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Corporate Governance and CEO Innovation

Vicar S. Valencia [1]

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Abstract A fundamental concern emerging from the corporate literature is the agency problem of innovation. While innovation is considered as a major driver of corporate growth and profitability, the Chief Executive Officer (CEO) has an intrinsic reluctance to pursue innovation projects. The thrust of this paper is to identify the mechanisms of corporate governance which help attenuate this problem, thereby encouraging the CEO to have the propensity to innovate. The empirical results suggest that firms with a widespread dispersion of shares among shareholders are less likely to encourage the CEO to innovate. The likelihood of innovation appears to increase, however, in the presence of a large shareholder. Contrary to prevailing beliefs, there appears to be no association between innovation and board independence. The same result holds for board size. Also, a diverse board appears to negate CEO predisposition to innovate. On the other hand, innovation increases when the CEO is not the Board Chair but has equity ownership, although the incentive effect is economically small. The paper uses a sample of domestically-owned, publicly-listed Australian firms over the period 1994–2003.

Keywords Corporate governance · Innovation · Patent applications · CEO

JEL G34 · O31 · O32

Introduction

The central theme underlying corporate agency theory is the potential divergence of interest between the stockholders and the chief executive officer or CEO. As the company's manager and chief strategist, the CEO has wide discretion and decision-making power to alter corporate policies and strategic directions. The theory establishes that these decisions do not necessarily coincide with the collective interest of the

✉ Vicar S. Valencia
vvalenci@iusb.edu

[1] Department of Economics, Judd Leighton School of Business and Economics, Indiana University South Bend, 1700 Mishawaka Avenue, South Bend, IN 46634-7111, USA

stockholders (Clacher et al. 2010). The literature documents evidence of managerial decisions at variance with the pursuit of shareholder value maximization (Becht et al. 2003; Baker and Anderson 2010). Empirical manifestations include misappropriating funds through gratuitous perquisites and transfer pricing by setting prices that exclusively benefit the CEO's personal affairs.

A main concern is that the CEO prefers suboptimal investment projects that do not have the potential to generate positive net present value returns in the long run. Rather, these choices simply reflect a predisposition towards overly safe projects that bolster managerial careers and corporate reputation (Antia et al. 2010). The CEO chooses suboptimal projects in the interest of entrenching his position in the company and elevating his prestige in the labor market, which implies that he will provide insufficient attention to risky, but potentially value-enhancing, projects. For instance, Hope and Thomas (2008) report that CEOs will choose to pursue investments that allow them to expand their control and dominion but yield inferior returns. Similarly, Asker et al. (2014) find that CEOs in the U.S. have a myopic investment horizon, which dissuades them from making long-term, value-enhancing investments.

The goal of this paper is to identify mechanisms, collectively called "corporate governance", which encourage the CEO to pursue innovation. Innovation is a prime example of a value-enhancing investment decision. The Boston Consulting Group (2010) reports that innovative companies (including Apple Computer, Google, and Tesla Motors) generated a total shareholder return 12.4 percentage points higher than their benchmark firms over the period 2006–2009. Looking at a ten-year period, the return is appreciably two percentage points higher. Innovation is a major driver of company growth and profitability. However, it is also a risky venture. While the financial rewards benefit stockholders, the intrinsic risk can negatively affect the CEO's future career. In a 2015 innovation survey, the Boston Consulting Group identifies the CEO as the person most responsible for implementing innovation. Its development and sustainability depend on the commitment and leadership of the CEO. Nonetheless, the survey also reveals a perceived lack of commitment by the CEO, stemming in large part from a risk-averse culture. The American Management Association (2006) highlights this overly conservative attitude, noting the generalized absence of corporate structures that foster innovation. The implementation and sustainability of innovation depends on the commitment and leadership of the CEO (Bock et al. 2012).

