies (Griliches, 1990; Hall, 2000; Jaffe, Trajtenberg, & Henderson, 1993), we used market value to represent each firm's economic performance (Montgomery & Wernerfelt, 1988). Unlike return on assets, the market value of a firm is forward looking, as it incorporates stock market expectations about future returns. It thus better

captures a firm's financial performance when long-term investments such as R&D expenditures are crucial to evaluating the firm's performance and the bias of accounting measures is likely to be severe (Lindenberg & Ross, 1981; Ross, 1983). We further adjusted the measure by the book value of a firm's total assets. Thus, our proxy for economic performance was the market-to-book ratio, in which the market value numerator was the year-end market value of a firm's common stock plus the book value of its preferred stock and debt, and the book value denominator was year-end total assets. Furthermore, following previous studies (Griliches, 1981; Hall, Jaffe, & Trajtenberg, 2005; Hirsch & Seaks, 1993), we conducted a logarithm transformation of market-to-book value. As Hirsch and Seaks explained, one key theoretical rationale for the logarithm transformation is that "intangible capital has a fixed cost and thus is likely to have multiplicative rather than additive effects on value" (1993: 382). In addition, the estimation equation with a logarithm transformation might be preferable to the linear form because the former "dampens the influence of observations with extreme and mismeasured values" (Hirsch & Seaks, 1993: 382).

**Innovative knowledge assets.** To capture a firm's level of innovative knowledge assets, we first constructed a patent-citation-based measure. Specifically, we employed the total citations of the cumulative numbers of patents that a firm possessed. Previous studies have shown that patent citations are a better measure of the level of a firm's innovative knowledge assets than a simple patent count (Hall, 2000).

On the other hand, patented knowledge may represent only a subset of a firm's innovative knowledge assets (Tabak & Barr, 1998). To mitigate this concern, we employed R&D intensity as an alternative proxy for innovative knowledge assets. Previous studies (Griliches, 1990; Jaffe et al., 1993) have treated investment in R&D as an innovation input and an important determinant of the intangible component of market value. Thus, we expected investment in R&D to positively contribute to the output or stock of a firm's innovative knowledge assets (DeCarolis & Deeds, 1999). To obtain this measure, we scaled each firm's yearly R&D expenditure by the firm's total assets.<sup>1</sup>

<sup>1</sup> We also conducted robustness tests by using a composite measure of firm innovative knowledge assets based on both R&D expenditures and patent citations (Balkin et al., 2000) and by including R&D expenditures simply as a control variable in models with patent cita-



In addition, the resource-based view of the firm also emphasizes that *firm-specific* knowledge is particularly important for helping a firm sustain its competitive advantage (Helfat, 1994; Henderson & Cockburn, 1994). This is because firm-specific knowledge, which by definition is not perfectly deployable in other firms, effectively prevents rivals from appropriating innovation rents through imitation (Mahoney & Pandian, 1992; Rumelt, 1984). However, when a high proportion of a firm's knowledge assets is firm specific, the information asymmetry among managers and owners is also likely to increase. In addition, greater managerial discretion will be necessary when managers make strategic decisions with regard to the deployment of firm-specific knowledge assets. Thus, the counterproductive effects of monitoring-based governance and the benefits of incentive-based governance will be more apparent for firms with high levels of *firm-specific* innovative knowledge.

Therefore, we constructed a measure of firm-specific innovative knowledge assets by taking further advantage of the patent citation data. If patents represent knowledge creation, and patent citations represent knowledge flows and subsequent impact (Jaffe et al., 1993), a firm's citing its own previous patents indicates the degree to which the patented knowledge is economically valued internally (Hoetker & Agarwal, 2007). Therefore, on the basis of patent citation data from 1975 to 1999, we derived a proxy for the level of firm-specific innovative knowledge using the percentage of prior patent citations that were self-citations. This measure was further scaled by the overall frequency of those patents' being subsequently cited by the focal company vis-à-vis by other companies:

*Firm-specific innovative knowledge = focal firm's self-citations as a percentage of all its patent citations × focal firm's citations of prior self-citations as a percentage of all the citations of focal firm's self-citations.*

We added the third factor, specifying the extent to which a firm subsequently self-cites its previously self-cited patents, to take into account the firm specificity of the firm's prior patented knowledge. A firm may cite its own previous patents, but if these previous patents are also widely cited by other firms (which will make the weight very

small), the degree of firm specificity in the knowledge should be discounted.<sup>2</sup>

