What Matters in Corporate Governance and Innovation

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Abstract

We provide a comprehensive study of how different corporate governance constructs influence innovation. We know that not all corporate governance mechanisms are created equal; we know that different corporate governance mechanisms can proxy for different incentives in different situations. Therefore, our purpose is to disentangle these different constructs and to understand how firms generate innovation. Specifically, we study six different corporate governance constructs: board busyness, interlocked directors, entrenchment, director expertise, board structure and director ownership. We find that busy boards generate less innovation, as do boards with CEOs or Chairs from other companies. We find that boards with more interlocked directors and more entrenched boards generate more innovation. Board structure, such as director independence, does not significantly affect innovation. And director ownership is weakly associated with greater innovation. We contribute two primary policy implications for firms looking to generate greater innovation. First, boards must be incentivized and empowered to focus on long-term strategies. Second, directors' professional relationships and activities matter. Given that not all corporate governance structures lead to the same outcomes, our findings should help firms design corporate governance structures that will be better aligned with how they can uniquely create value.

1. Introduction

Innovation is a critical strategy to help firms create a competitive advantage over their competition and to generate abnormal returns for shareholders. Yet innovation – through research & development, new products or patent development – is an expensive, risky and long-term investment. Firms must be willing to take long-term risks in order to innovate; this means that managers and directors must be incentivized to take these long-term risks. In the spirit of Hart (1995), a firm's corporate governance structure can be thought of as system of risk-sharing and incentives. That corporate governance structure, therefore, becomes responsible for creating the culture and incentives necessary for a firm to innovate.

An impressive literature has emerged in recent years to study how the relationship between corporate governance and innovation. Chemmanur and Tian (2017) show that firms subject to more anti-takeover provisions innovate more, while Sapra, Subramanian and Subramanian (2014) find a U-shaped relationship: innovation occurs when there are very few or very many anti-takeover provisions. They attribute this to the long-term nature of innovation; firms – through executives and directors – need the long-term incentives and protection necessary to invest in innovation. Manso (2011) suggests that managers can be motivated to innovate by incentivizing them with long-term options, golden parachutes and other devices that encourage entrenchment. These studies are novel in many ways, most relevantly because the corporate governance mechanisms that they find lead to innovation are the exact opposite of what the literature generally believes are associated with effective corporate governance structures (see Gompers, Ishii and Metrick (2003) or Bebchuk, Cohen and Ferrell (2009) on antitakeover provisions and Bhagat and Bolton (2013) on director compensation).

This creates a dilemma: if innovation is a fundamental driver of corporate success, how can the corporate governance mechanisms that lead to innovation *not* be the same mechanisms that lead to corporate success? We believe that the critical dynamics connecting these constructs are the specific individual characteristics of executives and directors. While the literature largely treats corporate governance as a menu of objective and observable metrics – board independence, executive compensation, anti-takeover provisions – the process of corporate governance is fundamentally one of human behavior. Yes, the objective and observable metrics can be proxies intended to capture the incentives or constraints that guide that human behavior. However, the processes that connect these proxies to humans actually implementing corporate strategies and investments can be highly complex and nuanced.

We study these highly complex and nuanced dynamics by initially considering the social network relationships of executives and directors to understand how they might be related to innovation, as measured by the number of future patents and patent citations that a firm generates. Specifically, we begin by analyzing the busyness of directors and the interlocking relationships between directors and boards. In theory, assuming a fixed supply of firms and directors, as directors serve on more and more boards, there is an increased likelihood that they will develop interlocking relationships with other firms' boards. The existing literature has found both costs and benefits from busy directors or interlocked directors. For example, Fich and Shivdasani (2006) find that busy directors lead to worse firm performance, while Field, Lowry and Mkrtchyan (2013) find that busy directors help increase valuations for firms going public. Larcker, So and Wang (2013) find that firms with well-connected directors enjoy greater longer-term risk-adjusted returns than less well-connected firms, while Fracassi and Tate (2012) find that directors with more external network ties to the CEO engage in more value-destroying

acquisitions. We are the first to study these constructs simultaneously in order to provide a more complete picture of the impact that directors' social network relationships have on innovation.

Our results show that firms with busy boards innovate less and that firms with interlocked directors innovate more. This result is mitigated by the directors' other relationships: when directors are busy but not interlocked there is a negative impact on innovation and when directors are interlocked but not busy there is a positive impact on innovation. However, neither of these dynamics dominates: when directors are both busy and interlocked, the effects offset each other and there is no significant impact on innovation.

We then study director entrenchment, following Sapra, Subramanian and Subramanian (2014) and Chemmanur and Tian (2017), to confirm that director entrenchment serves to protect the directors and firm investment policies from the short-term whims of the financial markets. While entrenchment, measured with different anti-takeover measures and indices, has been found to be associated with worse firm performance and lower firm value using traditional, possibly short-term, measures of performance and value, we find that entrenchment is, indeed, beneficial to firm innovation. This result holds using anti-takeover provision indices and using several different measures of director tenure as proxies for structures that insulate directors from market pressure.

From there, we turn to director specific expertise and experience. Directors are appointed to serve as both monitors and advisors; to the extent that firms can create value and competitive advantages through innovation, directors that can facilitate (or support) investment in innovation would be seen as effective advisors. We first consider the current professional role of directors to analyze how individual director expertise impacts innovation. We find that directors who are currently serving as CEOs or board Chairs at other firms are associated with less innovation at

the sample firm, possibly either because they are too busy in their day job to provide effective advice on the board or because their expertise is at such a macro-level that they cannot appreciate the value of specific investments, such as in innovation. Directors who are classified as financial experts based on the Sarbanes-Oxley criteria neither help nor hurt innovation. While these directors should appreciate the long-term value-creation potential of innovation better than other directors, perhaps their role is confounded by concerns about risk mitigation. Then we focus on director age, theorizing that directors at different ages will have different incentives and career concerns that would result in them supporting different investment policies. We find a positive, but insignificant, relationship between director age and innovation. While younger directors may be less risk-averse and may have greater incentive to invest in the option value associated with innovation, these incentives appear to be offset by the role that tenure and professional experience plays in supporting innovation.

Finally, we turn to two of the most traditional measures of general corporate governance: board structure and director ownership. Both board independence and director ownership have been found to be associated with better corporate governance in general, so we investigate if they are influential in leading a firm to generate more patents and patent citations. In short, they are not. We hypothesize that they are such broad measures of governance that they cannot capture the intricate and unique benefits of something as specific as a firm's innovation strategy.

Overall, our results paint a picture of how directors add value to a firm's strategic innovation process. Informed and connected directors can add value and improve a firm's innovation strategy, but only if they aren't too busy or distracted to focus on their advisory role. Individual experience and expertise is also a critical determinant of a firm being more successful in generating patents and patent citations. At the firm-level, the more entrenched and protected

that directors are from the short-term demands of financial markets, the more liberated the directors will be to generate successful investment in innovation. However, macro-level measures of corporate governance – such as board independence and director ownership – seem to be confounded by other dynamics and do not capture the value created by innovation.

This paper makes at least 3 key contributions to the literature. First, we provide the first comprehensive analysis of how different corporate governance mechanisms influence a firm's innovation success. Second, we show how specific director activities produce trade-offs in the boardroom. And, third, we show that certain mechanisms that have previously been shown to be associated with good corporate governance at a generic level may not be effective in leading to long-term innovation. Corporate governance is a highly nuanced construct; one size does not fit all and different measures of corporate governance may not impact different firms in the same ways. We attribute these findings to the fact that corporate governance is a function of human beings and who these humans are is what will determine how corporate governance is effected at each firm.

The rest of the paper proceeds as follows. The next section provides a literature review and introduces our 6 hypotheses. Section 3 presents our Data. Section 4 contains discussion and presentation of our empirical analyses and Section 5 concludes.

2. Literature Review & Hypothesis Development

In this paper, we analyze the effect that corporate governance structures have on corporate innovation. This is the first study to provide a comprehensive study on how different corporate governance measures influence innovation and on how directors' professional

relationships influence innovation. The purpose of this study is to better understand the tensions that boards face in their dual roles of monitor and advising.

Shleifer and Vishny (1997) define corporate governance as "the ways in which suppliers of finance assure themselves of getting a return on their investment." Hart (1995) characterizes corporate governance as a system that facilitates how firms make decisions regarding resource allocation and the tradeoffs between incentives and risk sharing. These tradeoffs, with the ultimate goal of maximizing firm value and the return to suppliers of capital, creates a natural tension between the structures that firms choose and the decisions boards of directors make. In competitive markets, firms must innovate – in products, in processes or otherwise – in order to succeed. Thus, studying the relationship between corporate innovation and the corporate governance mechanisms that firms choose helps us understand how they attempt to provide this return on investment.

One strand of the literature has considered the relationships between corporate governance and innovation at the macro-level. Sapra, Subramanian and Subramanian (2014) develop a model that predicts a U-shaped relationship between innovation and takeover pressure: greater innovation is generated in situations where anti-takeover laws are either very weak, so as to allow unobstructed innovation, or are very strong, so as to prevent external takeover pressure. They further find empirical support for this non-monotonic relationship. Chemmanur and Tian (2017) also study the relationship between innovation and anti-takeover provisions and find a similar result: firms with greater anti-takeover provisions enjoy greater innovation as they are protected from the short-term pressures of the takeover market and are allowed to make long-term investments. Manso (2011) focuses on the incentives required for executives and directors to be willing to invest in innovation. He shows that the optimal managerial incentive scheme

focuses on the long-term: stock option awards with long-vesting periods, golden parachutes and managerial entrenchment. And, Balsmeier, Fleming and Manso (2017) show that independent boards of directors are associated with greater innovation, as measured by patents and citations. Other research has studied the relationships between governance and innovation in specific situations. Chang, Hilary, Kang and Zhang (2017) find that firms with more conservative financial reporting – measured using Khan and Watts' (2009) *C-Score* – have less innovation. This manifests through myopic managers feeling the pressure to deliver short-term performance and being reluctant to make long-term investments. He and Tian (2013) find that firms that are covered by a larger number of research analysts have less innovation and have lower impact innovation. This is consistent with Chang et al. (2017) that conservatism, or perceived risk of loss or disappointment, leads to less innovation. Belloc (2011) shows that firms with greater CEO ownership, more director ownership and more employee directors enjoy greater innovation. And, Wang and Zhao (2015) extend the ownership perspective and find that firm ownership matters for innovation, as hedge fund ownership increases both the quantity and quality of patents, and commensurately increases firm value through this innovation effect. But, in order to better understand how specific corporate governance mechanisms influence innovation at both the macro-level and with respect to individual director characteristics, we study this relationship within six different corporate governance constructs: board busyness, interlocked directors, entrenchment, director expertise, board structure and director ownership.

2.1 Director Busyness and Innovation

Fich and Shivdasani (2006) led the intense focus on the general relationship between board busyness and firm performance. They studied the busyness of directors for the *Forbes 500*

in 1992, and found that firms with busy boards – or, boards where a majority of outside directors hold 3 or more other directorships – exhibited worse operating performance, lower market-to-book ratios and a lower likelihood to disciplinary CEO turnover following poor firm performance. Cashman, Gillan and Jun (2012) similarly find a negative relationship between board busyness and firm value using a more recent sample.

An extensive body of research has looked to better understand specific situations where board busyness matters. Ahn, Jiraporn and Kim (2010) find that firms with busy boards engage in more value-destroying acquisitions. Jiraporn, Kim and Davidson (2008) show that firms with busy boards are valued with a larger diversification discount. Falato, Kadyrzhanova and Lel (2014) use director deaths as a natural experiment, and show that busyness hurts firm value and monitoring as exposed by the sudden increase in director workload. And, Core, Holthausen and Larcker (1999) find that busy boards are associated with abnormally high CEO compensation.