The paper contributes to the literature by providing empirical evidence for corporate governance as a structure that encourages the CEO to innovate. Corporate governance is a nexus of incentive schemes and monitoring devices designed to align the interest of the CEO with that of the shareholders. While there is a multiplicity of studies that analyze corporate agency problems, the empirical evidence that specifically focuses on innovation and corporate governance is sparse (Sapra et al. 2014). At the core of corporate governance is the effective monitoring of the CEO's activities. Identifying an efficient system of monitoring managerial behavior is important because incentive schemes in the form of executive compensation cannot solely mitigate the preference incongruity in innovation between the CEO and the stockholders. The corporate governance of innovation particularly matters when ownership shares are widely dispersed (as in Australia and the U.S.), and unless the appropriate governance structures are in place, the CEO can virtually make investment decisions unwarranted by stockholders. I examine whether the facets of corporate governance such as

ownership structure, the composition of the board of directors, and CEO duality and stockholdings can characterize a system of incentives and supervision of the CEO's innovation decisions. My empirical specification employs panel models of count data using Australian firms. I use patent applications to measure innovation. Results suggest that firms with a concentration of shareholders are less likely to encourage the CEO to innovate. The likelihood of innovating appears to increase, however, in the presence of a large shareholder. This finding suggests that shareholder activism is best achieved through a single large shareholder, rather than several substantial shareholders. Controlling for endogeneity, I do not find any association between innovation and board independence. Contrary to prevailing beliefs which put increasing reliance on the benefits of independence, boards predominated by independent directors do not appear to be any better able to induce the CEO to pursue innovation. The same result holds for board size. In contrast, firms with less diverse boards are more likely to innovate. The result also holds when the CEO is not the chair of the board and when the CEO has equity ownership.

Hypotheses and Conceptual Framework

Holmstrom (1989) sums up the basis for viewing innovation within an agency framework. Innovation is (i) risky; (ii) unpredictable; (iii) long-term and multi-stage; (iv) labor-intensive; and (v) idiosyncratic. The CEO, however, wants to be viewed as an effective decision maker, skilled in selecting projects and nurturing them with success. Concerns for prestige and status will therefore dampen the inclination to undertake innovation projects. CEOs, in effect, will tend to choose investment projects that boost short-term earnings (Antia et al. 2010) or engage in a "quiet lifestyle" of safe, uncomplicated business ventures (Bertrand and Mullainathan 2003).

Ideally, the contract between the CEO and the stockholders should resolve the agency problem. However, even with the most appropriate design and intent, a contract which details the CEO's duties and the permissible boundaries of actions is ultimately second-best. Contracts involve substantial transactions costs which render them incomplete or incomprehensive. No contract can account for all future states of the world and the actions that the CEO may take. The divergence in interest and the inability to create a perfect contract provide a rationale for corporate governance (Hart 1995). When appropriately, implemented, corporate governance creates a system that impels the CEO to pursue innovation projects. Fundamentally, corporate governance helps mitigate the agency problem of innovation in two ways: (i) monitoring the CEO's performance and (ii) incentivizing the CEO through an appropriate compensation scheme. The key goal is to identify the governance mechanisms that foster innovation. To systematize the analysis, I group these mechanisms into three themes: (i) ownership structure; (ii) board of directors; and (iii) CEO duality/stockholdings.

Ownership Structure

Ownership structure pertains to the dispersion or concentration of equity shares and the resultant incentive and ability of the stockholder to monitor the CEO. A distinct feature

of market-oriented economies such as Australia, the UK, and the U.S. is the widespread dispersion of equity shares. In this situation, each shareholder owns a small fraction of outstanding stock. In a survey of corporate governance among member countries, the Organisation for Economic Cooperation and Development (OECD 2004) reports that the largest voting block in the U.S. and UK has a median holding of 10%. In my Australian data, the largest stockholder has a median holding of 18%. Dispersion conveys the economic merit of risk diversification and liquidity. However, when shares are widely dispersed, collective shareholder action becomes a problem. Although shareholders have the collective interest to enforce innovation as a value-maximizing strategy, the collective action to evaluate the CEO's performance is ultimately an individual decision that benefits everyone. Monitoring the CEO is a public good that is likely to lead to a free-rider problem. A stockholder with small ownership in the company has little or no incentive to supervise managerial behavior. Widespread dispersion creates a situation wherein each stockholder rationally thinks and hopes that somebody else will monitor the CEO, which results in understated or practically zero supervision. The CEO, in effect, become unaccountable to the stockholders and is not effectively controlled.

A governance mechanism that potentially remedies the free-rider problem is concentrated ownership. A large shareholder has the motivation to acquire information, verify performance, and enforce value-based innovation strategies. His significant ownership rights imbue his voice and power in the decision-making process. Cohn et al. (2016) contend that poorly performing firms benefit from increases in shareholder control. Moreover, Becker et al. (2011) and Cronqvist and Fahlenbrach (2009) find that firm profitability and firm value increase in the presence of a large shareholder. Value-based management is therefore reinforced when stockholders can exert adequate control and supervision. The hypothesis is concentrated ownership, or the presence of a large shareholder, encourages the CEO to have the propensity to innovate.