**Corporate governance variables.** We adopted three measures of monitoring mechanisms that previous researchers have widely employed in empirical governance studies (Dalton et al., 1998; Rediker & Seth, 1995; Zahra & Pearce, 1989; Zajac & Westphal, 1994). These were outsider representation on the board of directors, the presence of large outside blockholders, and CEO duality. Following previous studies, we measured outsider representation on the board by the percentage of independent outside directors. We measured the presence of large outsider blockholders by the percentage of shares held by outside shareholders with greater than 5 percent shareholding. CEO duality was a dummy variable set equal to 1 when a firm's CEO also chaired the board of directors.

We measured two important aspects of incentive-based corporate governance: CEO equity ownership and CEO contingency pay (Miller, Wiseman, & Gomez-Mejia, 2002; O'Connor, Priem, Coombs, & Gilley, 2006; Rediker & Seth, 1995). We measured CEO equity ownership as the shares of a company's common stock held by its CEO. We measured CEO contingency pay as the proportion of bonuses, long-term incentive payments, and stock options in the CEO's total compensation (Miller et al., 2002).

**Other control variables.** We included firm size, firm age, advertising expenditure, debt ratio, and CEO tenure as control variables, as these variables are often thought to also have performance implications. Previous research has established that firm size plays an important role in explaining market returns. The natural logarithm of the total number of employees was our proxy for firm size (Judge & Zeithaml, 1992; Tuschke & Sanders, 2003), given the evident positive skewness in this variable. Firm age, as measured by the number of years since a firm's initial public offering, may influence financial performance because it captures differences in competitiveness and agency conflicts associated with history (Claessens & Djankov, 1999). Advertising intensity reflects a firm's brand assets, a critical intangible resource that contributes to a firm's market value (Batra, Lehmann, Burke, & Jae, 1995; Kor & Mahoney, 2005). We measured advertising intensity similarly to R&D intensity, scaling each firm's yearly advertising expenditure by the firm's total assets. In addition, corporate governance research suggests that leverage (the debt ratio) affects agency costs and thereby influences firm performance

tions as the measure of innovative knowledge assets. The key results were consistent with those reported in this article. Details of these analyses are available from the authors on request.

<sup>2</sup> We thank an anonymous reviewer for reminding us of this important point.

(Jensen, 1986). We measured a firm's debt ratio as the ratio of its total long-term debt to total assets.

We also controlled for CEO tenure, which we measured by the number of years an individual had been the CEO of a focal firm. Adding CEO tenure as a control variable is particularly meaningful in this context because a CEO's intimate, firm-specific experience has important implications for his or her ability to make efficient resource allocation decisions in a firm relying heavily on innovative knowledge assets (Kor & Mahoney, 2005). In the models in which the firm specificity of knowledge was a key explanatory variable, we also included total citations received as a control variable, to take into consideration differences among firms in their overall levels of innovation output. In addition, all the models controlled for time and industry fixed effects by incorporating dummies for the years and the industries at the three-digit SIC level.

### Analysis

Our main explanatory variables included firm innovative knowledge assets and corporate governance. To test the moderating effects of governance mechanisms on the performance implications of innovative knowledge assets, we included their interaction terms in the estimation model. Thus, if  $MV$  is the market value of a firm and  $A$  is the book value of this firm's total assets, the overall estimation model is expressed as follows:

$$\begin{aligned} \text{Log}(MV_i/A_i) = & \alpha_0 + \beta_1 \text{innovative knowledge}_i \\ & + \beta_2 \text{corporate governance}_i \\ & + \beta_3 \text{innovative knowledge}_i \\ & \times \text{corporate governance}_i + \beta_4 \text{controls}_i + \varepsilon_i. \end{aligned}$$

Please note that although we have omitted time subscripts here to avoid unnecessary complication of the equation, we lagged all right-hand variables by one year, taking into consideration a possible delay before the effects of a firm's investing in innovation and the erection of corporate governance mechanisms would be reflected in its economic performance. Our main focus of interest is  $\beta_1$ , which captures the direct effect of innovative knowledge on firm market value, and  $\beta_3$ , which captures the moderating effects of corporate governance.