More recently, Field, Lowry and Mkrtchyan (2013) studied the board busyness of firms going through their initial public offerings (IPOs) from 1996-2008, with a focus on venture capital-backed IPOs. With this sample, they are able to distinguish between the advising benefits and the monitoring costs of having busy directors. They find that the advising effect dominates for public and newly public firms: board busyness is associated with higher market-to-book ratios in their sample. They include an analysis of a sub-sample of *Forbes 500* firms, similar to Fich and Shivdasani's (2006), and find that the benefits of busy boards do not extend to the largest, most mature firms. This suggests that different firms have different needs and that firms should choose the corporate governance structure that is most beneficial for their situations and needs.[1] Chen and Guay (2017) support this perspective, using shareholder voting to focus on

[1] This is consistent with a long literature showing that corporate governance structures should be customized for each firm, including Coles, Daniel and Naveen (1999), Wintoki (2007) and others.

shareholder satisfaction with director-specific attributes. They show that concerns for busy directors are less for directors with less time-consuming busyness and other professional responsibilities; for example, the negative relationship for busy directors is less severe for retired CEOs while it is more extreme for directors who are still employed as full-time executives.

Innovation is a long-term process and a long-term investment. But how board and director busyness influences innovation is uncertain; the existing research provides implications that board busyness could be either beneficial or detrimental to innovation. Board busyness could lead to directors being distracted monitors or it could lead to directors being more effective advisors. We examine two alternative hypotheses to empirically study this relationship:

Hypothesis #1a: *Busy boards and directors are associated with less innovation.*

Hypothesis #1b: *Busy boards and directors are associated with more innovation.*

2.2 Interlocked Directors and Innovation

The literature on interlocked directors can be broadened to consider professional networks and the connections between firms and individual directors. In theory, given a fixed number of firms and a fixed supply of directors, as directors become more busy, they are likely to have more interlocked relationship with other firms. The literature is mixed on whether or not such relationships are beneficial for firms.

Fracassi and Tate (2012) find that directors with more external network ties to the CEO – a more general measure than interlocking directorships – are associated with weaker governance; their firms engage in more value-destroying acquisitions and firm value increases when such directors leave the board. Devos, Prevost and Puthenpurackal (2009) find that interlocked relationships compromise director independence and creates unobservable conflicts of interests;

they find that firms with poor relative performance are more likely to have interlocked directors and that firms with more interlocked directors are associated with weaker CEO pay-performance sensitivity. Falato, Kadyrzhanova and Lel (2014) show that the problems associated with director busyness are most pronounced for firms with more interlocked directors. Bowen, Rajgopal and Venkatachalam (2008) show that interlocked directors are associated with greater accounting discretion, suggesting that interlocked directors are weaker monitors. And, Bizjak, Lemmon and Whitby (2009) find that firms with more network connections on the board are more likely to engage in option backdating.

However, other work highlights the benefits gained from the professional network connections associated with interlocking directorships. Larcker, So and Wang (2013) find that firms with well-connected directors enjoy greater longer-term risk-adjusted returns than less well-connected firms; further, they find that well-connected firms enjoy greater future growth that is not initially priced into stock prices. Cai and Sevilir (2012) find that firms with stronger network connections actually enjoy higher acquisition announcement returns. And, Hochberg, Ljungqvist and Lu (2007) study network connections in the venture capital industry and find that better-networked venture capital firms and their portfolio firms enjoy better performance, at both the fund and portfolio company level. And, Helmers, Patnam and Rau (2017) find that board interlocks have significant and positive effects on R&D spending and patents generated using a recent sample of firms in India.

While interlocked directors may be able to provide strategic insight that they gain from their professional relationships, it is uncertain whether these benefits will dominate the costs – through potential conflicts of interest and less focused monitoring – associated with directors

being interlocked. Ex ante, the expected relationship is unclear; thus, we present two alternative hypotheses to capture the relationship between interlocked directors and innovation:

Hypothesis #2a: *Boards with more interlocking relationships are associated with more innovation.*

Hypothesis #2b: *Boards with more interlocking relationships are associated with less innovation.*

2.3 Entrenchment and Innovation

Sapra, Subramanian and Subramanian (2014) develop a model that predicts a U-shaped relationship between innovation and takeover pressure: greater innovation is generated in situations where anti-takeover laws are either very weak, so as to allow unobstructed innovation, or are very strong, so as to prevent external takeover pressure. They further find empirical support for this non-monotonic relationship. Chemmanur and Tian (2017) also study the relationship between innovation and anti-takeover provisions and find a similar result: firms with greater anti-takeover provisions enjoy greater innovation as they are protected from the short-term pressures of the takeover market and are allowed to make long-term investments.

These findings are most interesting because the prior literature on the relationship between entrenchment and firm value or firm performance shows a negative relationship. Bebchuk and Cohen (2005), Faleye (2007) and others have studied the effects of boards being – or becoming – entrenched; in their cases, they use staggered (or classified) boards as the mechanism through which boards become entrenched. Gompers, Ishii and Metrick (2009) created an index using 24 anti-takeover provisions to assess whether a firm's corporate governance was entrenched and manager friendly (the "dictator" firms) or if it was open and shareholder friendly (the "democracy" firms); they found that less entrenched and more

democratic corporate governance structures were associated with higher firm value, higher profits and abnormal stock returns. Bebchuk, Cohen and Ferrell (2009) show that using only 6 of the 24 anti-takeover provisions yields similar results that entrenchment is associated lower firm value, while the other 18 provisions are unrelated to firm value.

Gompers, Ishii and Metrick (2009), however, also found that shareholder friendly, non-entrenched corporate governance structures were associated with the firms making fewer acquisitions and having lower capital expenditures, overall. This suggests there can be a difference between the short-term effects and long-term effects of entrenchment. He and Tian (2013) study the relationship between financial analyst coverage and innovation, and they find that firms covered by more analysts produce less innovation. While analyst coverage may be beneficial in terms of information transparency and price discovery, the short-term pressures associated with greater scrutiny lead boards to be more risk-averse and to invest less in innovation. And, Zhang (2017) suggests that CEO-Chair duality can be beneficial to firms with good governance as it provides a more efficient management structure; thus, boards need to evaluate their own specific needs and structures when deciding whether or not to separate the CEO and board Chair positions.

Ultimately, it remains an empirical question as to whether or not board entrenchment will induce more or less corporate innovation. Innovation is a long-term investment, similar to acquisitions in nature and purpose, so it may be that entrenchment leads to more innovation. Alternatively, entrenched corporate governance structures may foster a resistant culture of investment that reduces innovation. Thus, we present two alternative hypotheses:

Hypothesis #3a: *More entrenched boards are associated with more innovation.*

Hypothesis #3b: *More entrenched boards are associated with less innovation.*

2.4 Director Experience and Innovation

Given their dual roles of monitoring and advising, there is little doubt that the professional experience and expertise of directors is critical; in theory, that is exactly why they are being appointed to the board. However, "experience" and "expertise" are nebulous constructs that can be very difficult to measure in practice. An impressive recent literature has made great progress in identifying and measuring the experience of directors. Duchin, Matsuaka and Ozbas (2010) show that the effectiveness of outside directors is largely dependent on their knowledge about the firm – and how costly it is for them to gain the knowledge necessary to be an effective monitor; outside directors are most effective when the costs to gaining knowledge about the firm are low and least effective when those costs are high. Fich (2005) found that firms experienced significantly positive abnormal returns upon announcing they were adding an outsider CEO to the board of directors, but negative abnormal returns for all other director announcements; he further finds that the benefits associated with appointing outside CEOs improves long-term operating performance. Fich and White (2005) point out that nearly 1 in 7 large company boards had reciprocating CEO directors, where directors of different firms sat on the other's board, in a sample from the early 1990s. Clearly, boards believe that CEOs can add value. However, more recently, Fahlenbrach, Low and Stulz (2010) study the effects of firms appointing outside CEOs to the board, as CEOs are in high demand to serve as directors. Among their findings, they show that the stock market reacts favorably to a firm announcing the appointment of an outside CEO to the board. However, they do not find any significant differences in operating performance or decision-making following these appointments.

In 2002, The Sarbanes-Oxley Act (SOX) required public companies to disclose whether or not they have a "financial expert" on the audit committee. The definition of what constitutes a "financial expert" is pretty broad, allowing for both accounting and finance professionals to be classified as financial experts. DeFond, Hann, and Hu (2005) specifically study the addition of financial experts to the audit committee – using a sample prior to the SOX requirement. They find that firms experience a positive abnormal stock return when they add an accounting financial expert, but they find no stock price reaction when firms add a non-accounting financial expert. Given that financial experts appointed to audit committees will naturally serve the broader interests of the board and may serve on other committees, their impact should have influence beyond the firm's audit function. Güner, Malmendier and Tate (2005) study how financial experts serving on the board impacts a firm's investment decisions; they find that financial experts on the board significantly affect the firm's investment policies, but not to the benefit of shareholders. Firms with more financial expert directors make fewer value-creating internal investments and make more value-destroying acquisitions.

The final construct that we consider to measure experience is director age. While there is scant research on the influence of director age, considerable research has studied the impact of CEO age and other characteristics. Jenter and Lewellen (2015) study the relationship between CEO age and acquisitions; they find that firms led by younger CEOs have better corporate governance structures and are more likely to make acquisitions. Similarly, Kim (2013) shows that young CEOs make more large acquisitions because such acquisitions lead to large and permanent increases in salary for the CEO. Thus, large acquisitions represent a real option that can lead to large and permanent benefits for the CEO. While these studies focused on CEO characteristics, the same dynamics should apply to directors: young directors would want to be

associated with growth, acquisitions and large-scale investments in order to increase the permanent earning potential and career opportunities.

We expect the professional experience of directors to significantly impact a firm's innovation, but the specific impact will depend on the nature of that expertise. Given the findings in the prior literature for these three constructs that capture the individual directors' professional experience, we present three alternative hypotheses:

Hypothesis #4a: *Boards with more CEO directors will generate less innovation.*

Hypothesis #4b: *Boards with more finance expert directors will generate less innovation.*

Hypothesis #4c: *Boards with younger directors will generate more innovation.*

2.5 Board Structure and Innovation

As discussed above, Duchin, Matsuaka and Ozbas (2010) provide clear evidence that board independence matters for firms. Balsmeier, Fleming and Manso (2017) show that greater innovation follows boards moving to having a majority of independent directors and that these results are most pronounced for firms for which innovation is most important (those firms with high R&D expenditures). These benefits may come from the increased information sharing and advice that outside directors can provide; conceptually, this is similar to the benefits that can be through interlocking director relationships. More generally, work that has studied the relationship between board independence and firm performance has also found a positive relationship. Bhagat and Bolton (2013) find a negative relationship between firm performance and director independence prior to 2002, but a positive relationship after 2002 as The Sarbanes-Oxley Act and other factors led to an increased focus on director independence and quality. Knyazeva, Knyazeva and Masulis (2013) also find a positive relationship between board

independence and firm performance, uniquely controlling for each firm's local labor market. And, in their study looking at the impact of the sudden death of independent directors, Nguyen and Nielsen (2010) find that the stock market reacts negatively to the sudden death of an independent director.

Given the mixed findings on the impact of board independence on firm performance and board independence, we consider two alternative hypotheses for this relationship:

Hypothesis #5a: *More independent boards are associated with more innovation.*

Hypothesis #5b: *More independent boards are associated with less innovation.*

2.6 Director Ownership and Innovation

In the spirit of Jensen and Meckling (1976), director stock ownership is the ultimate moderator of principal-agent costs. Bhagat and Bolton (2013) provide empirical evidence showing that greater director ownership is a critical determinant of long-term value creation. Given that innovation is a uniquely long-term investment, we expect directors to value the long-term, but risky, correlation between innovation and their personal stock holdings in the firm. Bushee (1998) shows that mangers are less likely to cut research and development expenditures when institutional ownership is high. Aghion, van Reenen and Zingales (2013) develop a theoretical model to test this relationship, and they find a similar result, showing that greater institutional ownership is associated with more innovation, as measured by cite-weighted patents. And, Belloc (2011) finds that firms with greater CEO ownership, more director ownership and more employee directors enjoy greater innovation. Thus, the prior literature is generally consistent in suggesting that greater director ownership is an effective tool to mitigate

any principal-agent conflicts; given this, we expect to see a positive relationship between director ownership and innovation.