Board of Directors

Another corporate mechanism that stockholders can use to govern the innovation behavior of the CEO is the board of directors. Since the directors are elected by stockholders, the directors are supposed to represent the stockholders' rights and interests. It is through the board where managerial decisions are evaluated and strategic shifts specified. The board advocates shareholder policies that guide CEO behavior. An element crucial to the board's effectiveness in supervising the CEO is its independence. A typical board consists of insiders and outsiders. An insider is a director-executive who is a current or former employee of the company. An outsider is a non-executive director who is not working for the company. Apart from the directorship, an outsider practically has no financial ties and vested interests in the company. An outsider is viewed as an epitome of the virtues of independence: disinterested and probing. As such, outsiders are also called as independent directors and insiders as non-independent directors. The expectation is that a board predominated by or composed entirely of independent directors would have no preferential treatment towards managerial interests. They are not working for management and so the CEO cannot influence their judgment. However, one could also argue that board independence poses no significant

advantage. Because independent directors derive no marketable financial gain except perhaps prestige, not only can they be impartial in the affairs of the business, but can be uninterested as well. Corporate best practice guidelines (for example, Australia and the U.S.) espouse the benefits of board independence, recommending that the majority of board seats should be held by independent directors as often as possible (OECD 2004). It must be acknowledged, however, that there are limitations to the guidelines ascribed to board independence. For instance, a prospective board member may meet the formal criteria to qualify as an independent director, but the nomination was based on interests and dispositions congruent with the current board or CEO. This could potentially vitiate the intended active supervision of the CEO. In the case of the U.S., the Securities and Exchange Commission (SEC) has implemented disclosure requirements to mitigate contextual ambiguities in the criteria for board independence and to strengthen regulatory standards. That is, as part of their SEC filings, firms must specify all forms of relationships and contractual arrangements with designated independent directors not otherwise disclosed elsewhere (Tonello 2010).

The empirical evidence linking board independence and firm performance is mixed. Hermalin and Weisbach (2003) cast doubt on the association, suggesting that insiders and outsiders are equally likely to provide good or bad supervision. Pathan and Faff (2013) report that board independence lowers firm performance. In contrast, Knyazeva et al. (2013) find that independent directors are more likely to remove the CEO following poor performance, suggesting the idea that board independence can improve firm value through CEO replacement.

Apart from independence, I also examine the relevance of board size and diversity. As in any other group, the number and diversity of board members can have an effect on overall cohesion and group dynamics. Board size may matter because directors must collaborate with each other when evaluating the CEO. While a large board intuitively implies more monitoring directors, it also poses two potential problems. First, it can become bureaucratic, which impairs the coordination and implementation of decisions. Second, it creates an internal free-rider problem in that some directors might tacitly prefer to dodge responsibility, delegating it to the board as a whole. These imply that the quality and intensity of monitoring may weaken when boards become large. In contrast, a board of few directors might be able to examine issues more carefully, make more informative decisions, and better supervise the CEO. In a sample of UK listed firms over the period 1981–2002, Guest (2009) documents that large boards are associated with decreased profitability. On the other hand, Beiner et al. (2004) report no relationship between board size and performance.

I also test whether a diverse board instigates the CEO to innovate. A mix of directors with different backgrounds, for example, in terms of academic or industry expertise, opens up a variety of individual perspectives and experiences which possibly promote creativity and responsiveness to new ideas. In addition, the quality and intensity of CEO supervision may be enhanced because performance issues are viewed more broadly and problems are confronted with alternative solutions. In contrast, a grouping of people with common values, attitudes, and beliefs can become quite resistant to change and lead to stagnation of ideas and blunt receptiveness to creativity. Zhu and Westphal (2014) examine the relationship between CEO performance and board diversity. Using highest level of education attained (Ph.D., Masters, Bachelors) and area of expertise (marketing, sales, finance, accounting) as indicators of board diversity, they find improved firm

performance and lower CEO turnover for CEOs who have previously served on boards more diverse than the current one. Carter et al. (2010), examining board diversity in terms of gender and ethnicity, do not find an association between firm value and diversity. In contrast, Adams and Ferreira (2009) find that gender diversity appears to enhance the effectiveness of the board insofar as the directors become more involved in board meetings. Ancona and Caldwell (1992), on the other hand, caution against an unwavering reliance on diversity, noting that while group heterogeneity encourages creativity, it can also hamper the implementation process because of greater dissonance among members. The overall hypothesis is small, diverse, and independent boards are better able to allow the CEO to innovate.

