

Board of Director Composition, and Ownership and Their Relationship to Patents: An Empirical Study

David Epstein
University of Houston Downtown

Cory Angert
University of Houston Downtown

Charles Strain
University of Houston Downtown

In this paper we examine the impact of board structure on patenting activity. In particular, we look at inside directors, board diversity, inside ownership, and board size. Board diversity was significantly and negatively related to patenting activity and inside ownership was marginally and negatively related to patenting activity. The research is relevant to current businesses by illustrating the potential dangers of board diversity and inside ownership on patenting activity.

LITERATURE REVIEW

Much research on the relationship between boards of directors and outcomes has been published in management journals. Surprisingly, however, the field of academic research in marketing is comparatively deficient in this area – a review of the past ten years of the *Journal of Marketing* failed to uncover a single article on the subject. Given the importance of the topic to company performance and success, it is critical to examine historical and recent information on boards and to consider what factors contribute to marketing outcomes.

Boulton (1978) contended that boards generally do not perform their designated roles. Instead, the author observed that the boards of directors he sampled served in a limited capacity, only intervening in corporate affairs during times of crisis, when advice or counsel was necessary, or when their input was otherwise needed. Boulton (1978) found that, whether it was a result of researcher error or, more likely, a sign of changing business environmental conditions, boards actually did play a much larger role in corporate decision making and everyday affairs. Boulton attributed his findings to the increasing threat of litigation that obligated the boards in his study set to transcend the conventional legitimizing role to assume more active roles such as that of auditing and directing. The more active role by board members suggests that directorships influence business strategies.

Useem (1979) developed the notion of an inner group axis in which “those business people who are primary owners or top managers of several major corporations” are classified as the inner group. Useem’s study led to the conclusion that one’s inner group membership often results in a greater likelihood and

extent of participation in the governance of other enterprises. Burt's (1980) study of interlocking directorates expanded on this idea by approaching the construct from a distinctive angle. His research conclusions revolved around "cooptive corporate actor networks," defined as the extent to which a company's board of directors represents assorted business segments. Burt, using network methodology found that boards of directors form the backbone of decision making in corporate America.

Applying agency theory to the study of board composition enabled Li (1994) to propose that the configurations of corporate ownership and boards most directly shape governance and control. Although Westphal and Zajac (1995) agree with most of Li's statements, they believe that board members' demographic similarities have a stronger bearing on matters of control. Their study also finds that CEO power is the primary determinant of said similarities. Zajac and Westphal (1996a) looked at CEO characteristics and how these traits affect successor appointments. The writers extended their preceding exploration of the subject by examining potential antecedents to the appointment of an insider rather than outsider board member. The authors determined that successors are usually chosen on the basis of demographic similarity to the selecting incumbent.

Zajac and Westphal (1996b) felt that most analysis of corporate governance had simply assumed board composition as a given, concentrating exclusively on its consequences. The authors decided to scrutinize the antecedents of board makeup. The most significant determinant identified was internal politics involving interactions between a company's CEO and the board of directors. Additionally, the interaction between the CEO and the board plays a critical role in director hiring and retention.

Klein's (1998) study stated that inside directors inform companies in unsure situations. These directors provide pertinent knowledge that can put boards at ease during stressful and ambiguous situations. She determined that firm performance can be increased by insiders with valuable knowledge that can assist in educating boards and minimizing the uncertainty of risk taking actions.

Dalton, Daily, Johnson, and Ellstrand (1999) conducted a meta-analysis examining the variables of the number of directors on a board and the financial performance of the particular company. The authors found no consistent support for the influence of board size on financial performance. The same principle held true in their examination of director appointments, especially when boards grew in influential organizational power (Useem, 1993; Westphal & Zajac, 1995) and effected progressive modifications

Leadership, according to Waldman, Ramirez, House, and Puranam (2001) definitely matters, as director charisma influenced decision making, especially when the firms in question were undergoing periods of uncertainty. In such situations, say McDonald and Westphal (2003), CEOs and directors rely on their business acquaintances and colleagues for advice, meaning that interconnectedness between top managers of their own boards engenders associations that may ultimately form into working business alliances. In addition, find Ferris, Jagannathan, and Pritchard (2003), the amount of interconnectedness, as measured by the number of directorships an individual holds, may actually enhance that director's effectiveness and performance; in fact, discovered Perry and Shivdasani (2005), "Charged with hiring, evaluating, compensating, and on-going monitoring of management," the board actually provides its company with management control and direction. The researchers also aver that an outside board increases the likelihood of a firm's deciding to restructure assets. Perry and Shivdasani found that improvements in operating performance accrue largely to firms that both restructure and that have outside-dominated boards. These boards wield influence when determining a company's intention to engage in more, or less, research and development.