Hypothesis #6: *Directors with greater stock ownership are associated with more innovation.*

3. Data

We construct our innovation variables from the patent and citation database compiled by Kogan, Papanikolaou, Seru, and Stoffman (2017) (henceforth KPSS data), and various board governance variables from the Institutional Shareholder Services database (ISS - previously IRRC). We obtain firm financial information from Compustat, stock return data from the Center for Research in Security Prices (CRSP), executive compensation and ownership data from Execucomp, and institutional shareholder ownership from Thomas Reuters' 13f data. Our sample period starts in 1996 when ISS data are available, and ends in 2010 as the KPSS data ends. Since we require at least one year lead-lag in our regression analysis, therefore the innovation data (dependent variables) ranges from 1997-2010 and the board governance data, along with the control variables, ranges from 1996-2009. To mitigate sample selection bias, we follow Atanassov (2013) and He and Tian (2013) and assign zero value to firm-years with missing patent or R&D data, and include them in our regressions. The Appendix provides detailed variable definitions.

3.1 Patent Measures

To measure corporate innovation, we follow Trajtenberg, Henderson, and Jaffe (1997), Hall, Jaffe and Trajtenberg (2002), Hall (2005) and Wang and Zhao (2015) and employ several metrics including the number of patents filed per year (*Pats*) and the number of citations

received in life on all of the patents filed for in each year (*Cites*); to control for industry trend and truncation bias in patent data, we also use bias-adjusted measures, based upon U.S. Patent and Trademark Office (USPTO)'s technological classifications, of patent quantity and citations (*Pats_tn* and *Cites_tn*, respectively).

Specifically, *Pats* is the total number of patents filed for by a firm (and ultimately granted) in a calendar year. Consistent with Hall, Jaffe and Trajtenberg (2002), the relevant year is application or filing year, which is very close to the timing of the actual innovation rather than grant year. Then *Pats* is further divided by the average number of patents applied for across all firms in the same application year and the same U.S. Patent and Trademark Office (USPTO) technological class ($Pats_{TN}$) to correct for the truncation bias in patent grants ($Pats_{TC}$). The truncation bias arises as patents have on average a two year lag from application to grant date, and some patents that have been applied for may not have yet entered into the sample. *Ln(1+Pats)* is the natural logarithm of one plus *Pats*. We also construct $Ln(1+Pats_{TN})$ analogously.

Besides patent quantity, we also construct measures for patent quality and impact. *Cites* is the total number of future citations received in life on all patents applied for (and ultimately granted to) a firm in an application year. Patents that are more heavily cited are viewed as having more impact or being more important. $Cites_{TN}$ equals *Cites* scaled by the citations received on all patents filed in the same USPTO class and the same application year to account for the fact that patents that are granted earlier may have received more citations than recent ones. *Ln(1+Cites)* and $Ln(1+Cites_{TN})$ are the logarithms of one plus *Cites* and $Cites_{TN}$, respectively.

3.2 Corporate Governance Measures

Corporate governance and board measures are retrieved from the Institutional Shareholder Services database. The corporate governance measures that we use within each of our six constructs follow from the existing literature. Refer to the Appendix for more detail on each of these variables.

To measure the busyness of boards and directors, we use three primary variables. First, we calculate the percentage of directors who are on 3 or more other boards for each firm-year, as in Fich and Shivdasani (2006). Second, we use the natural logarithm of the average number of other boards each director serves on, as in Ferris, Jagannathan and Pritchard (2003). Finally, following Fich and Shivdasani (2006), we measure board busyness using an indicator variable equal to 1 if at 50% of the independent, non-affiliated directors are on at least 3 other boards, and equal to 0 otherwise.[2]

To measure interlocking director relationships, we use the percentage of directors who have an interlocking relationship, following Institutional Shareholder Services classification;[3] this is consistent with the prior literature, including Bizjak, Lemmon and Whitby (2009), Devos, Prevost and Puthenpurackal (2009), and others. Interlocking directors are those from a sample firm who serve on the board of another company which also has at least one other director serving on the board of the sample firm.

[2] Fich and Shivdasani (2006) use a sample of firms based on the *Forbes 500* from 1992; our sample is the S&P 1500 from 2000-2010. Given the difference in time period and sample firms, only 2.5% of our firms have a busy board using Fich and Shivdasani's definition, whereas 22% of their firms were busy. Given this, we focus on other measures of busyness to focus on the unique characteristics of the directors and firms in our sample.

[3] ISS defines an interlocking directorship as a "situation where a director and executive of company ABC sits on a board of company XYZ and a director and executive of company XYZ sits on the board of company ABC."

To measure director entrenchment, we consider three different types of corporate governance variables. First, we consider three director tenure variables as proxies for entrenchment; average tenure of all directors, the percentage of directors who have more than 15 years of service on the board and the percentage of directors who have less than 5 years of service on the board. Second, following Sapra, Subramanian and Subramanian (2014) and Chemmanur and Tian (2017), we use anti-takeover provisions as one measure of entrenchment; we use both the Bebchuk, Cohen and Ferrell (2009) *E-Index* and the Gompers, Ishii and Metrick (2003) *G-Index*. And finally we use an indicator variable equal to 1 if the CEO is also the board chair and 0 otherwise (*CEO-Chair Duality*).

To measure director experience and expertise, we consider three different categories of corporate governance variables to correspond with the three hypotheses. First, we consider the professional responsibilities or expertise of directors; we use the percentage of directors who are CEOs of other firms and the percentage of directors who are Board Chairs at other firms (from Fahlenbrach, Low and Stulz (2010)). Second, following on the work of Defond, Hann and Hu (2005) and Güner, Malmendier and Tate (2005), we use the percentage of directors classified as finance experts to measure director expertise. Finally, following Kim (2013) and Jenter and Lewellen (2015), we consider average director age to measure director experience.

To measure board structure, we consider the percentage of directors on the board who are classified as independent. Following Duchin, Matsuaka and Ozbas (2010) and Knyazeva, Knyazeva and Masulis (2013), the percentage of directors who are independent is a highly informative measure of board structure; thus, we believe that this measure can fully capture board structure.[4]

[4] Balsmeier, Fleming and Manso (2017) measure board independence as an indicator variable equal to 1 if a majority of directors are classified as independent and equal to 0 otherwise. We did not use this variable as our

Finally, to measure board ownership, we consider three different variables. First, following Bhagat and Bolton (2013), we use the median percentage of stock owned by board members. Second, we use the median dollar value of stock owned by a firm's directors (in natural log form). We calculate this number using the number of shares that each director beneficially owns, as specified in the firm's annual proxy statement, multiplied by the year-end stock price. Finally, we use the percentage of directors who do not own any company stock as a measure of director ownership, as it may proxy for a firm's culture of ownership.

3.4 Control Variables

In all of our regression models, we use a standard series of control variables to control for firm- and industry-specific characteristics. We control for firm size using market value (*Ln(MV)*), for investment policies using research & development expenditures (*R&D/Assets*), capital expenditures (*CAPX/Assets*) and fixed assets (*PPE/Assets*), for firm performance using return on assets (*ROA*), sales efficiency (*Ln(Sales/Emp)*) and Tobin's Q (*Q*), capital structure (*Debt/Assets*), liquidity (*Cash/Assets*), industry concentration using Herfindahl Index (*HI* and HI^2), firm age (*Ln(Age*) and corporate governance structure using institutional ownership (*Institutional Own.*), insider stock ownership (*Insider Ownership*) and executive compensation policy (*Equity/Total Pay*). We use firm and year fixed effects in all regressions. Full variable definitions are provided in the Appendix.

measure of board independence because nearly all of our firms – more than 92% – would be classified as independent and it would not provide significant heterogeneity in our sample. However, when we do use this variable in our tests, the results are qualitatively similar to using the percentage of directors who are independent.

3.5 Summary Statistics

Summary statistics for our innovation and corporate governance variables are presented in Tables 1 and 2; the variables are defined in Appendix 1.[5] From Panel C of Table 1, we can see that the firms we are studying are large firm, with an average market capitalization of $8.4 billion and average assets of $7.4 billion. Most of the other averages show characteristics that we would expect with a sample of S&P 1500 firms: leverage of 23%, institutional ownership of 61%, insider ownership of 3% and a Tobin's Q of 2.02. Interestingly, more than half of our firms do not report any research & development expenditures; while this does not necessarily mean that these firms are not investing in innovation and patents, it does show that our sample of firms is very diverse in the investments they make and how they might address innovation.

Panel B presents the corporate governance statistics for the firms in our study. The average board of directors has 9 members, 72% of whom are independent; the average director is 60.3 years old and has 10.4 years of service; 22% of the directors have more than 15 years of service and 21% have fewer than 5 years of service. The anti-takeover provision indices are similar to other studies: the average firm has a Gompers, Ishii and Metrick (2003) *G-Index* of 9.4 and a Bebchuk, Cohen and Ferrell (2009) *E-Index* of 1.6. With respect to professional experience, 9% of the directors are actively employed as CEO of another firm, 8% are actively serving as the board chair of another firm, and 14% of the directors meet the Sarbanes-Oxley criteria for being a financial expert. With respect to director activity and professional relationships, 10% of the directors are busy (on more than 3 or more other boards), 7% are busy outside directors, 1% has interlocking relationships, and the average director serves on 0.87 other boards.

[5] We did not create a table with correlation coefficients due to the number of variables and the difficulty in presenting those relationships. All correlation coefficients are available from the authors upon request.

Panel A presents our innovation variables. On average, firms generate 26.4 patents a year in total and 4.8 patents a year when adjusted for the total number of patents files in the same year and the same technological class. However, these statistics are heavily skewed; the number of patents generated is equal to zero in more than half of the firm-years (consistent with the R&D spending numbers). The average firm generates 190.9 patent citations in the future, while the average patent receives 1.49 future citations.

Table 2 looks more specifically at these innovation variables, by year and by industry. The mean number of future patents and future citations is highest in the late-1990s and early-2000s; the number of future patents and citations decreases over the decade of the 2000s. Panel B presents the industry distribution using the Fama-French 48 industry classifications. Consumer goods, medical equipment, construction materials, machinery, electrical equipment, aircraft, shipbuilding and shipping containers, precious metals, computers, chips, and measuring and control equipment are the most active innovators, in terms of future patents and citations. Importantly, more than half of the 48 industries have median values equal to zero. Due to the extreme heterogeneity in innovation generation across time and across industries, we control for both of these factors in all of our analyses.

4. Empirical Results

4.1 Methodology

Understanding the tradeoffs firms make as they choose their corporate governance structures is the natural evolution of corporate governance research. As the previous literature has shown, there are situations where busy boards can be beneficial and there are situations where busy boards can be detrimental; similarly, boards with strong network connections and

interlocking relationships have been shown to be beneficial and detrimental to firms in different situations. The purpose of this paper is to disentangle these confounding findings in the specific context of corporate innovation. Innovation is an expensive and long-term investment. Innovation is risky. Firms must be willing to take these risks in order to create value for the firm – potentially through low-probability, high-return investments. And boards of directors must be incentivized to focus on the long-term rather than the short-term.