CEO Stockholdings and Duality

A distinct board characteristic exhibited by some firms is CEO duality, wherein the CEO is also Chair of the Board. This creates a potential problem in that it invalidates the premise of the board supervising the CEO. The CEO is being monitored by a board presided over by the very same person being monitored. A duality in function leads one to question the impartiality of decisions made by the board. As such, separating the CEO from the Board Chair position reinforces the board's integrity, which leads to better supervision and firm performance. The empirical evidence on duality is mixed. While Duru et al. (2016) support the separation of roles, Krause et al. (2014) report a negative impact on future performance when a firm is operating profitably.

In conjunction with supervision, a straightforward aspect of governance is to incentivize the CEO by tying his compensation to the firm's performance. I test whether the CEO will take a value-based approach to innovation if part of his compensation is equity-based. Providing the CEO equity rights might help attenuate the agency costs of innovation because he assumes co-ownership of the firm. On this basis, the CEO is then inclined to innovate, viewing it as an appropriate strategy to increase not only the shareholders' wealth but his own as well. Over the 20-year period from 1992–2011, Murphy (2013) reports an increasing trend in the use of equity-based compensation for the median S&P 500 firms. The trend is exhibited worldwide, but more modest compared to U.S. levels (Becht et al. 2003). Lilienfeld-Toal and Ruenzi (2014) find that CEO stockownership engenders firm value and efficiency, while Himmelberg et al. (1999) find no systematic association. The hypothesis is innovation is increasing in CEO equity compensation. A separation of CEO-Board Chair roles makes for better control of managerial tasks conducive to innovation.

Variables and Data Description

I use *Patent Applications* as my measure of innovation. Patent applications motivate the idea of a production function approach to innovation, following Hausman et al. (1984). In this setup, the mechanisms of corporate governance serve as an input to the innovation process, the outcomes of which are the patent applications. The annual number of patents applied for by a firm is viewed as a way to represent the CEO's effort to innovate. An advantage of this approach is that patent applications are a useful

indicator of the actual timing of a firm's innovation outcome. Since the patent applications are essentially count data, they measure not only the propensity but also the outcome or realization of the innovation activity. We recognize that, as in any other metric, the use of patent applications has its shortcomings in that not all innovation outcomes will result in a patent application. Data permitting, the number of citations a patent receives can be used as an alternative measure of innovation. Citations are useful for gauging the quality of research and impact to society of the innovation outcome. Research and development (R&D) expenditures can also be used as a measure of innovation. This metric essentially summarizes the inputs or resources devoted to the innovation process, albeit it may not necessarily lead to an innovation outcome. Finally, one can also use indices or "scoreboards" to measure innovation, which are weighted averages of performance benchmarks such as sales of new-to-market products and sales of new-to-firm products, among others (Greenhalgh and Rogers 2010).

I characterize a firm's ownership structure by measuring the concentration of equity shares and the stockholder's incentive and ability to monitor the CEO. I use the Herfindahl Equity Index to measure equity concentration. Given data on all N equity holdings, then the Herfindahl index H_N can be computed as

$$H_N = \sum_{i=1}^{N} \left(\frac{S_i}{T_N} \right)^2,$$

where S_i= equity holding of stockholder i and $T_N = \sum_{i=1}^{N} S_i$. A value close to zero indicates that ownership is widely dispersed, while a value close to one indicates that equity shares are highly concentrated. However, I can only get data on outstanding common equity shares for the top 20 stockholders and the sum of all N holdings. A potential problem exists in that the remaining $N-20$ shares need to be accounted for and ignoring them would likely produce biased estimates of the Herfindahl index. I circumvent this problem by adjusting the computation for the index using the method prescribed by Cubbin and Leech (1983). For ease of interpretation of the empirical results, I multiply the index by 100 to express it as a percent. Apart from equity concentration, I verify whether the presence of a large shareholder can help mitigate the agency problem of innovation using the Banzhaf power index. A large shareholder is conventionally defined in terms of a stockholder owning an arbitrary, fixed percentage of shares which gives the person voting rights to control the CEO's behavior. However, a fixed criterion does not incorporate variations in equity holdings. While substantial shareholding is required for a highly concentrated ownership, a smaller proportion may just as well be sufficient for control when shares are widely dispersed. I use this insight in gauging the power or the ability and incentive of the largest shareholder to supervise the CEO. The Banzhaf index, in particular, measures the ability of the largest shareholder to influence the voting outcome (Leech 2002). I use the variable *Banzhaf* to designate the Banzhaf index of the largest shareholder, expressed as a percent.