Fich and Shivdasani (2006) contradict Ferris, et al (2003), and Perry and Peyer (2005) claim that executives' outside directorships enhance firm value, by asserting that companies with directors too involved in outside directorships do not fare as well as companies with fewer interlocked directors, as evidenced in lower "market-to-book ratios" and profitability, two key capital structure determinants,

Ruigrok, Peck, and Keller (2006) conclude that while the board's monitoring function has been the subject of much work, less examined is the role that the board has in setting company strategy, leading the researchers to concentrate on the effect that the directors have on the firm they represent. The focus of their investigation was on Swiss companies, but the findings may be considered generalizable. Using agency and network perspectives, the researchers found that powerful CEOs tend to constrain board input

to mainly contributions that will assist in strategy formation and that bank representation on the board may negatively affect the company. Ruigrok, et al. (2006) advise that companies should safeguard against their directorships' becoming too interlocked. While individual charisma and expertise definitely influence the effectiveness of a director, Ruigrok et al. (2006) contend that companies would be wise to assign the CEO and chairperson roles to two distinct individuals, in order to advance a company's economic advantage.

Hypotheses

Useem (1979) examined the impact of inside directors on governance decisions. His study suggested that inner groups of directors are able to mobilize more corporate resources. This finding seems particularly relevant to R&D expenditures. R&D involves a commitment by the firm of considerable resources for an uncertain return. Innovative products offer the potential for considerable return; in high technology industries such as biotechnology and semiconductors, R&D is an important business function. Other sectors, such as hospitality and service industries, might, however, produce smaller rates of product innovation. The risk inherent in innovation suggests that corporate decisions for R&D expenditures might originate at the highest levels.

Baysinger, Kosnik, & Turk (1991) found that inside directors are associated with higher R&D spending. Since R&D spending is often used as a proxy for innovation, this finding supports the likelihood that these firms would produce more patents. Baysinger and Hoskisson (1990) observe that outsiders usually sit on several boards. Between managing their own businesses and sitting on multiple boards, outside directors may lack the ability to understand another's business as well as these outsiders understand their own. Consequently, outside directors may tend to defer to inside directors' knowledge when effecting corporate decision making. Inside directors who are likely more familiar with their own business may be more likely to reward top management for strategic decisions while outside directors may have a more superficial view. One primary goal of R&D is innovation, a construct that can be objectively represented by the securing of patents.

Therefore it is proposed that:

Hypothesis One: Firms with a higher proportion of inside directors will produce more patents in the same industry than will firms with a smaller proportion of inside directors.

Tripsas & Gavetti (2000) view demographic heterogeneity as a good representation of cognitive heterogeneity. This may vary somewhat by the measure of heterogeneity however. Tenure heterogeneity however would address the fact that some board members have been with the firm longer than others and may become more acculturated to the "way things are done".

Green, Witt, and Greer (2012) in a meta-analysis observe that conflict can benefit the quality of specific tasks; however it can have negative consequences for group trust. Where group heterogeneity is higher, differing mental models are likely to lead to task conflict which in turn can lower group trust. This lack of trust can lead to dysfunctional characteristics such as factionalization leading to fewer initiatives and less innovation (Hambrick, 1995).

Heterogeneity can have positive benefits for specific tasks as well. (Kosnik (1990) suggests that diverse boards provide benefits for the firm by providing different perspectives on issues, reducing complacency, and reducing narrow-mindedness among board members. However, diversity may also render strategic decision making more difficult, because the different perspectives may hinder the process. Contemplation of multiple perspectives may ultimately lead to higher quality decisions; however, resolution may take longer as members assess more viewpoints. Additionally, the likelihood of conflict and disagreement may increase when many positions are being considered. R&D represents a significant investment by the firm that may require approval from the board. One measure of R&D is the issuance of patents. Thus it is proposed that:

Hypothesis Two: Board diversity will be negatively related to patents issued within a given industry.

Goodstein (1994) examined the impact of board size and board diversity on strategic outcomes in a hospital setting. Board size was partially supported as a variable slowing strategic change while board diversity was found to slow strategic change in the hospital setting. The authors suggest that larger boards are probably less cohesive, are more difficult to coordinate, and are more likely to develop factions and coalitions. Lack of cohesiveness would possibly make consensus about strategic decisions less likely. Further, difficulty with coordination among board members might delay strategic decision making. Finally, factions and coalitions could severely hinder strategic decisions when coalitions find themselves in opposition on an issue.