Our analysis will focus on the interrelationships between these dynamics. Our primary empirical model will study the effects these corporate governance dynamics have on corporate innovation:

$$Innovation_{i,t+1} = \alpha + \beta Governance_{i,t} + \theta Controls_{i,t} + \varepsilon$$

The focus of this study is to disentangle the monitoring and advisory tensions, the professional expertise and governance characteristics of boards of directors. We run ordinary least squares (OLS) regressions with the above model for each of our six hypotheses, regressing our four measures of *Innovation* on different measures of *Governance*. While it is possible that certain types of directors may be attracted to firms that are already innovative, any concerns about endogeneity and simultaneity bias should be reduced because we are considering the effect of current *Governance* on *future Innovation.* All models include firm and year fixed effects to control for any unobservable, time-invariant, firm-specific characteristics, and are estimated using standard errors adjusted based on the Huber-White sandwich estimate and are clustered by firm.

4.2 Director Busyness and Innovation

Table 3 presents the results of our analysis of *Hypothesis #1* on the relationship between innovation and director busyness. Our primary variable of interest is *Busy Directors*, or the percentage of directors who are on 3 or more boards in Panel A. We note a negative and significant relationship; busy directors are associated with fewer future patents and fewer future citations. In Panel B, we focus exclusively on *Busy Outside Directors* (defined as Busy Independent Directors); again, we see a significant and negative relationship across all measures of innovation. In Panel C, we only consider *Busy Inside Directors* (or Busy Employee Directors); here, we note that the relationship is positive – busy insiders are associated with more innovation – but insignificant, except with respect to the *Ln(1 + Cites)* variable, which is significant at a 10% level. In Panel D, rather than using the percentage of directors who are busy as the primary explanatory variable, we consider the average number of boards that directors serve on as the measure for director busyness.[6] The relationship between this measure of busy directors and innovation is also positive, supporting the finding that busy directors are associated with less innovation. Thus, we conclude that our evidence supports the prediction of *Hypothesis #1a*, that busy boards and directors are too busy to focus on the firm and, thus, are associated with less generation of productive innovation.

4.3 Interlocked Directors and Innovation

Table 4 presents the results of the relationship between director interlocks and innovation. Across all four measures of innovation, we notice positive and significant

[6] In untabulated results, we also consider the number of other boards variable for busy outsiders and busy insiders separately; the results are similar to those presented in Panels B and C.

relationships: boards with more *Interlocked Directors* generate more patents and citations. This provides support for *Hypothesis #2a*.

However, the results in Tables 3 and 4 present something of a dilemma. While it is entirely possibly that board busyness and interlocking directors are entirely separate constructs with entirely separate populations and effects, it is perhaps more likely that there are interactions between the two variables. In theory, as a director becomes more busy, she is more likely to develop interlocking relationships within the boards on which she serves. To address how these two dynamics interact, we create three new variables: (1) *Busy Non-Interlocked Directors*, (2) *Interlocked Non-Busy Directors*, and (3) *Busy and Interlocked Directors*. In Table 5, we present the results from performing the same regressions of innovation on these 3 new variables.

In Panel A, we see that the results for *Busy Non-Interlocked Directors* are very similar to – and slightly stronger than – the results in Table 3 using the primary measures for *Busy Directors*. Thus, the *Busy Director* effect is not being driven by *Interlocked Directors*; *Busy Directors* generate less innovation. In Panel B, we see that the results for *Interlocked Non-Busy Directors* are much stronger than those observed in Table 4 for with the base *Interlocked Directors* analysis. *Interlocked Directors* who are not busy are better able to focus, provide effective advice and share knowledge without their attention being diluted due to other board service. This further supports the theory behind *Hypothesis #2a* that interlocked directors can be very effective advisors under the appropriate circumstances. Finally, we address the mechanical fact that as directors become busier they are more likely to develop interlocking relationships between boards; we consider only those directors who are both *Busy and Interlocked* as the primary explanatory variable. Importantly, we note that all of the effects go away; the costs of directors being busy cancel out the benefits of directors having beneficial interlocking

relationships on other boards. Across all measures of innovation, the *Busy and Interlocked Directors* variable is insignificant. This result provides novel evidence of the how critical director activities and relationships are towards generating value for the firms and boards on which they serve. Not all boards, directors and relationships are the same; as such, it is imperative to understand who the directors are and what relationships they have that can provide value.

4.4 Entrenchment and Innovation

An impressive literature has studied the relationship between innovation and board entrenchment, both theoretically and empirically; Sapra, Subramanian and Subramanian (2014) and Chemmanur and Tian (2017) found a positive relationship between patents & citations and anti-takeover provisions. These anti-takeover provisions protect managers – and directors – from takeover threats; they can allow managers to focus on the long-term and to executive expensive and risky strategies, or they can insulate managers from market discipline, thereby leading to ineffective corporate governance and entrenching managers. The prior literature finds that anti-takeover provisions are associated with more innovation, supporting the theory that they protect managers from market pressure and allow them to focus on long-term strategies.

In Table 6, we analyze the relationship between innovation and director entrenchment, utilizing several different measures of entrenchment. In Panel A, we present the results using *Director Tenure* as the measure of entrenchment; we find highly significant results that show firms with longer-tenured directors generate more patents and more citations. As shown in Table 1, the median tenure for directors in our sample is 10 years; 22% of the directors have board tenures longer than 15 years and 21% of directors have tenures less than 5 years. Thus, we

create two new variables to determine if the general results of *Innovation on Director Tenure* are driven by either extreme. The results are in Table 6, Panels B and C. Directors with board tenure of more than 15 years are associated with significantly more innovation, although this result is weaker than the overall measure of *Director Tenure*. Directors with board tenure of less than 5 years are negatively, but insignificantly, associated with innovation. The results from Table 6, Panels A, B and C support the theory that director entrenchment is beneficial for innovation; this dynamic could be driven by these directors having greater experience and firm-specific knowledge, by them having fewer long-term career concerns or by them having more option value from risky investments due to having accumulated more stockholdings.

In Panels D and E, we turn to anti-takeover provisions as our measure of entrenchment. In Panel D, we show that the Bebchuk, Cohen and Ferrell (2009) *E-Index* is significantly positively associated with all four measures of innovation. In Panel E, we show that the Gompers, Ishii and Metrick (2003) *G-Index* is significantly associated with more future patents but not with more future citations (the relationship is positive, but statistically insignificant). These findings are generally consistent with the prior literature that more anti-takeover provisions provide managers and directors with the protection to invest in long-term, but possibly risky, projects.[7]

In Panel F, we consider *CEO-Chair Duality*, or whether the CEO of the sample firm also serves as the Board Chair, as our final measure of entrenchment. The results show that *Duality*

[7] The distinction between Table 6, Panels D and E is also consistent with the findings in Bebchuk, Cohen and Ferrell (2009), who show that their E-Index, which is a 6-provision subset of Gompers, Ishii and Metrick's (2003) 24-provision G-Index, includes the only provisions that matter with respect to providing this protection or entrenchment.

is positively and significantly related to future, bias-adjusted citations, but insignificantly related to the other 3 measures of innovation.

Altogether, the results presented in Table 6 support *Hypothesis #3a* that greater director entrenchment protects the directors from the short-term pressures of the takeover and financial markets and allows them to focus on executing long-term strategies, thus leading to more firm innovation through patents and patent citations. This finding, which extends the prior literature, is important because it highlights the nuanced nature of measuring corporate governance constructs. In general, the prior literature has found that director and manager entrenchment – including both Bebchuk, Cohen and Ferrell (2009) and Gompers, Ishii and Metrick (2003) – is associated with lower firm value. However, the current findings show that not all entrenchment is bad. Thus, it is critical to focus on the specific director characteristics and firm dynamics to better understand these nuanced relationships within corporate governance structures.

4.5 Director Experience and Innovation

Our next set of analyses attempts to better understand director-specific characteristics, including their professional experience and expertise, and how they influence their firm's innovation strategy. The results of these analyses are presented in Table 7. In Panel A, we begin by looking at the percentage of directors who are current CEOs of other firms; Table 1 shows that about 9% of our directors are CEOs at other firms. The results show a negative and highly significant relationship between *CEO of Other Firm* and *Innovation*. Perhaps this result is because CEO-directors have too much responsibility with their employer firm and are unable to focus adequately, or perhaps it is because CEO-directors are too high-level to appropriately advise on the benefits of long-term investments in innovation. In Table 7, Panel B we also show

a negative and highly significant relationship between *Chair of Other Firm* and *Innovation*; this result should not be surprising given the naturally high correlations between *CEO of Other Firm* and *Chair of Other Firm*. The findings in Panels A and B support *Hypothesis #4a* that CEO (and Chair) directors are associated with generating less innovation.

We address *Hypothesis #4b* on the relationship between directors who are financial experts and firm innovation. The results show a negative, but insignificant, relationship between *Financial Expertise* and I*nnovation*. While these results do not support *Hypothesis #4b* that *Financial Expertise* will be associated with less firm innovation, it is generally consistent with Güner, Malmendier and Tate (2005) in that finance experts are not associated with more value-creating investments.[8]

Finally, we address *Hypothesis #4c* on the relationship between director age and innovation. *Hypothesis #4c* predicts that younger directors will lead to greater firm innovation based on the existing literature showing that CEO age is associated with firms making more acquisitions and large-scale investments. The results in Table 7, Panel C show a positive, but insignificant, relationship between *Director Age* and *Innovation*. Thus, the results do not support *Hypothesis #4c*.[9] As we saw earlier, *Director Tenure* is positively and significantly associated with innovation; it seems plausible that younger directors do exhibit the same career-enhancing desires demonstrated in Kim (2013) and Jenter and Lewellen (2015), but that these goals are not reflected in how they influence a firm's innovation strategy due to their lack of firm-specific experience on the board.

[8] The sample size for the Table 7, Panel C analyses is much smaller than the other analyses because ISS/IRRC did not begin tracking Financial Expertise until 2007.

[9] In additional tests, we consider additional age variables. We consider the percentage of directors who are younger than 40, younger than 45, younger than 50, older than 65 and older than 70. In all cases, the results are statistically insignificant.

4.6 Board Structure and Innovation

The results in Table 8 show that there is no relationship between *Board Independence* and innovation. This finding is important given the past 15+ years of regulatory emphasis – SOX, Dodd-Frank, exchange listing requirements – on board independence being associated with better corporate governance. To be sure, our results do not say that board independence is associated with weak corporate governance, just that it does not contribute to a firm's innovation activity. In untabulated results, we also find that neither the percentage of employee directors nor the percentage of affiliated directors is associated with firm innovation. Thus, we do not find evidence to support either *Hypothesis #5a* or *#5b*; *Board Independence* does not seem to impact firm innovation.

4.7 Director Ownership and Innovation

In our final set of analyses, we focus on *Director Ownership* as a measure of corporate governance and incentive alignment. *Hypothesis #6* predicts that greater *Director Ownership* should be associated with more innovation. To the extent that innovation is a long-term investment, director stock ownership should incentivize directors to focus on implementing strategies and investments designed to maximize firm value over the long-term. In Table 9, we consider 3 different measures of *Director Ownership* to address the *Hypothesis #6* prediction that greater *Director Ownership* will lead to more firm-level innovation. In Panel A, we present the results using the *Percentage Stock Owned by the Median Director* as the measure of *Director Ownership*;[10] while *% Median Ownership* is positively related to all 4 measures of innovation, it is only significantly related to *Ln(1 + Pats)*.

[10] In Panels A and B we focus on the stock owned by the *median* director. The logic behind this is that this director may serve as the deciding vote in any contested decisions, so this measure is more informative than using mean

In Panel B, we use the *Median Dollar Value of Director Ownership* as our measure of *Director Ownership*. As shown in Table 1, the average median dollar value of stock owned by directors is approximately $2,000,000; for the majority of directors, this amount of ownership should be substantial enough to incentivize them to proactively invest in strategies that will maximize the long-term value of the firm. The results in Table 9, Panel B show a positive, but statistically insignificant, relationship between the *Dollar Value of Director Ownership* and *Innovation*. Thus, while director ownership may be associated with better incentive alignment and corporate governance overall – like board independence – it may be too much of a macro-level governance construct to significantly capture the specific benefits of investing in innovation.