I use the variable *Board Independence* to estimate the hypothesized relationship between board independence and innovation. Board independence is measured by the percentage of directors that are independent. I follow Becht et al. (2003, p. 31) to verify independence. A director is independent if he is "not employed by the corporation, is not engaged in business with the corporation, and is not a family member." Also, I do

not consider as independent a director who holds substantial shares in the company, which is at least 5% as defined in Australia's Corporations Act of 2001. To explain how the number of directors can affect the CEO's innovation decision, I create the variable *(log) Board Size*, which is the number of directors, in natural logs. I use the variable *Board Diversity*, which is an entropy-based diversity index to capture functional diversity on the board. I classify each director into three categories (business, science, and the arts), which represent the director's distinct industry expertise and academic background. I use Teachman's (1980) index to measure diversity given as $Board\ diversity = \sum_{i=1}^{3} p_i(\ln p_i)$, where p_i is the proportion of directors classified into a particular category *i*. The greater the distribution of directors across categories, the higher is the value of the index. I express the index in percentage form.

To test the hypothesis that a separation of CEO-Chairman roles is associated with a higher propensity to innovate, I define the variable $CEO/\{Chairman\} = 1$, if the CEO is not the Chairman of the Board. The idea of incentivizing the CEO to innovate through the provision of equity ownership is represented by the variable *CEO Stockholdings*, which is the percentage of outstanding equity held by the CEO. I include *CEO Tenure*, which is the number of years that a CEO has served in his position, as a control for the CEO's experience. The idea that large firms innovate more is captured by the variable *(log) Employees*, which is the natural log number of employees a firm has. I use the variable *(log) R&D/employees* to account for the positive patent-R&D relationship posited by Hausman et al. (1984). Also, Stein (2003) documents the idea that firms with more cash and less debt invest more. I examine this proposition in the case of investments in innovation using the variables *Cash flow/Assets* = (cash flow before interest expense/total assets)·100% and *Debt/Assets* = (total liabilities/total assets)·100%. In addition, I consider the effect of competition on innovation using the industry *Lerner index*, following Aghion et al. (2005).

Data

Firm data on patents and corporate governance are difficult to obtain. Data permitting, I use a panel of 197 firms drawn from the IBIS World database, provided by the Melbourne Institute of Applied Economic and Social Research (2009) over the period 1994–2003. The IBIS dataset supplies information on patent applications, R&D expenditures, and number of employees for both domestic and multinational firms. From this, I draw a sample of locally-owned Australian companies listed on the Australian Stock Exchange. Publicly-listed firms are likely to exhibit the agency problem of innovation. Corporate governance data on board size and CEO profile are hand-collected from company annual reports, downloaded from Aspect Huntley Annual Reports Online (2009). Company financial data are sourced online from DatAnalysis Premium (Morningstar (2009), formerly Aspect Huntley FinAnalysis). These are then matched with the IBIS dataset. The classification scheme of the MCSI (2009) Global Industrial Classification Standard is used to group the firms. Almost 60% of the sampled data come from the materials (31%), capital goods (16%), and food, beverage, and tobacco (12%) industries.

Table 1 provides some descriptive statistics on the variables. The mean Herfindahl equity index is 11.70%, which indicates that the shares are widely dispersed. There are several stockholders owning small shares. The largest stockholder owns 24% of outstanding stock, on average. This translates to a Banzhaf power index of 48%. More than half of the total observations recorded stockholders owning less than 20% of company shares. The wide dispersion of shares and the paucity of majority stockholders suggest the possibility of limited shareholder control over the CEO's decisions. The number of directors ranged from 2 to 15, with a mean of 7. Independent directors constitute 61% of the board, reflective of the best practice guideline to have majority independent directors. The typical board is fairly diverse, with a mean functional diversity of 68%. The average Australian CEO owns 9% of outstanding shares. Less than a fifth of total observations reported a dual CEO-Chairman.