Beiner, Drobetz, Schmid, and Zimmerman (2004) examine whether board size was an independent variable or was actually dependent on other board and organizational variables. In their empirical study, they discovered that board size actually impacted Tobin's Q even when related variables were considered which suggests that board size is worth considering.

Golden and Zajac (2001) found that larger boards are associated with less strategic change. The authors view this outcome as the likely result of social loafing and factionalization of board members in larger boards. In terms of research and development, the creation of new products is a strategic decision to move in a specific direction towards innovation. Larger boards would be slower to act or less likely to act due to the possibility of differing factions or even noninvolvement by some board members.

Hypothesis Three: Board size will be negatively related to patents issued within a given industry.

Hill and Snell (1998) found that higher ownership among outsiders was negatively related to innovation. This could be the result of risk aversion when one's personal holdings are tied to the results of the firm. The same study however found no relationship for inside ownership. Wright, Ferris, Sarin, and Awasthi (1996) examined the impact of insider equity for board members on strategic decision making. The authors found that insiders who hold larger equity in their firms tend to be more risk averse. This relationship holds for firms possessing growth opportunities; however, the relationship between risk taking and insider equity decreases as growth opportunities decrease. Growth opportunities may be related to the industry or may be the characteristics peculiar to the firm, such as superior resources. Where growth opportunities are present, the firm faces a decision of whether to pursue those opportunities. Pursuing opportunities, particularly those requiring innovation, could be viewed as a risk taking activity, since R&D proves expensive and, historically, innovation efforts exhibit greater likelihood of failure than of success. Insider board members with high equity holdings may be unwilling to take risks with the firm's resources. Additionally, insiders holding larger equity in the firm might be more entrenched, possibly through stock options over time; stock equity in the firm might be larger for seasoned members of the board than for newer members. The length of time that individuals has been employed by the firm might in turn lead to lower willingness to take risks, because these insiders are well established within their firms. Thus it is proposed that:

Hypothesis Four: Insider equity will be negatively related to patents issued for the firm such that higher insider equity will be associated with fewer patents issued by the firm compared to the number of patents produced by firms with lower insider equity.

METHODS

Sample

The sample consists of publicly traded firms in the pharmaceutical industry (SIC codes 2833 and 2834). This industry is a subset of the industries used by Schilling and Phelps (2007) in their study of interfirm collaboration networks. They specifically chose firms from industries designated as high technology by the Bureau of Labor Statistics. These firms were chosen for two reasons. First, this study examines the impact of ownership and board composition on patents. Firms in the pharmaceutical

industry frequently use patents to protect their intellectual property. Secondly this sample provides a rich range of firms from the very large to the very small. The size and increased range of the firms increases the likelihood of finding differences in the study variables.

Companies were chosen that had data available in January 1997 on Mergent Online. Mergent Online provides a database of 15,000 U.S. companies listed on the NYSE, AMEX, and NASDAQ exchanges. This database consists of active and inactive firms. The list of firms chosen from Mergent was accessed by SIC code and year selections. Firms were chosen that were listed as United States businesses or whose primary headquarters was located in the United States.

VARIABLES

Dependent Variable

The dependent variable in this study will be patents issued by the firm. Patent data were obtained from the United States Patent and Trademark Office Web site. Full text patents are available from 1976 to the present; however, some high tech industries have come into existence or changed dramatically in this time period. For this investigation, we will view patents from 1996 to 2006. Annual patent issuance data for each firm are provided in the patent database. The number of patents issued will be the dependent variable in the analysis.

Independent Variables

Inside director equity was calculated as equity holdings of inside directors divided by common shares outstanding (Hoskisson, Hitt, Johnson, and Grossman, 2002). The independent variable of inside/outside director percentage has been used in a number of studies involving the board of directors (Dalton, et al, 1999; Dulewicz & Herbert, 2004; Kroll, Walters, & Wright, 2008). This percentage will be measured as inside directors divided by total board size and board size will be a simple count of the appointed board members.

Board diversity for this study is measured as the coefficient of variation of the board's tenure. Newer board members may bring different ideas than established board members which could produce conflict and lower the number of patents. Finally board size is measured as a simple count of the board members/ These variables are all available through the Edgar database that provides proxy statements containing board data.