Finally, we consider the number of directors who do not own any stock as our measure of *Director Ownership*. Table 1 shows that 5% of the directors in our sample do not own any stock in their firms. In theory, these directors do not have any incentive to focus on and invest in the long-term value creation of their firms. Thus, we would expect a negative relationship between *% Shares Zero* and *Innovation*. The results show small and insignificant relationships between *% Shares Zero* and both patents and citations. Overall, our results do not support the prediction in *Hypothesis #6* that greater *Director Ownership* should lead to more firm-level innovation.

5. Conclusion

We provide a comprehensive study of how different corporate governance constructs influence innovation. We know that not all corporate governance mechanisms are created equal; we know that different corporate governance mechanisms can proxy for different incentives in

director ownership, which may be highly skewed to large stock positions held by CEOs or founders; see Bhagat and Bolton (2013) for more information.

different situations. Therefore, our purpose is to disentangle these different constructs and to understand how firms can generate innovation. Specifically, we study six different corporate governance constructs: board busyness, interlocked directors, entrenchment, director expertise, board structure and director ownership. We find that busy boards generate less innovation, as do boards with CEOs or Chairs from other companies. We find that boards with more interlocked directors and more entrenched boards generate more innovation. Board structure, such as director independence, does not significantly affect innovation. And director ownership is only weakly associated with greater innovation.

Coles, Daniel and Naveen (2008) show that not all boards are created equally. Different firms have different objectives, operate in different environments and engage different stakeholders. All of these firm-specific differences lead to different needs for the boards of directors and within the corporate governance function of any firm. Coles, Daniel and Naveen (2008) find that R&D intensive firms and firms which rely on investment in innovation to create value need more industry- and firm-specific knowledge on the board of directors. They show that this presents a need for more employee directors; we show that this need for industry- and firm-specific knowledge extends to the professional expertise and relationships of individual board members. Sapra, Subramanian and Subramanian (2014) show that innovation is the result of corporate governance environments that either provide the incentives to capitalize on the option value of innovation or provide the incentives to make long-term investments in innovation. Our results corroborate these theories and extend them to a more holistic understanding of how the unique aspects of corporate governance dynamics can have different implications for different firms in different situations.

We contribute two primary policy implications for firms looking to generate greater innovation. First, boards must be incentivized and empowered to focus on long-term strategies. Second, directors' professional relationships and activities matter. Given that not all corporate governance structures lead to the same outcomes, our findings should help firms design corporate governance structures that will be better aligned with how they can uniquely create value.

In addition to those two policy implications, this study makes at least three significant contributions to the corporate governance and innovation literature. First, we provide the first comprehensive analysis of how different corporate governance mechanisms influence a firm's innovation success. Second, we show how specific director activities produce trade-offs in the boardroom. And, third, we show that certain mechanisms that have previously been shown to be associated with good corporate governance at a generic level may not be effective in leading to long-term innovation. Corporate governance is a highly nuanced construct; one size does not fit all and different measures of corporate governance may not impact different firms in the same ways. We attribute these findings to the fact that corporate governance is a function of human beings and who these humans are is what will determine how corporate governance is effected at each firm. The more we, as researchers, can understand the dynamics that take place between directors in the boardroom, the professional experiences of the key individuals in the corporate governance functions and the personal and professional incentives of the key individuals responsible to executing value-creating initiatives, the better firms can structure their corporate governance systems to meet the specific objectives of each firm.

Appendix: Variable Definitions

Variable	Definition
Patent Innovation in year t+1:	
Pats	The total number of patents filed by (and ultimately granted to) a firm in year t+1 (sample period: application year over 1997-2010).
$Pats_{TN}$	Equals Pats divided by the average number of patents filed across all firms in the same application year and the same U.S. Patent and Trademark Office (USPTO) technological class.
Cites	Total future citations received in life on all patents filed by (and ultimately granted to) a firm in year t+1 (sample period: application year over 1997-2010).
$Cites_{TN}$	Equals Cites divided by the total number of citations received on all patents filed in the same USPTO class (HJT technological category) for the same application year.
Ln (1+Pats)	Natural logarithm of one plus Pats in year t+1.
Ln (1+$Pats_{TN}$)	Natural logarithm of one plus $Pats_{TN}$ in year t+1.
Ln (1+Cites)	Natural logarithm of one plus Cites in year t+1.
Ln (1+$Cites_{TN}$)	Natural logarithm of one plus CitesTN in year t+1.
Board Governance Variables in year t:	
Busy Directors	The percentage of directors who are on three or more other board (not including the sample firm).
Busy Outside Directors	The percentage of independent directors who are on three or more other boards.
Busy Insider Directors	The percentage of employee directors who are on three or more other boards.
# of Other Boards	The average number of other boards that directors serve on.
Interlocked Directors	The percentage of directors with any interlocking relationship with another board.
Busy Non-Interlocked Directors	The percentage of directors who are busy (on three or more other boards) but not interlocked.
Interlocked Non-Busy Directors	The percentage of directors who are not busy but interlocked.
Busy and Interlocked Directors	The percentage of directors who are both busy and interlocked.
Director Tenure	The average tenure, on the board, of directors.
Tenure > 15 Yrs	The percentage of directors with a tenure on the board of 15 years or more.
Tenure < 5 Yrs	The percentage of directors with a tenure on the board of less than 5 years.
BCF E-Index	The sum of six anti-takeover provisions as in Bebchuk, Cohen and Ferrell (2009), including staggered board, poison pill, supermajority to approve mergers, limits to amend bylaws, limits to amend charters, and golden parachutes.
GIM G-Index	The anti-takeover provisions index from Gompers, Ishii and Metrick (2003).
CEO-Chair Duality	=1 if the firm has a dual CEO-Chair position, and zero otherwise.
CEO of Other Firm	=1 if the board has any outside directors whose primary job title includes CEO, and zero otherwise.
Chair of Other Firm	=1 if the board has any outside directors whose primary job title includes Chairman of the Board, and zero otherwise.
Financial Expertise	The percentage of directors who can be classified as a Financial Expert, per Sarbanes-Oxley.
Director Age	The average age of directors on the board.
Board Independence	The percentage of directors who are independent.
%Median Ownership	The percentage ownership of the median director.
Median Dollar	The median dollar value of director ownership.
Median Shares	The median number of shares owned by directors.
%Shares Zero	The percentage of directors on the board that owns zero shares.

Control Variables in year t:

Ln (MV)	Natural logarithm of market value of equity [#25*#199].
R&D/Assets	Research and development expenditure over assets [#46/#6].
Ln (Sales/Employee)	Natural logarithm of total sales (#12) scaled by the total number of employees (#39).
CAPX/Assets	Capital expenditure over assets [#128/#6].
PPE/Assets	Net property, plant and equipment to assets [#8/#6].
ROA	Return on assets defined as operating income before depreciation over assets [#13/#6].
Debt/Assets	Book value of debts over book value of total assets [(#34+#9)/#6].
Cash/Assets	Cash to assets [#1/#6].
Q	Tobin's q defined as market value of assets over book value of assets [(#6-#60+abs(#25*#199))/#6].
HI	Herfindahl index of sales of 4-digit SIC industry where the firm belongs.
HI^2	The square of HI.
Ln (Age)	Natural logarithm of one plus firm age, measured as the number of years listed on CRSP.
Insider Ownership	The percentage of the company's shares owned by top five executives.
Equity/Total Pay	The total value of new restricted stocks and stock options granted as a percentage of annual total pay for the top five executives.

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Table 1. Summary Statistics

This table provides summary statistics on the key variables. All except binary variables are winsorized at the upper and lower 1% level. Variables are defined in the Appendix.

Variable	N	Mean	Std Dev	Min	P25	Median	P75	Max
Panel A: Innovation Variables in Year t+1 (1997-2010)								
Pats	13,621	26.36	157.55	0.00	0.00	0.00	3.00	4,422.00
$Pats_{TN}$	13,621	4.79	24.33	0.00	0.00	0.00	0.71	684.17
Cites	13,621	190.93	1,838.02	0.00	0.00	0.00	2.00	95,000.00
$Cites_{TN}$	13,621	26.21	159.93	0.00	0.00	0.00	1.54	4,357.32
Cites per Patent	13,621	1.49	5.09	0.00	0.00	0.00	0.48	157.00
$Cites_{TN}$ per Patent	13,621	0.34	0.84	0.00	0.00	0.00	0.39	20.80
Ln (1+Pats)	13,621	0.94	1.58	0.00	0.00	0.00	1.39	5.86
Ln (1+$Pats_{TN}$)	13,621	0.53	1.04	0.00	0.00	0.00	0.54	4.23
Ln (1+Cites)	13,621	1.08	2.05	0.00	0.00	0.00	1.10	7.70
Ln (1+$Cites_{TN}$)	13,621	0.83	1.57	0.00	0.00	0.00	0.93	5.85
Panel B: Board Governance Variables in Year t (1996-2009)								
Director Busyness:								
Busy Directors	8,553	0.10	0.11	0.00	0.00	0.09	0.17	0.44
Busy Outside Directors	8,553	0.07	0.09	0.00	0.00	0.00	0.13	0.38
Busy Insider Directors	8,553	0.01	0.02	0.00	0.00	0.00	0.00	0.14
# of Other Boards	8,553	0.87	0.48	0.00	0.50	0.82	1.17	2.25
Director Interlock:								
Interlocked Directors	8,564	0.01	0.03	0.00	0.00	0.00	0.00	0.14
Interactions between Director Busyness and Interlocks:								
Busy Non-Interlocked Directors	8,553	0.10	0.11	0.00	0.00	0.09	0.17	0.43
Interlocked Non-Busy Directors	8,553	0.01	0.03	0.00	0.00	0.00	0.00	0.15
Busy and Interlocked Directors	8,564	0.00	0.01	0.00	0.00	0.00	0.00	0.06
Director Entrenchment:								
Director Tenure	8,544	10.43	3.99	3.00	7.50	9.88	12.71	22.67
Tenure > 15 Yrs	8,553	0.22	0.18	0.00	0.10	0.20	0.33	0.71
Tenure < 5 Yrs	8,553	0.21	0.17	0.00	0.10	0.20	0.33	0.80
BCF E-Index	11,371	1.56	1.07	0.00	1.00	2.00	2.00	4.00
GIM G-Index	11,371	9.42	2.48	4.00	8.00	9.00	11.00	15.00
CEO-Chair Duality	8,562	0.37	0.48	0.00	0.00	0.00	1.00	1.00
Director Experience:								
CEO of Other Firm	8,564	0.09	0.10	0.00	0.00	0.08	0.14	1.00
Chair of Other Firm	8,564	0.08	0.09	0.00	0.00	0.00	0.13	1.00
Financial Expertise	2,675	0.14	0.14	0.00	0.00	0.11	0.23	0.50
Director Age	8,562	60.25	4.23	48.75	57.63	60.43	63.00	71.00
Board Structure:								
Board Independence	8,564	0.72	0.15	0.33	0.63	0.73	0.82	1.00
Director Ownership								
%Median Ownership	8,561	0.01	0.03	0.00	0.00	0.00	0.00	0.26