Although our primary objective was to examine the relationship between innovative knowledge and economic performance and the moderating effects of corporate governance mechanisms on this relationship, it is quite likely that a firm's innova-

tive knowledge and corporate governance influence each other and, in addition, that they are both affected by a firm's past economic performance. For example, outside directors and institutional owners generally encourage long-term investments in R&D (David, Hitt, & Insead, 2001; Hill & Snell, 1989; Lee & O'Neill, 2003), whereas managers tend to make inadequate investments in R&D, especially when they are rewarded on the basis of short-term financial measures (Baysinger & Hoskisson, 1990). Moreover, the use of stock options may encourage CEOs to make investments with high variance (Sanders & Hambrick, 2007). On the other hand, a firm's investment patterns may also affect its corporate governance system. For example, previous studies have suggested that certain incentive-based mechanisms, such as CEO compensation, are influenced by a firm's R&D intensity (Gomez-Mejia et al., 2003; Sanders & Hambrick, 2007). Thus, both innovative knowledge and corporate governance variables are likely to be endogenous, and it was possible that factors affecting these variables could be correlated with the dependent variable, the firm's economic performance.

Therefore, we explicitly took into consideration the endogeneity of innovative knowledge and corporate governance mechanisms by adopting a series of two-stage models (Greene, 2000). The first-stage tests had the innovative knowledge and corporate governance variables (at time  $t - 1$ ) as the dependent variables, and other predictors (at time  $t - 2$ ) as independent variables. For example, for regressions with innovative knowledge as the dependent variable, the predictors included corporate governance variables, prior performance, firm size, firm age, debt ratio, and year and industry dummies. In addition, we included lagged innovative knowledge variables (at time  $t - 2$ ) as instruments. We obtained new variables by regressing the first-stage models. From the first-stage results, we found that, largely in keeping with our predictions, the corporate governance and innovative knowledge variables were significantly intercorrelated. Moreover, prior performance also had an influence on both corporate governance and innovative knowledge. The only exception was large outside shareholders, which showed no significant relationship with either innovative knowledge or prior performance.

The second stage had economic performance (at time  $t$ ) as the dependent variable, using the newly estimated variables and their interactions (at time  $t - 1$ ) as regressors. Because each equation included multiple endogenous variables, we used the newly estimated variables to *replace* the original endogenous variables (Kennedy, 2003). Note that although the second stage of a two-stage model is generally

TABLE 1  
Descriptive Statistics and Correlations<sup>a</sup>

Variables	Mean	s.d.	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Market value/total assets	0.73	0.49													
<i>Knowledge asset measures</i>															
2. Input: R&D intensity	0.05	0.05	.31*												
3. Output: Total citations received	0.39	4.05	.09*	.29*											
4. Firm-specific innovative knowledge assets	0.12	0.12	.14*	.10*	.02										
<i>Corporate governance variables</i>															
5. CEO shareholding	0.43	0.35	.24*	-.05	-.01	-.01									
6. CEO contingency pay	0.72	0.19	.31*	.14*	.04	.10*	-.02								
7. CEO duality	0.73	0.45	.03	-.15*	-.06	-.00	.07	.05							
8. Outside blockholders	8.90	9.39	-.19*	-.08*	.01	-.02	-.04	-.08	-.02						
9. Percentage of outsiders on board	68.8	15.7	.02	-.07	.04	.07	-.12*	.21*	.24*	-.20*					
<i>Other controls</i>															
10. Advertising intensity	0.01	0.04	.25*	.04	.05	.10*	.18*	.13*	.16*	-.04	.06				
11. Firm size	2.45	1.32	.07	-.15*	.03	.12*	.06	.27*	.22*	-.21*	.23*	.25*			
12. Firm age	19.9	14.8	.01	.07	.03	-.06	.03	.10*	.07	.11*	.02	.12*	.23*		
13. Firm debt	0.16	0.12	-.35*	-.25*	-.06	.04	.07	-.04	.05	.15*	.03	.01	.09*	.10*	
14. CEO tenure	6.19	7.47	.04	-.00	.03	-.12*	.17*	-.16*	.18*	-.02	-.14*	.03	-.06	.15*	.03

<sup>a</sup>  $n = 546$ . Market value/total assets, a logarithm, was measured at time  $t$ . The values for all other variables were measured at time  $t - 1$ .