Control Variables

Outside directors was measured as the number of business specialists divided by the board size. The number of business specialists was determined by disaggregating board members into business specialists, outside directors from inside the industry, inside directors, support specialists, and community members (Hillman, Cannella, and Paetzold, 2000). Support specialist is defined as the percentage of board members who provide a support function (Law, accounting, consulting). Community board members are the percentage of board members who are from the community such as generals, politicians, charitable organization leaders. Finally board members with previous experience in the pharmaceutical or biotech industry are the percentage of these members on the board. The purpose behind categorizing board members in this way is to find differences that might otherwise be overlooked. However a separate measurement that simply treated these categories as outsiders was also conducted and found not significance with patents. Duality occurs when the CEO is also the chairman of the board and was represented as coded 1 if dual and 0 otherwise. Duality has been found to impact strategic decision making (Dalton & Kesner, 1987; Rechner & Dalton, 1991). Log Sales was used as a measure of firm size and was measured as the log of company sales. Earnings per share (EPS) was used as a measure of performance from a shareholder perspective and the data was obtained from Mergent Online. Outside director equity was calculated as equity holdings of outside directors divided by common shares outstanding (Hoskisson, Hitt, Johnson, and Grossman, 2002).

ANALYSIS

Model and Estimation

The dependent variable in this study, total patents is a positive count variable with a mean of 7.41 and a variance of 951. Negative binomial regression is appropriate when the dependent variable is a count measure and when over-dispersion is present (Greene, 2012). Negative binomial distribution takes the form: $\ln \lambda_i = \beta' x_i + \varepsilon$. The disturbance term ε can reflect specification error or cross-sectional heterogeneity, λ_i represents the mean and variance of the distribution, and x_i is a vector of regressors.

In the context of panel analysis, another choice must be made between random and fixed effects. The general form of the panel regression equation is $y_{it} = i\alpha_i + X_i\beta + \varepsilon_i$ (Greene, 2012). The random effect model preserves degrees of freedom but assumes that individual effects are uncorrelated with other regressors. The Hausman test was used to determine which model is more appropriate (Greene, 2012). The null hypothesis that random effects was appropriate was rejected (p=.000). Therefore the model used in this analysis is a fixed effects negative binomial model.

RESULTS

Table 1 provides the correlation matrix for the study variables along with the means and standard deviations. Table 2 provides the negative binomial regression results for patents. Two models are reported below. Model 1 includes only control variables. Model 2 adds the independent variables of inside directors, board heterogeneity, board size, and inside ownership to the control variables.

TABLE 1
DESCRIPTIVE STATISTICS AND BIVARIATE CORRELATIONS

Variable	Mean	s.d.	1	2	3	4	5	6	7
1. patents	7.4	30	1						
2. Duality	0.55	0.5	0.1**	1					
3. Outside	0.27	0.19	0.21**	0.13**	1				
4. Support	0.12	0.13	0.08**	0.02	-0.2**	1			
5. Community	0.04	0.08	0.05*	-0.04	-0.05	-0.04	1		
6. IntrainB	0.31	0.22	-0.15	-0.15**	-0.56**	-0.3**	-0.18**	1	
7. Oblock	0.08	0.12	-0.11**	-0.14**	0.01**	-0.12**	-0.04	-0.02	1
8. EPS	-3.16	28.98	0.03	-0.03	0	0	-0.07**	-0.02	0
9. LogSales	2.7	2.95	0.41**	0.16**	0.25**	-0.02	0.12**	-0.19**	-0.12**
10. TMTSize	5	2	0.1**	0.09**	-0.02	-0.07**	0.08**	0.09**	-0.06**
11. Inside	0.27	0.15	-0.15**	0.04	-0.25**	-0.12**	-0.12**	-0.35**	0.02
12. Iblock	0.09	0.11	-0.16**	0.21**	0	0	-0.08**	-0.28**	-0.02
13. BoardHet	0.61	0.12	-0.01	0.01	0.02	0.31**	0.3**	-0.2**	-0.02
14. BoardSize	7.2	2.1	0.44**	0.1**	0.23**	0.03	0.18**	-0.01	-0.03
Variable	Mean	s.d.	8	9	10	11	12	13	14
8. EPS			1						
9. LogSales			0.1**	1					
10. TMTSize			-0.01	0.1**	1				
11. Inside			0.05	-0.01	-0.08**	1			
12. Iblock			0.02	0.05	-0.11**	0.44**	1		
13. BoardHet			-0.07**	0.02	0	-0.23**	-0.11**	1	