Median Dollar	8,561	2,000,000	3,000,000	7	490,000	1,000,000	2,100,000	20,000,000
Median Shares	8,561	64,000	93,000	4,537	21,000	36,000	65,000	640,000
%Shares Zero	8,561	0.05	0.08	0.00	0.00	0.00	0.10	0.33
Panel C: Control Variables in Year t (1996-2009)								
MV ($mn)	13,621	8,402.53	24,000.00	7.79	763.40	1,998.14	5,762.10	500,000.00
Sales ($mn)	13,621	6,313.52	18,000.00	0.18	671.28	1,742.80	5,267.00	430,000.00
Assets ($mn)	13,621	7,444.01	21,000.00	10.23	701.66	1,921.07	5,984.40	480,000.00
R&D ($mn)	13,621	145.00	627.50	0.00	0.00	0.00	52.35	12,000.00
Employees (000)	13,621	24.65	69.47	0.01	2.45	7.10	21.50	2,100.00
Ln (MV)	13,621	7.71	1.50	3.43	6.64	7.60	8.66	11.54
R&D/Assets	13,621	0.03	0.05	0.00	0.00	0.00	0.04	0.42
Ln (Sales/Emp)	13,621	5.59	0.84	3.11	5.09	5.52	6.04	7.98
CAPX/Assets	13,621	0.06	0.05	0.00	0.02	0.04	0.07	0.31
PPENT/Assets	13,621	0.30	0.23	0.00	0.11	0.23	0.44	0.88
ROA	13,621	0.14	0.10	-0.59	0.09	0.14	0.19	0.43
Debt/Assets	13,621	0.23	0.18	0.00	0.07	0.22	0.34	0.92
Cash/Assets	13,621	0.14	0.17	0.00	0.02	0.07	0.20	0.90
Q	13,621	2.02	1.28	0.75	1.23	1.60	2.32	8.66
HI	13,621	0.23	0.19	0.03	0.09	0.18	0.31	1.00
HI^2	13,621	0.09	0.16	0.00	0.01	0.03	0.09	1.00
Age	13,621	26.30	20.86	0.00	10.00	20.00	37.00	84.00
Institutional Own.	13,621	0.61	0.34	0.00	0.45	0.70	0.85	2.44
Insider Own.	13,621	0.03	0.07	0.00	0.00	0.01	0.02	0.40
Equity/Total Pay	13,621	0.52	0.26	0.00	0.34	0.56	0.73	0.94

Table 2. Sample Distribution by Year and Industry

This table provides sample distribution of innovation variables by year (Panel A) and Fama-French 48 industry (Panel B). All except binary variables are winsorized at the upper and lower 1% level. Variables are defined in the Appendix.

		Patents		Cites	
	N	Mean	Median	Mean	Median
Panel A: Distribution by Year					
1997	501	60.22	1.00	1,123.82	6.00
1998	501	60.14	2.00	959.13	0.00
1999	494	63.74	1.00	853.27	0.00
2000	503	65.33	1.00	674.66	0.00
2001	526	61.89	1.00	461.50	0.00
2002	722	56.18	1.00	314.34	0.00
2003	748	53.23	0.00	191.84	0.00
2004	1,433	26.93	0.00	66.57	0.00
2005	1,427	24.48	0.00	36.78	0.00
2006	1,232	19.11	0.00	18.32	0.00
2007	1,284	12.16	0.00	7.17	0.00
2008	1,408	5.29	0.00	2.07	0.00
2009	1,432	0.92	0.00	0.27	0.00
2010	1,410	0.00	0.00	0.00	0.00
Panel B: Distribution by FF 48 Industry					
1 Agriculture	37	27.38	0.00	55.59	0.00
2 Food Products	320	3.26	0.00	12.44	0.00
3 Candy & Soda	47	0.06	0.00	0.13	0.00
4 Beer & Liquor	85	2.85	0.00	17.35	0.00
5 Tobacco Products	38	9.92	1.50	87.84	0.00
6 Recreation (Toys)	83	15.81	4.00	88.10	4.00
7 Entertainment	157	3.07	0.00	16.96	0.00
9 Consumer Goods	98	93.64	7.00	512.37	8.00
10 Apparel	160	0.06	0.00	0.09	0.00
11 Healthcare	249	0.06	0.00	0.03	0.00
12 Medical Equipment	375	22.07	2.00	277.40	0.00
16 Textiles	53	4.66	0.00	7.60	0.00
17 Construction Materials	1,847	23.44	0.00	116.46	0.00
18 Construction	207	4.06	0.00	19.39	0.00
19 Steel Works	241	9.71	0.00	56.59	0.00
20 Fabricated Products	24	0.71	0.00	0.83	0.00
21 Machinery	574	30.05	3.00	197.16	1.50
22 Electrical Equipment	227	23.30	2.00	157.16	0.00
23 Automobiles and Trucks	56	9.36	0.00	62.84	0.00
24 Aircraft	290	66.41	2.00	265.90	0.00
25 Shipbuilding, Railroad Equipment	117	115.65	19.00	505.61	10.00
26 Defense	28	8.25	0.50	48.29	0.00

27 Precious Metals	40	65.85	4.00	360.90	2.00
28 Non-Metallic & Industrial Metal Mining	37	0.19	0.00	0.30	0.00
29 Coal	71	0.54	0.00	0.87	0.00
30 Petroleum and Natural Gas	32	0.00	0.00	0.00	0.00
31 Utilities	596	8.92	0.00	80.74	0.00
32 Telecom	973	0.14	0.00	0.78	0.00
33 Personal Services	398	16.90	0.00	85.36	0.00
34 Business Services	169	0.08	0.00	2.11	0.00
35 Computers	1,393	40.07	0.00	274.55	0.00
36 Electronic Equipment (Chips)	559	93.35	3.00	953.09	1.00
37 Measuring and Control Equipment	924	100.82	6.50	844.06	3.00
38 Business Supplies	303	22.55	4.00	94.78	2.00
39 Shipping Containers	315	29.67	1.00	222.13	0.00
40 Transportation	80	6.43	0.00	47.81	0.00
41 Wholesale	417	0.44	0.00	2.20	0.00
42 Retail	489	1.17	0.00	8.39	0.00
43 Restaurants, Hotels, Motels	1,068	0.23	0.00	0.74	0.00
44 Banking	291	0.26	0.00	0.05	0.00
45 Insurance	5	0.00	0.00	0.00	0.00
46 Real Estate	85	0.04	0.00	0.66	0.00
48 Other	63	7.17	0.00	17.41	0.00

Table 3. Regressions of Innovation on Director Busyness

This table presents regression results of innovation on various measures of director busyness. Panel A examines Busy Directors, defined as the percentage of directors who are on three or more other boards (not including the sample firm); Panel B examines Busy Outside Directors, defined as the percentage of independent directors who are on three or more other boards; Panel C examines Busy Insider Directors, defined as the percentage of employee directors who are on three or more other boards, and Panel D examines Ln (# of Other Boards), defined as the natural logarithm of the average number of other boards that directors serve on. Control variables are omitted for brevity in Panels B, C and D. All regressions contain firm and year fixed effects. All except binary variables are winsorized at the upper and lower 1% levels. Full variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Standard errors are adjusted based on the Huber-White sandwich estimate of variances and are clustered by firm. *** indicates significance at the 1% level, ** 5% and * 10%.

Panel A: Busy Directors

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Busy Directors	**-0.2686****	**-0.2204*****	**-0.3782****	**-0.3149*****
	(-2.46)	**(-2.94)**	**(-2.25)**	**(-2.60)**
Ln (MV)	0.0784*	0.0573*	0.1113	0.0721
	(1.87)	(1.88)	(1.61)	(1.52)
R&D/Assets	-0.6007	0.0851	0.3949	-0.7285
	(-0.68)	(0.14)	(0.27)	(-0.65)
Ln (Sales/Emp)	0.1781**	0.1086*	0.3552**	0.2162**
	(2.22)	(1.88)	(2.52)	(2.26)
CAPX/Assets	-0.6699	-0.7121***	-1.3304**	-0.8839*
	(-1.61)	(-2.68)	(-2.02)	(-1.94)
PPENT/Assets	1.7821***	1.0385***	2.9506***	1.7568***
	(6.45)	(5.30)	(6.50)	(5.74)
ROA	-1.1075***	-0.6651***	-1.8892***	-1.3568***
	(-4.31)	(-3.92)	(-4.41)	(-4.71)
Debt/Assets	-0.0101	-0.0119	0.0676	-0.0318
	(-0.06)	(-0.10)	(0.23)	(-0.16)
Cash/Assets	0.1317	-0.0489	-0.0302	0.1242
	(0.73)	(-0.40)	(-0.10)	(0.60)
Q	0.0825***	0.0451**	0.1858***	0.1170***
	(3.25)	(2.49)	(4.20)	(3.96)
HI	0.5536	0.5450	1.2175	0.6048
	(0.99)	(1.34)	(1.32)	(0.98)
HI^2	-0.5669	-0.5674	-1.3031	-0.6932
	(-1.05)	(-1.44)	(-1.39)	(-1.15)
Ln (Age)	0.5170***	0.3818***	0.6167**	0.4220***
	(3.75)	(3.65)	(2.50)	(2.67)
Institutional Own.	0.0496	0.0573	0.2403	0.1031
	(0.45)	(0.73)	(1.19)	(0.80)
Insider Ownership	-0.5296	-0.5123**	-1.0368	-0.7394*
	(-1.40)	(-2.14)	(-1.58)	(-1.92)
Equity/Total Pay	0.0590	0.0105	0.1630*	0.0823
	(1.13)	(0.31)	(1.92)	(1.40)
Constant	-3.8613***	-2.6406***	-6.2157***	-3.8029***
	(-5.13)	(-4.96)	(-4.90)	(-4.49)
Observations	8,596	8,596	8,596	8,596
R-squared	0.335	0.278	0.399	0.287
Firm & Year FE	Yes	Yes	Yes	Yes

Panel B: Busy Outside Directors

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Busy Outside Directors	**-0.2396****	**-0.2041****	**-0.3404***	**-0.2970****
	(-2.07)	**(-2.58)**	**(-1.95)**	**(-2.34)**
Observations	8,596	8,596	8,596	8,596
R-squared	0.335	0.278	0.398	0.287
Firm & Year FE	Yes	Yes	Yes	Yes

Pane C: Busy Insider Directors

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Busy Insider Directors	**0.5577**	**0.4067***	**0.5973**	**0.3833**
	(1.64)	**(1.72)**	**(1.04)**	**(0.89)**
Observations	8,596	8,596	8,596	8,596
R-squared	0.334	0.277	0.398	0.286
Firm & Year FE	Yes	Yes	Yes	Yes

Pane D: Ln (# of Other Boards)

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Ln (# of Other Boards)	**-0.1177*****	**-0.0822*****	**-0.1490*****	**-0.1217*****
	(-6.55)	**(-6.85)**	**(-5.29)**	**(-5.82)**
Observations	8,596	8,596	8,596	8,596
R-squared	0.334	0.277	0.398	0.286
Firm & Year FE	Yes	Yes	Yes	Yes

Table 4. Regressions of Innovation on Director Interlocks

This table presents regression results of innovation on Interlocked Directors, defined as the percentage of directors with any interlocking relationship with another board. All regressions contain firm and year fixed effects. All except binary variables are winsorized at the upper and lower 1% levels. Full variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Standard errors are adjusted based on the Huber-White sandwich estimate of variances and are clustered by firm. *** indicates significance at the 1% level, ** 5% and * 10%.