\*  $p < .05$

an ordinary least squares (OLS) regression, using OLS to estimate panel data could result in biased estimates because of the potential presence of heteroskedasticity and autocorrelation (Greene, 2000). To address this concern, we ran the regression with panel-corrected standard errors (PCSEs).<sup>3</sup>

## RESULTS

Table 1 presents the descriptive statistics and correlation matrix for the key variables. Overall, no correlations among the explanatory variables and control variables were high enough to raise major concerns about multicollinearity. As expected, all three measures of innovative knowledge assets were significantly and positively correlated with firm economic performance. However, the correlations between the corporate governance variables and economic performance were somewhat ambig-

uous. For example, CEO equity ownership and contingency pay were positively correlated with firm economic performance, but the presence of outside blockholders was negatively correlated with performance. CEO duality and outsider representation on the board, however, were not significantly correlated with economic performance. We may interpret such an ambiguity as providing indirect insights into our basic theoretical position: Different governance mechanisms have asymmetric roles, and corporate governance should be examined in the context of a firm's resource configuration.

To test the joint effect of firm innovative knowledge assets and corporate governance on firm performance, we followed the usual procedure of testing moderating effects by first including the key independent and control variables and then running partial and full models with interactions. Because we employed three different measures of firm innovative knowledge assets, we conducted three separate analyses. Tables 2, 3, and 4 present the results.<sup>4</sup>

Table 2 confirms that the level of innovative knowledge input (R&D intensity) was a strong pre-

<sup>3</sup> Because some recent researchers (Kristensen & Wawro, 2003) have argued that PCSEs with lag specifications can be problematic if observation-specific effects are not properly controlled for, we also performed firm fixed-effect estimations as a robustness test. We obtained consistent results for several key variables of interest, although with somewhat weaker effects. Detailed results of the firm fixed-effect estimation are available from the authors on request.

<sup>4</sup> We do not report the first-stage results because we want to focus on the key second-stage results, but they are available from the authors on request.

**TABLE 2**  
**Results of Second-Stage PCSE Regression Analysis for Firm Economic Performance: Innovative Knowledge Input<sup>a</sup>**

Variables	Models						
	1a	2a	3a	4a	5a	6a	7a
Intercept	0.68*** (0.15)	0.67*** (0.15)	0.72*** (0.14)	0.70*** (0.15)	0.77*** (0.15)	0.68*** (0.15)	0.80*** (0.14)
Innovative knowledge input <sup>b</sup>	2.07*** (0.37)	2.04*** (0.37)	1.76*** (0.36)	2.16*** (0.37)	1.60*** (0.37)	2.18*** (0.37)	1.35*** (0.35)
Firm size	-0.01 (0.01)	-0.01 (0.01)	-0.02† (0.01)	-0.01 (0.01)	-0.02† (0.01)	-0.01 (0.01)	-0.02* (0.01)
Firm age	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)
Advertising intensity	2.27*** (0.52)	2.22*** (0.51)	2.14*** (0.50)	2.27*** (0.52)	2.13*** (0.50)	2.27*** (0.51)	1.90*** (0.48)
Firm debt	-1.45*** (0.14)	-1.41*** (0.14)	-1.41*** (0.13)	-1.48*** (0.14)	-1.43*** (0.14)	-1.40*** (0.14)	-1.28*** (0.13)
CEO tenure	0.00 (0.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
<i>Incentives</i>							
CEO shareholding		0.03*** (0.01)					0.04*** (0.01)
CEO shareholding × innovative knowledge input		0.25* (0.12)					0.84* (0.41)
CEO contingency pay			0.61*** (0.09)				1.67*** (0.08)
CEO contingency pay × innovative knowledge input			2.81* (1.36)				2.71* (1.35)
<i>Monitoring</i>							
CEO duality				0.05 (0.04)			0.05 (0.03)
CEO duality × innovative knowledge input				1.59** (0.66)			1.24* (0.62)
Outside blockholders					-0.01*** (0.00)		-0.01*** (0.00)
Outside blockholders × innovative knowledge input					-0.07† (0.04)		-0.06† (0.04)
Percentage of outsiders on board						0.00 (0.00)	0.00 (0.00)
Percentage of outsiders × innovative knowledge input						-0.07** (0.03)	-0.10*** (0.03)
Adjusted R <sup>2</sup>	.39	.42	.43	.41	.44	.40	.52

<sup>a</sup> n = 546. Industry and year control variables were included but are not reported. Standard errors are shown in parentheses.