Methodology and Results

The economic thrust of this paper is to identify the mechanisms of corporate governance that can potentially alleviate the agency problem of innovation, thereby encouraging the CEO to have the propensity to innovate. Empirically, this involves analyzing the

Table 1 Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
Patent Applications	1	5.34	0	97
Ownership Structure				
Herfindahl Equity Index (%)	11.70	13.53	0.19	78.96
Banzhaf (%)	48.23	33.65	9.17	100
Shares of Largest Stockholder (%)	24.23	18.36	0.79	88.77
Board of Directors				
Board Independence (%)	60.52	20.10	0	100
Board Size	7	2.13	2	15
Board Diversity (%)	68.31	29.61	0.23	109.86
CEO Stockholdings & Duality				
CEO/{Chair} = 1 if the CEO is not Board Chair	0.85	0.35	0	1
CEO Stockholdings (%)	7.99	15.12	0	69.95
Controls				
CEO Tenure (years)	6	5.09	1	33
Employees	2807	7723.21	13	88,995
R&D Expenditures (in $ millions)	6.03	17.00	0.003	246.00
Lerner Index (%)	97.80	1.59	85	100
Debt/Assets (%)	22.29	15.73	0.02	93.08
Cash flow/Assets (%)	1.68	10.91	−93.48	84.70

The paper uses a sample of domestically and publicly listed Australian firms over the period 1994–2003. Sources: IBIS World (Melbourne Institute of Applied Economics and Social Research 2009), Aspect Huntley Annual Reports Online (Aspect Huntley 2009), and DatAnalysis Premium (Morningstar 2009)

propensity to innovate (number of patent applications) in terms of ownership structure, the profile of the board of directors, and CEO stockholdings and duality, which constitute my thematic set of corporate governance variables. I employed fixed effects Poisson regression since the patent applications are intrinsically count data. To check for robustness and account for overdispersion, negative binomial estimates were obtained. To account for endogeneity, I employed Windmeijer's (2008) two-step generalized method of moments (GMM) estimator for panel count data. Table 2 summarizes the results from a Poisson (column 1), negative binomial (column 2), and GMM (column 3) regression.

Table 2 Regression results

Dependent variable: patent applications			
Explanatory variables	Poisson (1)	Negative binomial (2)	GMM (3)
Herfindahl Equity Index	−0.049	−0.023	−0.016
	(0.021)**	(0.012)***	(0.006)*
Banzhaf	0.016	0.008	0.006
	(0.005)*	(0.003)**	(0.001)*
Board Independence	0.013	0.008	−0.0004
	(0.007)***	(0.004)**	(0.001)
(log) Board Size	0.018	−0.083	−0.001
	(0.606)	(0.257)	(0.088)
Board Diversity	−0.009	−0.003	−0.008
	(0.010)	(0.003)	(0.002)*
CEO/{Chair}	0.899	0.523	0.223
	(0.359)**	(0.269)***	(0.058)*
CEO Stockholdings	−0.007	−0.002	0.009
	(0.014)	(0.008)	(0.002)*
CEO Tenure	0.027	0.016	0.027
	(0.019)	(0.012)	(0.005)*
(log) Employees	0.264	0.255	0.707
	(0.312)	(0.066)*	(0.055)*
(log) R&D/employees	0.222	0.091	0.268
	(0.113)**	(0.043)**	(0.017)*
Lerner Index	0.308	0.244	0.233
	(0.125)**	(0.065)*	(0.028)*
Debt/Assets	−0.004	−0.004	0.0095
	(0.008)	(0.005)	(0.001)*
Cashflow/Assets	0.006	0.003	0.0089
	(0.006)	(0.005)	(0.001)*
Observations	837	837	1773

The paper uses a sample of domestically and publicly listed Australian firms over the period 1994–2003. Sources: IBIS World (Melbourne Institute of Applied Economics and Social Research 2009), Aspect Huntley Annual Reports Online (Aspect Huntley 2009), and DatAnalysis Premium (Morningstar 2009). Robust standard errors are in parentheses; negative binomial allows for overdispersion; GMM standard errors are asymptotically efficient. *** significant at 10%; ** significant at 5%; * significant at 1%