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Interlocked Directors	**0.5230****	**0.4066****	**0.9382****	**0.7693*****
	(2.03)	**(2.38)**	**(2.25)**	**(2.60)**
Ln (MV)	0.0754*	0.0555*	0.1043	0.0678
	(1.80)	(1.83)	(1.52)	(1.44)
R&D/Assets	-0.6443	0.0535	0.3209	-0.7884
	(-0.73)	(0.09)	(0.22)	(-0.70)
Ln (Sales/Emp)	0.1799**	0.1105*	0.3564**	0.2164**
	(2.25)	(1.91)	(2.54)	(2.26)
CAPX/Assets	-0.6700	-0.7158***	-1.3183**	-0.8914*
	(-1.61)	(-2.69)	(-2.00)	(-1.96)
PPENT/Assets	1.7622***	1.0219***	2.9124***	1.7357***
	(6.39)	(5.22)	(6.44)	(5.69)
ROA	-1.1101***	-0.6686***	-1.8882***	-1.3560***
	(-4.32)	(-3.94)	(-4.41)	(-4.70)
Debt/Assets	-0.0105	-0.0103	0.0633	-0.0357
	(-0.06)	(-0.09)	(0.21)	(-0.19)
Cash/Assets	0.1139	-0.0622	-0.0599	0.1029
	(0.63)	(-0.51)	(-0.20)	(0.50)
Q	0.0835***	0.0457**	0.1882***	0.1183***
	(3.29)	(2.52)	(4.26)	(4.01)
HI	0.5645	0.5545	1.2203	0.6079
	(1.01)	(1.37)	(1.32)	(0.98)
HI^2	-0.5788	-0.5773	-1.3108	-0.6998
	(-1.06)	(-1.45)	(-1.38)	(-1.15)
Ln (Age)	0.5200***	0.3842***	0.6173**	0.4246***
	(3.77)	(3.67)	(2.50)	(2.68)
Institutional Own.	0.0559	0.0617	0.2527	0.1115
	(0.51)	(0.80)	(1.26)	(0.87)
Insider Ownership	-0.5455	-0.5268**	-1.0709	-0.7656**
	(-1.44)	(-2.18)	(-1.63)	(-1.97)
Equity/Total Pay	0.0618	0.0122	0.1675**	0.0852
	(1.18)	(0.36)	(1.97)	(1.44)
Constant	-3.8820***	-2.6636***	-6.2006***	-3.8054***
	(-5.14)	(-4.97)	(-4.88)	(-4.48)
Observations	8,607	8,607	8,607	8,607
R-squared	0.334	0.277	0.398	0.286
Firm & Year FE	Yes	Yes	Yes	Yes

Table 5. Director Busyness, Interlocks, and Innovation

This table presents regression results of innovation on interactions between director busyness and interlocks. Panel A examines Busy Non-Interlocked Directors, defined as the percentage of directors who are busy (on three or more other boards) but not interlocked; Panel B examines Interlocked Non-Busy Directors, defined as the percentage of directors who are not busy but interlocked; Panel C examines Busy and Interlocked Directors, defined as the percentage of directors who are both busy and interlocked. Control variables are omitted for brevity in Panels B and C. All regressions contain firm and year fixed effects. All except binary variables are winsorized at the upper and lower 1% levels. Full variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Standard errors are adjusted based on the Huber-White sandwich estimate of variances and are clustered by firm. *** indicates significance at the 1% level, ** 5% and * 10%.

Panel A: Busy Non-Interlocked Directors

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Busy Non-Interlocked Directors	**-0.2725****	**-0.2240*****	**-0.3842****	**-0.3156****
	(-2.47)	**(-2.95)**	**(-2.27)**	**(-2.58)**
Ln (MV)	0.0782*	0.0572*	0.1111	0.0719
	(1.87)	(1.88)	(1.61)	(1.52)
R&D/Assets	-0.6029	0.0834	0.3920	-0.7313
	(-0.68)	(0.14)	(0.27)	(-0.65)
Ln (Sales/Emp)	0.1778**	0.1084*	0.3548**	0.2159**
	(2.22)	(1.88)	(2.52)	(2.25)
CAPX/Assets	-0.6713	-0.7133***	-1.3324**	-0.8857*
	(-1.62)	(-2.68)	(-2.02)	(-1.95)
PPENT/Assets	1.7834***	1.0395***	2.9524***	1.7581***
	(6.45)	(5.31)	(6.50)	(5.74)
ROA	-1.1057***	-0.6636***	-1.8866***	-1.3548***
	(-4.30)	(-3.91)	(-4.41)	(-4.70)
Debt/Assets	-0.0109	-0.0126	0.0665	-0.0326
	(-0.06)	(-0.11)	(0.22)	(-0.17)
Cash/Assets	0.1324	-0.0483	-0.0293	0.1247
	(0.73)	(-0.40)	(-0.10)	(0.60)
Q	0.0825***	0.0451**	0.1858***	0.1170***
	(3.25)	(2.49)	(4.20)	(3.97)
HI	0.5522	0.5438	1.2155	0.6034
	(0.99)	(1.34)	(1.32)	(0.98)
HI^2	-0.5650	-0.5658	-1.3005	-0.6913
	(-1.05)	(-1.44)	(-1.39)	(-1.15)
Ln (Age)	0.5164***	0.3814***	0.6159**	0.4214***
	(3.75)	(3.65)	(2.50)	(2.67)
Institutional Own.	0.0492	0.0569	0.2398	0.1027
	(0.45)	(0.73)	(1.19)	(0.80)
Insider Ownership	-0.5268	-0.5099**	-1.0327	-0.7366*
	(-1.39)	(-2.13)	(-1.58)	(-1.91)
Equity/Total Pay	0.0589	0.0104	0.1628*	0.0822
	(1.13)	(0.31)	(1.92)	(1.40)
Constant	-3.8562***	-2.6363***	-6.2084***	-3.7978***
	(-5.12)	(-4.95)	(-4.90)	(-4.49)
Observations	8,596	8,596	8,596	8,596
R-squared	0.335	0.278	0.399	0.287
Firm & Year FE	Yes	Yes	Yes	Yes

Panel B: Interlocked Non-Busy Directors

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Interlocked Non-Busy Directors	**0.5804****	**0.5532*****	**1.2229*****	**1.1207*****
	(2.08)	**(3.10)**	**(2.75)**	**(3.53)**
Observations	8,596	8,596	8,596	8,596
R-squared	0.334	0.277	0.398	0.287
Firm & Year FE	Yes	Yes	Yes	Yes

Pane C: Busy and Interlocked Directors

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Busy and Interlocked Directors	**-0.2565**	**-0.1460**	**-0.4564**	**-0.9982**
	(-0.25)	**(-0.22)**	**(-0.28)**	**(-0.90)**
Observations	8,607	8,607	8,607	8,607
R-squared	0.334	0.277	0.397	0.286
Firm & Year FE	Yes	Yes	Yes	Yes

Table 6. Regressions of Innovation on Director Entrenchment

This table presents regression results of innovation on various measures of director entrenchment. Panel A examines Director Tenure, defined as the average tenure, on the board, of directors; Panel B examines Tenure >15 Yrs, defined as the percentage of directors with a tenure on the board of 15 years or more; Panel C examines Tenure < 5 Yrs, defined as the percentage of directors with a tenure on the board of less than 5 years; Panel D examines BCF E-Index, defined as the sum of six anti-takeover provisions as in Bebchuk, Cohen and Ferrell (2009), including staggered board, poison pill, supermajority to approve mergers, limits to amend bylaws, limits to amend charters, and golden parachutes; Panel E examines GIM G-Index, defined as the anti-takeover provisions index from Gompers, Ishii and Metrick (2003); and Panel F examines CEO-Chair Duality, defined as an indicator variable that equals one if the firm has a dual CEO-Chair position, and zero otherwise. Control variables are omitted for brevity in Panels B, C, D, E, and F. All regressions contain firm and year fixed effects. All except binary variables are winsorized at the upper and lower 1% levels. Full variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Standard errors are adjusted based on the Huber-White sandwich estimate of variances and are clustered by firm. *** indicates significance at the 1% level, ** 5% and * 10%.

Panel A: Director Tenure

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Director Tenure	**0.0116*** **	**0.0078*** **	**0.0166*** **	**0.0144*** **
	(3.18)	**(3.18)**	**(2.85)**	**(3.43)**
Ln (MV)	0.0759*	0.0557*	0.1078	0.0691
	(1.81)	(1.82)	(1.56)	(1.46)
R&D/Assets	-0.6534	0.0459	0.3201	-0.7921
	(-0.74)	(0.08)	(0.22)	(-0.70)
Ln (Sales/Emp)	0.1817**	0.1114*	0.3603**	0.2205**
	(2.27)	(1.92)	(2.55)	(2.29)
CAPX/Assets	-0.6146	-0.6765**	-1.2508*	-0.8147*
	(-1.48)	(-2.54)	(-1.90)	(-1.79)
PPENT/Assets	1.7529***	1.0171***	2.9091***	1.7215***
	(6.33)	(5.17)	(6.40)	(5.62)
ROA	-1.1205***	-0.6750***	-1.9076***	-1.3723***
	(-4.36)	(-3.97)	(-4.46)	(-4.76)
Debt/Assets	-0.0109	-0.0120	0.0664	-0.0330
	(-0.06)	(-0.10)	(0.22)	(-0.17)
Cash/Assets	0.1098	-0.0661	-0.0612	0.0981
	(0.60)	(-0.54)	(-0.20)	(0.47)
Q	0.0832***	0.0455**	0.1867***	0.1178***
	(3.29)	(2.51)	(4.24)	(4.01)
HI	0.5643	0.5544	1.2323	0.6170
	(1.01)	(1.37)	(1.34)	(1.00)
HI^2	-0.5818	-0.5795	-1.3240	-0.7107
	(-1.08)	(-1.47)	(-1.41)	(-1.18)
Ln (Age)	0.5342***	0.3943***	0.6413***	0.4430***
	(3.86)	(3.74)	(2.59)	(2.78)
Institutional Own.	0.0555	0.0619	0.2488	0.1102
	(0.51)	(0.80)	(1.24)	(0.86)
Insider Ownership	-0.5248	-0.5137**	-1.0291	-0.7314*
	(-1.41)	(-2.17)	(-1.59)	(-1.93)
Equity/Total Pay	0.0623	0.0128	0.1676**	0.0863
	(1.20)	(0.38)	(1.98)	(1.47)
Constant	-4.0564***	-2.7801***	-6.4941***	-4.0409***
	(-5.35)	(-5.16)	(-5.08)	(-4.73)

Observations	8,596	8,596	8,596	8,596
R-squared	0.336	0.278	0.399	0.288
Firm & Year FE	Yes	Yes	Yes	Yes

Panel B: Tenure > 15 Yrs

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Tenure > 15 Yrs	**0.1382****	**0.0899****	**0.1631**	**0.1580****
	(2.17)	**(2.15)**	**(1.60)**	**(2.16)**
Observations	8,596	8,596	8,596	8,596
R-squared	0.335	0.277	0.398	0.287
Firm & Year FE	Yes	Yes	Yes	Yes

Panel C: Tenure < 5 Yrs

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Tenure < 5 Yrs	**-0.0706**	**-0.0547**	**-0.0956**	**-0.1057**
	(-1.05)	**(-1.23)**	**(-0.90)**	**(-1.37)**
Observations	8,596	8,596	8,596	8,596
R-squared	0.334	0.277	0.398	0.286
Firm & Year FE	Yes	Yes	Yes	Yes

Panel D: BCF E-Index

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
BCF E-Index	**0.0774***	**0.0641***	**0.1408***	**0.0863***
	(1.81)	**(1.95)**	**(1.85)**	**(1.70)**
Observations	11,416	11,416	11,416	11,416
R-squared	0.321	0.260	0.366	0.268
Firm & Year FE	Yes	Yes	Yes	Yes

Panel E: GIM G-Index

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
GIM G-Index	**0.0345***	**0.0301***	**0.0581**	**0.0299**
	(1.78)	**(1.93)**	**(1.61)**	**(1.26)**
Observations	11,416	11,416	11,416	11,416
R-squared	0.321	0.260	0.366	0.267
Firm & Year FE	Yes	Yes	Yes	Yes

Panel F: CEO-Chair Duality

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
CEO-Chair Duality	**0.0237**	**0.0207**	**0.0361**	**0.0417***
	(1.23)	**(1.53)**	**(1.23)**	**(1.90)**
Observations	8,607	8,607	8,607	8,607
R-squared	0.334	0.277	0.397	0.286
Firm & Year FE	Yes	Yes	Yes	Yes

Table 7. Regressions of Innovation on Director Experience

This table presents regression results of innovation on various measures of director experience. Panel A examines CEO of Other Firm, defined as an indicator variable that equals one if the board has any outside directors whose primary job title includes CEO; Panel B examines Chair of Other Firm, defined as an indicator variable that equals one if the board has any outside directors whose primary job title includes Chairman of the Board; Panel C examines Financial Expertise, defined as the percentage of directors who can be classified as a Financial Expert, per Sarbanes-Oxley; and Panel D examines Director Age, defined as the average age of directors on the board. Control variables are omitted for brevity in Panels B, C, and D. All regressions contain firm and year fixed effects. All except binary variables are winsorized at the upper and lower 1% levels. Full variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Standard errors are adjusted based on the Huber-White sandwich estimate of variances and are clustered by firm. *** indicates significance at the 1% level, ** 5% and * 10%.