<sup>b</sup> Measured as R&D intensity.

† p < .10

\* p < .05

\*\* p < .01

\*\*\* p < .001

TABLE 3  
Results of Second-Stage PCSE Regression Analysis for Firm Economic Performance: Innovative Knowledge Output<sup>a</sup>

Variables	Models						
	1b	2b	3b	4b	5b	6b	7b
Intercept	0.71*** (0.15)	0.70*** (0.15)	0.75*** (0.14)	0.73*** (0.15)	0.80*** (0.15)	0.70*** (0.15)	0.71*** (0.15)
Innovative knowledge output <sup>b</sup>	0.03*** (0.01)	0.02* (0.01)	0.03*** (0.01)	0.03*** (0.01)	0.03*** (0.01)	0.03*** (0.01)	0.03*** (0.01)
Firm size	-0.01 (0.01)	-0.02 (0.01)	-0.02 <sup>†</sup> (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Firm age	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)
Advertising intensity	2.25*** (0.53)	2.19*** (0.52)	2.07*** (0.50)	2.17*** (0.53)	2.05*** (0.52)	2.25*** (0.53)	2.25*** (0.53)
Firm debt	-1.66*** (0.14)	-1.60*** (0.14)	-1.65*** (0.13)	-1.68*** (0.14)	-1.58*** (0.13)	-1.69*** (0.14)	-1.66*** (0.14)
CEO tenure	0.00 (0.00)	0.00 (0.00)	0.00 <sup>†</sup> (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
<i>Incentives</i>							
CEO shareholding		0.03** (0.01)					0.17*** (0.04)
CEO shareholding × innovative knowledge output		0.06* (0.03)					0.29*** (0.11)
CEO contingency pay			0.59*** (0.09)				1.81*** (0.27)
CEO contingency pay × innovative knowledge output			0.13 <sup>†</sup> (0.07)				0.40 <sup>†</sup> (0.25)
<i>Monitoring</i>							
CEO duality				0.05 (0.04)			0.06 (0.11)
CEO duality × innovative knowledge output				0.05* (0.02)			0.12 (0.10)
Blockholders					-0.01*** (0.00)		-0.03*** (0.01)
Blockholders × innovative knowledge output					-0.00 (0.00)		-0.00 (0.00)
Percentage of outsiders on board						0.00 (0.00)	0.00 (0.00)
Percentage of outsiders × innovative knowledge output						-0.01* (0.00)	-0.01* (0.00)
Adjusted R <sup>2</sup>	.38	.41	.41	.40	.41	.39	.50

<sup>a</sup> n = 546. Industry and year control variables were included but are not reported. Standard errors are shown in parentheses.

<sup>b</sup> Measured as total citations received.

<sup>†</sup> p < .10

\* p < .05

\*\* p < .01

\*\*\* p < .001

TABLE 4  
Results of Second-Stage PCSE Regression Analysis for Firm Economic Performance: Firm-Specific Innovative Knowledge Assets<sup>a</sup>

Variables	Models						
	1c	2c	3c	4c	5c	6c	7c
Intercept	0.71*** (0.15)	0.73*** (0.15)	0.75*** (0.14)	0.73*** (0.15)	0.80*** (0.15)	0.72*** (0.15)	0.81*** (0.14)
Firm-specific innovative knowledge assets	0.52*** (0.13)	0.56*** (0.13)	0.45*** (0.13)	0.52*** (0.13)	0.48*** (0.13)	0.52*** (0.13)	0.33** (0.12)
Firm size	-0.01 (0.01)	-0.01 (0.01)	-0.02* (0.01)	-0.02 (0.01)	-0.03* (0.01)	-0.01 (0.01)	-0.03* (0.01)
Firm age	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)
Advertising intensity	2.50*** (0.53)	2.38*** (0.52)	2.39*** (0.50)	2.44*** (0.53)	2.25*** (0.51)	2.48*** (0.53)	1.99*** (0.47)
Firm debt	-1.64*** (0.14)	-1.59*** (0.14)	-1.56*** (0.13)	-1.65*** (0.14)	-1.55*** (0.13)	-1.64*** (0.14)	-1.42*** (0.13)
CEO tenure	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Total patent citations received	1.21* (0.48)	1.24* (0.47)	1.25* (0.48)	1.21* (0.49)	1.15* (0.48)	1.30* (0.50)	1.33* (0.52)
<i>Incentives</i>							
CEO shareholding		0.04*** (0.01)					0.03*** (0.01)
CEO shareholding × firm-specific knowledge assets		0.40** (0.15)					0.31* (0.14)
CEO contingency pay			0.70*** (0.09)				0.70*** (0.08)
CEO contingency pay × firm-specific knowledge assets			2.75*** (0.78)				2.33** (0.78)
<i>Monitoring</i>							
CEO duality				0.05 (0.04)			0.05 (0.03)
CEO duality × firm-specific knowledge assets				0.59* (0.29)			0.52† (0.27)
Blockholders					-0.01*** (0.00)		-0.01*** (0.00)
Blockholders × firm-specific knowledge assets					-0.05** (0.02)		-0.04** (0.01)
Percentage of outsiders on board						0.00 (0.00)	-0.00 (0.00)
Percentage of outsiders × firm-specific knowledge assets						-0.01† (0.00)	-0.01* (0.00)
Adjusted R <sup>2</sup>	.38	.41	.42	.39	.42	.39	.49