Under a Poisson estimation, the corporate governance variables displayed statistical significance, except for board size, board diversity, and CEO stockholdings. The Herfindahl equity index shows that ownership concentration negatively affects the CEO's propensity to innovate; a percentage point increase in equity concentration reduces the expected number of patent applications by about 5%. On the other hand, the estimate for the Banzhaf index provides support for the hypothesis that a large shareholder can monitor the CEO's propensity to innovate. Taken together, this complements broad-brush presumptions about organizational dynamics and delegation. A CEO supervised or receiving instructions singularly from a monitoring large shareholder is better able to process the information, carry out the assigned task, and avoid the dissonance associated with having several shareholder-supervisors. Also, the presence of several active stockholders may result in conflicting company objectives. This conflict may dilute consensus, particularly on decisions that involve long-term (innovation) projects. The Herfindahl equity index remains negative and significant even when the Banzhaf index is omitted. Also, the correlation between the two variables is low, about −0.09. When the percentage share of the largest stockholder is used in lieu of the Banzhaf index, the results remained the same. It yielded an estimate of 0.094 (with p-value = 0.006), indicating that a percentage point increase in equity ownership by the largest stockholder increases patent applications by about 9%. The Poisson standard errors are adjusted for possible variance misspecification. To do so, I use panel robust standard errors, obtained from bootstrapping (Cameron and Trivedi 2013). Following recommended practice, I use 200 bootstrap samples to estimate the standard error.

I also estimated the negative binomial model as an alternative way to characterize the distribution of the patent applications and check for the robustness of the results. The model explicitly takes into account overdispersion in the sample data by introducing an overdispersion parameter in the variance. Overall, the negative binomial results are in accord with the Poisson conclusion identifying the presence of a large shareholder, board independence, and separation of CEO-Board Chair as the corporate governance instruments that increase the CEO's propensity to innovate, thereby attenuating the agency problem of innovation.

A crucial element needed in consistent parameter estimation is the strict exogeneity of the explanatory variables. Strict exogeneity essentially asserts that the corporate governance variables do not react to what has happened in the past. This seems untenable. For instance, board independence may be an endogenous choice. Hermalin and Weisbach (2003) posit that more independent directors are appointed following poor firm performance. Such feedback violates the strict exogeneity assumption. One way to account for endogeneity is to relax the strict exogeneity assumption, viewing the explanatory variables instead as sequentially exogenous. This means that once unobserved firm heterogeneity is controlled for, past values of the explanatory variables do not affect the dependent variable. Windmeijer (2008) provides generalized method of moments (GMM) estimation of panel count data models with multiplicative unobserved effects and endogenous regressors. The idea is to take a quasi-differencing transformation to remove firm heterogeneity and use the lagged values of the regressors to obtain consistent parameter estimates. In particular, I used the two-step GMM estimator to obtain asymptotically efficient standard errors.

Overall, the estimates are in line with previous results suggesting that the CEO's propensity to innovate is encouraged by a single, large shareholder rather than several

shareholders. That is, to the extent that a CEO prefers to engage in myopic behavior, a large shareholder acts as a governance mechanism to remediate the free-rider problem of shared monitoring and attenuate the agency cost of innovation. Similarly, Tribo et al. (2007) report that a large shareholder helps improve a firm's innovation performance, whereas having several large shareholders may lead to differing, conflicting company objectives. This conflict dilutes consensus, particularly for decisions that involve long-term innovation projects. As a matter of corporate policy, a separation of CEO and Board Chair duties induces the CEO to innovate, increasing patent applications by a factor of exp.(0.223) = 1.25 or 25%. The impact is reasonably modest, compared with the previous baseline Poisson estimate which does not take endogeneity into account. The significance of duality echoes Jensen's (1993) assertion that any potential divergence of views between the board and CEO-Chairman almost always gets tilted in favor of the CEO. A separation of roles reinforces the board's integrity, which leads to better supervision and firm performance.