Panel A: CEO of Other Firm

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
CEO of Other Firm	**-0.4954*** **	**-0.3668*** **	**-0.6852*** **	**-0.5398*** **
	(-4.49)	**(-4.92)**	**(-4.09)**	**(-4.27)**
Ln (MV)	0.0772*	0.0568*	0.1073	0.0703
	(1.86)	(1.88)	(1.57)	(1.50)
R&D/Assets	-0.6592	0.0431	0.3068	-0.7986
	(-0.75)	(0.07)	(0.21)	(-0.71)
Ln (Sales/Emp)	0.1766**	0.1082*	0.3524**	0.2133**
	(2.22)	(1.88)	(2.52)	(2.24)
CAPX/Assets	-0.6426	-0.6953***	-1.2775*	-0.8588*
	(-1.55)	(-2.62)	(-1.94)	(-1.89)
PPENT/Assets	1.7346***	1.0014***	2.8742***	1.7056***
	(6.30)	(5.13)	(6.36)	(5.60)
ROA	-1.1026***	-0.6632***	-1.8791***	-1.3490***
	(-4.34)	(-3.95)	(-4.43)	(-4.73)
Debt/Assets	-0.0130	-0.0119	0.0624	-0.0360
	(-0.07)	(-0.10)	(0.21)	(-0.19)
Cash/Assets	0.1404	-0.0427	-0.0237	0.1314
	(0.78)	(-0.35)	(-0.08)	(0.64)
Q	0.0851***	0.0469***	0.1903***	0.1200***
	(3.37)	(2.60)	(4.31)	(4.08)
HI	0.5487	0.5430	1.2006	0.5926
	(0.99)	(1.34)	(1.30)	(0.96)
HI^2	-0.5650	-0.5672	-1.2932	-0.6861
	(-1.05)	(-1.44)	(-1.38)	(-1.14)
Ln (Age)	0.5101***	0.3770***	0.6043**	0.4145***
	(3.73)	(3.63)	(2.46)	(2.64)
Institutional Own.	0.0509	0.0580	0.2456	0.1059
	(0.47)	(0.75)	(1.23)	(0.83)
Insider Ownership	-0.5072	-0.4984**	-1.0175	-0.7236*
	(-1.35)	(-2.09)	(-1.56)	(-1.88)
Equity/Total Pay	0.0666	0.0158	0.1742**	0.0904
	(1.29)	(0.48)	(2.07)	(1.55)
Constant	-3.8104***	-2.6115***	-6.1114***	-3.7364***
	(-5.09)	(-4.92)	(-4.84)	(-4.44)
Observations	8,607	8,607	8,607	8,607
R-squared	0.337	0.280	0.399	0.289
Firm & Year FE	Yes	Yes	Yes	Yes

Panel B: Chair of Other Firm

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Chair of Other Firm	**-0.7242*** **	**-0.5330*** **	**-0.9923*** **	**-0.8579*** **
	(-6.00)	(-6.30)	(-5.38)	(-6.19)
Observations	8,607	8,607	8,607	8,607
R-squared	0.339	0.283	0.401	0.292
Firm & Year FE	Yes	Yes	Yes	Yes

Panel C: Financial Expertise

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Financial Expertise	**-0.1367**	**-0.0799**	**-0.1138**	**-0.0901**
	(-0.71)	(-0.64)	(-0.72)	(-0.45)
Observations	2,686	2,686	2,686	2,686
R-squared	0.224	0.201	0.150	0.156
Firm & Year FE	Yes	Yes	Yes	Yes

Panel D: Director Age

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Director Age	**0.0040**	**0.0032**	**0.0156**	**0.0051**
	(0.53)	(0.62)	(1.18)	(0.59)
Observations	8,607	8,607	8,607	8,607
R-squared	0.334	0.277	0.398	0.286
Firm & Year FE	Yes	Yes	Yes	Yes

Table 8. Regressions of Innovation on Board Structure

This table presents regression results of innovation on Board Independence, defined as the percentage of directors who are independent. All except binary variables are winsorized at the upper and lower 1% levels. Full variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Standard errors are adjusted based on the Huber-White sandwich estimate of variances and are clustered by firm. *** indicates significance at the 1% level, ** 5% and * 10%.

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Board Independence	**-0.0331**	**-0.0143**	**0.0123**	**0.0014**
	(-0.69)	**(-0.44)**	**(0.16)**	**(0.02)**
Ln (MV)	0.0765*	0.0563*	0.1064	0.0695
	(1.83)	(1.86)	(1.55)	(1.47)
R&D/Assets	-0.6321	0.0643	0.3507	-0.7649
	(-0.71)	(0.11)	(0.24)	(-0.68)
Ln (Sales/Emp)	0.1807**	0.1113*	0.3589**	0.2184**
	(2.26)	(1.93)	(2.55)	(2.28)
CAPX/Assets	-0.6596	-0.7088***	-1.3062**	-0.8807*
	(-1.59)	(-2.66)	(-1.98)	(-1.93)
PPENT/Assets	1.7607***	1.0213***	2.9132***	1.7360***
	(6.39)	(5.22)	(6.43)	(5.68)
ROA	-1.1117***	-0.6704***	-1.8943***	-1.3606***
	(-4.32)	(-3.94)	(-4.42)	(-4.71)
Debt/Assets	-0.0031	-0.0049	0.0742	-0.0265
	(-0.02)	(-0.04)	(0.25)	(-0.14)
Cash/Assets	0.1132	-0.0629	-0.0615	0.1016
	(0.62)	(-0.52)	(-0.21)	(0.49)
Q	0.0833***	0.0456**	0.1876***	0.1179***
	(3.29)	(2.51)	(4.25)	(4.00)
HI	0.5696	0.5585	1.2295	0.6154
	(1.02)	(1.38)	(1.33)	(0.99)
HI^2	-0.5833	-0.5805	-1.3165	-0.7048
	(-1.07)	(-1.46)	(-1.39)	(-1.16)
Ln (Age)	0.5226***	0.3859***	0.6198**	0.4269***
	(3.79)	(3.68)	(2.51)	(2.70)
Institutional Own.	0.0547	0.0611	0.2526	0.1112
	(0.50)	(0.79)	(1.26)	(0.87)
Insider Ownership	-0.5453	-0.5265**	-1.0695	-0.7646**
	(-1.44)	(-2.18)	(-1.63)	(-1.97)
Equity/Total Pay	0.0614	0.0120	0.1676**	0.0851
	(1.18)	(0.36)	(1.97)	(1.44)
Constant	-3.8807***	-2.6712***	-6.2524***	-3.8412***
	(-5.15)	(-4.99)	(-4.92)	(-4.53)
Observations	8,607	8,607	8,607	8,607
R-squared	0.334	0.277	0.397	0.286
Firm & Year FE	Yes	Yes	Yes	Yes

Table 9. Regressions of Innovation on Director Ownership

This table presents regression results of innovation on various measures of director ownership. Panel A examines %Median Ownership, defined as the percentage ownership of the median director; Panel B examines Ln (Median Dollar), defined as the natural logarithm of the median dollar value of director ownership; Panel C examines Ln (Median Shares), defined as the natural logarithm of the median number of shares owned by directors; and Panel D examines %Shares Zero, defined as the percentage of directors on the board that owns zero shares. All except binary variables are winsorized at the upper and lower 1% levels. Full variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Standard errors are adjusted based on the Huber-White sandwich estimate of variances and are clustered by firm. *** indicates significance at the 1% level, ** 5% and * 10%.

Panel A: %Median Ownership

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
%Median Ownership	**0.6119***	**0.3869**	**0.6885**	**0.3416**
	(1.70)	**(1.54)**	**(1.15)**	**(0.85)**
Ln (MV)	0.0756*	0.0556*	0.1057	0.0692
	(1.81)	(1.83)	(1.54)	(1.47)
R&D/Assets	-0.6350	0.0608	0.3462	-0.7665
	(-0.72)	(0.10)	(0.23)	(-0.68)
Ln (Sales/Emp)	0.1802**	0.1108*	0.3586**	0.2183**
	(2.25)	(1.92)	(2.55)	(2.28)
CAPX/Assets	-0.6695	-0.7142***	-1.3137**	-0.8846*
	(-1.61)	(-2.68)	(-1.99)	(-1.94)
PPENT/Assets	1.7650***	1.0245***	2.9150***	1.7373***
	(6.40)	(5.23)	(6.44)	(5.68)
ROA	-1.1076***	-0.6666***	-1.8882***	-1.3577***
	(-4.31)	(-3.92)	(-4.41)	(-4.71)
Debt/Assets	-0.0074	-0.0082	0.0729	-0.0273
	(-0.04)	(-0.07)	(0.25)	(-0.14)
Cash/Assets	0.1138	-0.0624	-0.0616	0.1015
	(0.63)	(-0.51)	(-0.21)	(0.49)
Q	0.0838***	0.0460**	0.1883***	0.1182***
	(3.31)	(2.54)	(4.27)	(4.01)
HI	0.5687	0.5580	1.2368	0.6196
	(1.02)	(1.37)	(1.33)	(1.00)
HI^2	-0.5819	-0.5798	-1.3225	-0.7080
	(-1.07)	(-1.46)	(-1.40)	(-1.16)
Ln (Age)	0.5254***	0.3879***	0.6236**	0.4287***
	(3.82)	(3.71)	(2.53)	(2.71)
Institutional Own.	0.0584	0.0631	0.2538	0.1118
	(0.54)	(0.82)	(1.27)	(0.88)
Insider Ownership	-0.5415	-0.5242**	-1.0625	-0.7609**
	(-1.44)	(-2.19)	(-1.62)	(-1.97)
Equity/Total Pay	0.0624	0.0127	0.1688**	0.0858
	(1.19)	(0.38)	(1.98)	(1.45)
Constant	-3.9132***	-2.6852***	-6.2581***	-3.8480***
	(-5.20)	(-5.03)	(-4.93)	(-4.54)
Observations	8,604	8,604	8,604	8,604
R-squared	0.334	0.277	0.397	0.286
Firm & Year FE	Yes	Yes	Yes	Yes

Panel B: Ln (Median Dollar)

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
Ln (Median Dollar)	**0.0044**	**0.0037**	**0.0078**	**0.0036**
	(1.31)	**(1.56)**	**(1.47)**	**(1.00)**
Observations	8,601	8,601	8,601	8,601
R-squared	0.334	0.277	0.397	0.286
Firm & Year FE	Yes	Yes	Yes	Yes

Panel C: %Shares Zero

	Ln (1+Pats)	Ln (1+$Pats_{TN}$)	Ln (1+Cites)	Ln (1+$Cites_{TN}$)
%Shares Zero	**-0.0506**	**-0.0187**	**0.0865**	**-0.0056**
	(-0.45)	**(-0.25)**	**(0.56)**	**(-0.05)**
Observations	8,604	8,604	8,604	8,604
R-squared	0.334	0.277	0.397	0.286
Firm & Year FE	Yes	Yes	Yes	Yes