<sup>a</sup> n = 546. Industry and year control variables were included but are not reported. Standard errors are shown in parentheses.

† p < .10

\* p < .05

\*\* p < .01

\*\*\* p < .001

dictor of firm economic performance. The coefficients were consistently positive and significant ( $p < .001$ ). Therefore, Hypothesis 1 was supported when we used R&D intensity as the measure of firm innovative knowledge assets. As our main focus was the joint effect of firm innovative knowledge assets and corporate governance on firm performance, we were particularly interested in the coefficients on the interaction terms. Supporting Hypothesis 3, the two incentive-based governance variables positively moderated the relationship between firm innovative knowledge assets and economic performance ( $p < .05$  in both partial and full models). The results summarized in Table 2 also indicate the ineffectiveness of monitoring-based governance mechanisms. In models 4a and 6a, the coefficients on the interactions involving CEO duality and outside directors were both significant at the .01 level, with predicted signs. Largely consistent results were also present in the full model (7a). Similarly, the moderating effects of outside blockholders were negative and significant at the .1 level in both partial and full models (5a and 7a). These results are consistent with the predicted counterproductive effects of monitoring mechanisms.

When we measured firm innovative knowledge assets by the total patent citations that a firm received (Table 3), the main effect of firm innovative knowledge on performance was also positive and significant (mostly at  $p < .05$ ). With regard to the moderating effects of incentive-based governance mechanisms, we found both CEO shareholding and CEO contingency compensation to strengthen the relationship between firm innovative knowledge and performance, again providing support for Hypothesis 3. Concerning monitoring-based mechanisms, we found negative moderating effects of outside directors in both the partial (6b) and full (7b) models ( $p < .05$ ). In addition, CEO duality, which indicates less monitoring, showed a positive moderating effect (model 4b). The only exception was the moderating effects of outside blockholders, which we found to be insignificant (although with the expected negative signs). Taken together, these results were largely consistent with Hypothesis 2.

As explained in the methodology section, the challenges to corporate governance for an innovative firm may be particularly severe when an important portion of the firm's knowledge assets is firm specific. Correspondingly, we speculated that the asymmetric effects of incentives and monitoring might be more apparent for firms with high levels of *firm-specific* innovative knowledge assets. The results shown in Table 4 largely supported our speculations. Incentive-based governance appeared to strengthen the positive relationship between the

firm specificity of knowledge assets and firm performance. In the partial models (2c and 3c), the moderating effects of CEO shareholding and CEO contingency pay were found to be significant, at the .01 and .001 levels, respectively. On the other hand, we found monitoring-based governance mechanisms to weaken this relationship, indicating the counterproductive effects of monitoring in the context of firms with high knowledge specificity. Specifically, the moderating effects of outside blockholders were significant ( $p < .05$ ) in both the partial and full models (5c and 7c), while those of CEO duality and outside directors were significant at .05 or .10. Further, all the signs of the coefficients were consistent with our predictions.