14. BoardSize			0.04	0.43**	0.33**	-0.37**	-0.25**	0.18**	1

N=2281 * p<.05 ** p<.01

TABLE 2
NEGATIVE BINOMIAL PANEL REGRESSION OF PATENTS

Variables	Model 1	Model 2
Duality	-0.109	-.094
	(.069)	(.068)
Outside	.165	-.573
	(.328)	(.688)
Support	.568*	.237
	(.383)	(.669)
Community	-1.27	-1.83*
	(.623)	(.851)
IntrainB	.077	-.656
	(.295)	(.683)
OBlock	-1.01**	-1.07**
	(.376)	(.377)
EPS	-.077	-.008
	(.018)	(.005)
LogSales	.077***	.065***
	(.018)	(.018)
TMTSize	.019	.008
	(.016)	(.016)
Inside		-.447
		(.674)
Board Diversity		-.879*
		(.380)
Board Size		.028
		(.019)
IBlock		-1.32+
		(.773)

Hypothesis one predicted that higher percentages of inside directors would lead to increases in patenting activity. The results were not significant for inside directors in the full model $-.446$ ($p > .10$). Board heterogeneity was significant and negative in the full model $-.879$ ($p < .05$) supporting hypothesis two. Hypothesis three, predicting that board size would be negatively related to patenting activity was not supported $.028$ ($p > .10$). Finally hypothesis four proposed that higher amounts of ownership among inside directors would be negatively related to patenting activity. This hypothesis was marginally supported -1.31 ($p < .10$). The control variable Community was significant in the partial model -1.27 ($p < .05$) and the full model -1.83 ($p < .05$). LogSales was highly significant in the partial $.077$ ($p < .001$) and the full model $.065$ ($p < .001$). Finally, outside ownership was highly significant in the partial -1.0 ($p < .01$) and in the full model -1.06 ($p < .01$).

DISCUSSION

Board variables have been considered in a number of contexts. For instance, board size and board composition have also been studied extensively (Dalton, et al., 1999). In both instances, Dalton used meta-analysis to examine these board variables, which requires that a reasonably large number of studies exist. While broader strategic decisions have been examined in past studies, the impact of board composition and characteristics on research and development and innovation has not been studied. This is surprising considering the substantial amount of research on firm innovation that includes many theoretical and empirical studies. We do not propose that the board is the sole antecedent to R&D expenditures. Rather, we propose that the board is worth considering, since important strategic decisions are generally made at the top levels of the organization.

In this study, we found some support that tenure heterogeneity on the board and insider ownership were negatively related to patent output. In the case of heterogeneity, the most likely cause can be found in differing mental models among board members. Those members who have been with the firm longer would be more in tune with the company culture while the newer members might bring models from other companies and industries. The result could be a slowdown in decision making resulting from conflicting models and leading to fewer patents. In the case of inside ownership, higher company ownership could make executives more risk averse since their own financial wellbeing is at stake. R&D is an inherently speculative activity requiring large investments with uncertain outcomes. Executives with stock ownership may find such risks less acceptable.

Three control variables were significant: LogSales, outside ownership and community. LogSales is a measure of the size of the firm and was positively related to patents. The fact that larger firms produce more patents is not surprising as these firms have greater resources to produce patents with. Outside director ownership was negatively related to patents. In some ways this lends credence to the idea that ownership whether by inside or outside directors makes these directors more risk averse and focuses their attention upon more immediate results. Finally community board members were negatively related to patents. This relationship may be the result of an endogenous variable, the type of board that would select influential community members to be on the board. Such firms may seek success through more political channels rather than through research. Another possibility is that having well known board members could be good for business through positive publicity. This is an area for future research.

This study has several limitations. Patents may be considered an inaccurate proxy for R&D expenditures. Firms may spend a considerable amount of money on R&D without having many, or even any, successful patents. However, patents represent a desired outcome of the R&D process and should be highly correlated to R&D expenditures. Beyond the studied variable of industry membership, diversity in race and religion might also be considered. It is reasonable to expect that business decisions requiring ethical judgments might be strongly influenced by race and religion. However, this data is not readily available, and we consider industry experience, gender, and other like factors to provide a partial measure of diversity.

In conclusion, we propose to examine the impact of board composition on R&D using patents as a proxy. We consider the possible importance of board size, board diversity, equity holdings, and percentage of inside and outside directors to be important variables. We believe that this study has important implications for the fields of research involving boards of directors and innovation.

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