Board size remains insignificant, a result suggestive of Hermalin and Weisbach's (2003) equilibrium interpretation that firms determine their optimal number of directors. That is, a large or a small board has no differential effect on the management and supervision of CEO innovation. Board size, in effect, is a byproduct of organizational needs and structure. On the other hand, board diversity becomes significant. The negative sign implies that while functional diversity among board members is a promising reflection of creativity or innovativeness, it may not necessarily be helpful when it comes to CEO supervision. Diversity may harbor bureaucracy and coordination problems that can impinge on the actual implementation of innovation projects. This echoes Kor's (2006) result that management teams with a considerable degree of functional diversity are less likely to advocate innovation projects. With the removal of the effect of endogeneity, contrary to previous estimates, board independence does not induce the CEO to innovate. This again complements Hermalin and Weisbach's (2003) proposition that firms optimally choose the number of independent directors. This appears surprising, given the prevailing corporate belief espousing the benefits of independence. Nevertheless, the empirical result implies the need for nuance in the design of policy recommendations. That is, specific to the need for encouraging innovation, a blanket requirement that all or a majority of directors be independent may not necessarily matter after all. The GMM results also show that, unlike previous estimates, the sign for CEO equity ownership becomes positive and statistically significant. However, the incentive effect is economically inconsequential, indicating that a percentage point increase in stockholdings induces a 0.9% increase in the number of patent applications.

The GMM estimates are consistent and asymptotically efficient provided that the model is correctly specified. This requires that the lagged values of the regressors are valid instruments and there is no second-order serial correlation. The first criterion is evaluated using the Sargan test for overidentifying restrictions. The test statistic is 69.268, with p-value 0.401, which means that we cannot reject the null hypothesis of instrument validity. The second criterion implies that the model is incorrectly specified if serial correlation is persistent, as the error terms are picking up possible omitted variables and dynamics not in the model. Under the null of no serial correlation, the tests for serial correlation indicate the presence of first-order serial correlation (p-value of 0.019) and the absence of second-order serial correlation (p-value of 0.997).

Conclusion

The goal of this paper is to identify the mechanisms of corporate governance that encourage the CEO to innovate. There is an agency problem in innovation in that while innovation is considered a major driver of corporate growth and profitability, the CEO, who is principally responsible for making corporate decisions, is not necessarily inclined to pursue innovation projects. Innovation is inherently risky and its commercial failure can adversely affect the CEO's career and reputation. The contribution of this paper is to provide empirical support for the importance of corporate governance in innovation. Fundamentally, firms must have the appropriate platform in place to monitor and encourage the CEO to innovate. I examine ownership structure, the profile of the board of directors, and CEO stockholdings and duality as potential mechanisms. I use panel count data models and GMM estimations that control for unobserved firm effects and the potential endogeneity of the corporate governance variables. I find that shareholder supervision of the CEO's innovation propensity is best achieved through a single, large stockholder rather than several stockholders. The dissonance, conflict, and free riding of several shareholders can impair the ability to adequately monitor managerial behavior. Controlling for endogeneity, I do not find any association between innovation and the virtues linked with board independence and board size. Taken together, this implies that policy recommendations requiring most, if not all, board members to be independent and stipulating an absolute number of directors may not be a requisite component for the management of CEO innovation. In contrast, a diverse board appears to negate the CEO's inclination to innovate. Importantly, the empirical results advocate for enhancing board integrity through the separation of CEO and Board Chairman duties. CEO duality is strongly associated with CEO innovation, as well as the provision of CEO stock ownership, although the equity incentive effect on innovation is not economically significant.

The present study has limitations which lend itself for future research. First, data were not available to identify the nature of the large shareholder. It would be useful to understand the quality of monitoring and extent of supervision by large shareholders such as family holding companies, pension funds, and institutional investors, among others. Second, to enrich perspective on the results, the empirical design can be expanded to a cross-country analysis, such as making comparisons between OECD and non-OECD countries. Third, there are innovations for which a patent may not have been applied for. That is, patentable innovations are usually envisaged as product inventions. However, we also have process innovations, which are equally important. These run the gamut from changing the business culture to enhancing the workflow of information which improves productivity, lowers costs, and sustains efficiencies. A future goal of this research would be to ascertain the extent to which corporate governance could facilitate process innovations. These innovations may not necessarily meet the threshold for patenting, but are critical for the firm's growth and profitability. Equally important, burgeoning research indicates that the provision of equity shares for directors would enhance their attitude regarding co-ownership. For instance, directors with substantial shares are more likely to actively monitor CEO activities and are associated with higher firm profitability (Bhagat and Bolton 2013). Data permitting, it would be an interesting empirical question to examine the relationship between director

shareholdings and their behavioral response towards innovation. That is, whether the directors would be more open to innovative strategic investments. All in all, as Hermalin and Weisbach (2003, p. 4) state, "wanting to be seen as doing the right thing and doing the right thing are not always the same." Corporate governance is about creating structures that foster CEO innovation and ensuring that the CEO does just that.

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