Note that we have argued that compared to outsiders, top managers generally have greater firm-specific knowledge and intimate experiences that are critically important in innovation-intensive firms. In reality, however, it is not necessarily the case that top managers of innovative firms all perfectly possess such knowledge and experiences. For example, it is not likely that a top manager of a large, diversified, and innovative company has a thorough understanding of the specific processes and technical aspects of all its businesses. For such firms, the degree of the information asymmetry, as well as the need for managerial discretion, may be weaker. We may also apply similar arguments to top managers who have short tenure with their firms: With limited learning opportunities, they are less likely to develop intimate knowledge and understanding of the firms. Thus, the hypothesized moderating effects of corporate governance mechanisms may vary across firms with different sizes and CEO tenures.

Therefore, as robustness tests, we conducted some supplementary analyses to explicitly take into consideration such variations. In particular, we divided our sample firms into subgroups according to firm size and CEO tenure and then reran all the models for each subgroup. We did not find any significant difference in terms of the moderating role of corporate governance between firms with long CEO tenure and those with short CEO tenure. On the other hand, we found some differences for the two subgroups based on firm size. Although the hypothesized moderating effects of corporate governance mechanisms still held for both subsamples, the effects for the large firms were generally weaker, in terms of both significance levels and magnitudes, than those for the small firms.<sup>5</sup>

<sup>5</sup> Details of these results are available from the authors on request.

Therefore, although we found some evidence that the extent to which a CEO has intimate knowledge of his or her company varies across firms (especially in respect to firm size), none of the findings could invalidate our main arguments.

In summary, we found support for our hypotheses in most models. The various dimensions of firm innovative knowledge in respect to its input, output, and firm specificity were all positively associated with a firm's economic performance measured by market-to-book value. In addition, we found both positive moderating effects of incentive-based governance and negative moderating effects of monitoring in most models.

## DISCUSSION

This study has developed the argument that a firm's internal resource configuration constitutes a critical context for understanding the roles of various corporate governance mechanisms. Adopting governance mechanisms that can effectively ensure efficient deployment of firm resources will enable a firm to better deploy its resources and to reduce the gap between potential and realized economic rents. A key insight of this study is that the roles of the two broad categories of corporate governance, monitoring and incentives, are asymmetric in relation to deploying innovative knowledge assets. In a highly innovative firm, incentive-based interest alignment is more appropriate for motivating managers; monitoring will normally be less effective, and in some cases may even be counterproductive. Our key empirical results broadly supported these arguments.

The study makes several theoretical contributions. First, it extends previous corporate governance research by pointing out that governance effectiveness is contingent not only on environmental factors such as risk and strategic complexity (Zajac & Westphal, 1994), but also on a firm's own internal resource composition. Second, although incentives and monitoring are usually viewed as either substitutes or complements (Rediker & Seth, 1995; Tosi et al., 1997; Zajac & Westphal, 1994), we propose an alternative by arguing that the roles of the two broad governance mechanisms may be asymmetric when innovative knowledge is at a high level: Incentive-based mechanisms can increase the benefits obtained from deploying innovative knowledge assets, whereas monitoring may reduce them.

This study also contributes to the resource-based view of the firm literature. To date, with only a few exceptions (Castanias & Helfat, 1991; Gottschalg & Zollo, 2007; Makadok, 2003; Wang & Barney,

2006),<sup>6</sup> the authors of most studies following the resource-based or knowledge-based tradition have generally assumed away potential agency problems in the resource deployment process. However, as managers generally play critical roles in resource deployment (Castanias & Helfat, 1991, 2001; Kor & Mahoney, 2005), the economic rents that knowledge assets generate should be affected by the effectiveness of corporate governance mechanisms in reducing agency costs. The agency problem may be particularly critical in highly innovative firms, as the same features of innovative knowledge that function as "isolating mechanisms" for sustaining a firm's competitive advantage (Rumelt, 1984), such as causal ambiguity and firm specificity, are also likely to increase information asymmetry between its managers and shareholders. Therefore, innovative knowledge resources and the effectiveness of a firm's corporate governance mechanisms should be considered jointly to properly understand the actual generation of economic rents from the firm's resource base. This study has thus filled a gap by explicitly examining the influence of various corporate governance mechanisms on the value realized from deploying innovative knowledge resources.

In addition to its contribution to theory, this study is, to our knowledge, the first empirical effort to test the role of corporate governance mechanisms in affecting a firm's knowledge-based advantages. Furthermore, our study provides insight into the organizational consequences, especially the performance effects, of corporate governance mechanisms. Although quite a few studies have examined the relationship between corporate governance and firm performance, the empirical evidence has been inconclusive overall (for reviews, see Dalton, Daily, Certo, and Roengpitya [2003]; Dalton et al. [1998]; Dalton, Johnson, and Ellstrand [1999]). Although the inconclusiveness might be attributed to differences in data, measurements, sampling, and statistical methods, this study's analysis suggests another possibility. Because the effectiveness of certain corporate governance mechanisms is contingent on the composition of a firm's resource base, there may be no standard criteria for what constitutes effective corporate governance.

Despite its contributions to theory and empirics, this study has some limitations, and further research is required to advance its key arguments.

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<sup>6</sup> None of these studies, however, explicitly examined the joint effects of knowledge resources and corporate governance in determining firm economic performance. Furthermore, none of the studies tested its arguments empirically, as we did here.



First, it was based on the premise that innovative knowledge is a primary driver of competitive advantage. However, a firm also possesses knowledge assets of other kinds—those embedded, for example, in its marketing, social, and information systems. These knowledge assets also play important roles in the firm's value creation process. Furthermore, knowledge assets have to be combined with other resources, such as human, financial, and relational resources, for their potential to be realized. Comprehensive understanding of corporate governance mechanisms thus requires an integrative consideration of other components of a firm's knowledge base, as well as of the relationships among various types of firm resources.

Second, we have discussed and tested the role of incentives in facilitating the exploitation of knowledge assets for value creation. But incentives cannot perfectly resolve all the agency problems in innovative firms, because these mechanisms, although helpful in achieving interest alignment among managers and owners in general, may sometimes also promote managers' overly aggressive investments (Sanders & Hambrick, 2007) or manipulation of firm earnings (Zahra et al., 2005). Moreover, *some* innovation-intensive firms may face especially high risk, which may increase the costs of using incentive-based governance mechanisms (Zajac & Westphal, 1994). It would be interesting for future studies to examine the specific conditions under which such costs are significant and the associated governance issues that may arise. More generally, it should be fruitful for future research to explore governance contexts in which multiple issues (e.g., information asymmetry and risk) may coexist and interact in complex ways. It may also be important for future studies to investigate ways of designing incentive-based governance mechanisms that minimize potential costs.

Third, although we focus on a firm's internal resource composition as the primary context for understanding the roles of corporate governance mechanisms, we should note that a high level of innovative knowledge assets is not the only context in which information asymmetry is high and monitoring is difficult. For example, in a dynamic industry setting, information asymmetry among managers and owners is also likely to be high, thus compromising the effectiveness of monitoring (Boyd, 1995). Therefore, we believe that it is both necessary and promising for future research to examine how such external factors affect the roles of various governance mechanisms, as well as how internal and external factors may jointly affect the effectiveness of these mechanisms.

Fourth, this study focused on the corporate-level governance mechanisms designed to motivate top managers to serve owners' interests. Such a focus is based on the understanding that top managers play a key role in deciding how firm resources are deployed. Future studies might investigate the motivations of organization members at other levels, such as nonexecutive employees, and how their motivations and firm resources jointly affect firm performance.

Finally, this study was to some extent limited by the availability of data. Although R&D expenditures and patent data are reasonable proxies for the inputs and outputs of innovative knowledge, and patent citations provide rich information on knowledge flow, they still address only a narrow portion of a firm's innovative knowledge base. This limitation must be kept in mind when interpreting our regression results. Future research might use survey or field data to explore other aspects of innovative knowledge that are not reflected in R&D spending or patents. In addition, because the performance measure used in this study was based on data covering 1996 to 1999, a period when the stock market experienced an abnormal boom, the market values of the high-tech companies might have been biased upward. Although the logarithm transformation of the performance measure to some extent mitigates such a concern, readers should interpret the empirical findings with caution. We hope that future studies will be able to avoid this potential bias by employing data from other time periods that are not subject to this concern.

This study has examined and found support for the asymmetric roles of monitoring- and incentive-based governance mechanisms in affecting the efficient deployment of a firm's innovative knowledge assets toward value creation. It demonstrates that individual governance mechanisms interact with a firm's internal resource composition in complex ways to jointly determine the firm's economic performance. We hope that this study will be a first step toward research that integrates different streams of strategy and organizational economics thinking to advance understanding of the roles of corporate governance as well as firm resources.

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