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Board Characteristics, Ownership Structure and Technological Efforts in Emerging Market Firms: The Case of India

Abstract

This study examines the relationship between board characteristics and investment in R&D among Indian manufacturing firms during the period 2004-2015. Our results indicate that board size and board interlocks are positively affecting investment in innovative activities, supporting various hypotheses emanating from resource dependence view of firms in emerging markets. These results along with insignificant relationship between R&D investment and board independence are not consistent with the often-highlighted monitoring role played by boards. Further, we examine the sensitivity of these results by classifying firms with differences in monitoring mechanisms such as presence of dominant shareholder, institutional ownership and business group affiliation.

Keywords: Corporate governance, R&D investment, Board characteristics, Institutional ownership, BG affiliation

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1. Introduction

There seems to be a growing consensus among researchers that active monitoring mechanisms can alleviate agency conflicts associated with firm level investments in technology (Aghion et al 2013; Balsmeier 2014; Honore et al 2015). However, the relative role of monitoring by board, dominant shareholder, and institutional investors is not yet well understood especially in the context of emerging markets. Our study addresses this key research question by analyzing the impact of board quality on R&D investments using firm level panel data from India. Further, we examine how other monitoring mechanisms like concentrated ownership, business group (BG) affiliation and institutional ownership influences the above relationship. There are several motivations for the current study. *First*, though there is evidence that better monitoring by boards is associated with improved earnings quality (Sarkar et al 2008) and higher audit fees (Johl et al 2016), the impact of board quality on firm's strategic choice such as R&D has not received adequate empirical attention. *Second*, our study period coincides with the introduction of *clause 49*[1] (similar to Sarbanes-Oxley Act 2002 of the United States) that provide us a natural setting on how external governance reforms can impact firm level innovation (Black and Khanna 2007). *Finally*, the study period witnessed multiple changes in Indian corporate regulations leading to significant holdings by domestic and foreign institutional investors, even though concentrated ownership by "promoters" is still visible in India (Chakrabarti et al 2008). The impact of this evolution in ownership on innovation is an interesting aspect, which require further examination.

The remainder of the article is organized as follows. In the section 2, we discuss the overview of the literature on the relationship between R&D, board characteristics, dominant shareholder, and BG affiliation. The data source, variables and estimation methods is presented in the section 3. Results of the econometric analysis are presented in section 4. Section 5 provides concluding remarks.

2. Review of Literature

In this section, we begin by looking at how board characteristics affect innovation efforts. Subsequently, we discuss the impact of ownership concentration and presence

[1] For a detailed discussion, refer to Chakrabarti et al (2008)

of dominant shareholder on the relationship between board quality and innovation.

2.1 Board Characteristics and R&D

Theoretically, board of directors can influence strategic outcomes and shareholder interests of a firm by monitoring management and resource provisioning (Core et al. 1999). One strand of prior research on board effectiveness deals with board characteristics i.e., size, structure, composition and quality of the board (Anderson & Reeb 2004).

2.1.1 Board Size

Board of directors plays multiple roles by effective monitoring of management and provider of '*board capital'* (Zahra and Pearce 1989). From a theoretical perspective, the relationship between board size and R&D is ambiguous, since larger board may not do a good job in monitoring while providing better resources. As shown by previous studies, large boards suffer from agency problems and control/coordination problems (Dalton et al. 1999; Cheng 2008). Monitoring role is looked through the lens of agency perspective while resource provision role is based on resource dependence theory. It is well documented that as the larger boards are ineffective due to complex coordination/communication problems and agency problems (Jensen 1993) lowering corporate performance. As the board size increases CEOs assumes greater power and board members become '*captive*' (Cheng 2008). Larger boards are susceptible to factionalism, coalition formation leading to conflicts and special interest groups making consensus difficult in strategic issues (Goodstein et al 1994). In the context of investment in R&D which are inherently risky in nature, consensus among members of large boards are difficult due to the lack of trust and cohesion (Kor 2006).

Resource dependency theory linked with corporate governance posit that board members have a significant role in improving firm performance in accessing resources through their networks (Pfeffer and Salancik 1978; Hillman & Dalziel 2003; Nicholson & Kiel 2007; Hillman, Withers, and Collins 2009). Pfeffer and Salancik (1978) note that '*when an organization appoints an individual to a board, it expects the individual will come to support the organization, will concern himself with its problems, will variably present it to others, and will try to aid it*' (1978: 163).

Resource dependence theories attribute boards as a provider of capital i.e., human (experience, expertise, reputation) and relational (network of ties to other firms and external contingencies) (Hillman & Dalziel 2003). Using their human and relational capital corporate boards can play an important role in the provision of resources through (i) advice and counsel, (ii) providing legitimacy, (iii) channels of communication, and (iv) tangible resources (Hillman & Dalziel 2003). These resources are crucial for innovative activities and larger boards will be useful in provisioning vast pool of these resources which can aid R&D efforts by the firm. Kor (2006) emphasize that both board composition and top management team composition have direct and additive effects on R&D investment across technology intensive firms in the U.S.

In one of the earliest studies, Baysinger et al. (1991) using a sample of U.S. firms report that a high representation of outsiders on the board positively affects corporate R&D spending. More recently, Tong & Zhang (2013) study of U.S.-listed firms find that R&D investments are higher when boards have larger proportions of independent directors and when independent directors have more outside directorships. Osma (2008) finds that presence of independent director on boards constrains the manipulation R&D spending in U.K. In contrast, Xie & O'Neill (2013) find that diverse boards has negative effect on R&D investment since highly diverse boards may experience communication problems leading to lower board effectiveness.

2.1.2 Board Independence

Board of directors is vested with the responsibility of overcoming 'myopia' and agency problems associated with risky but valuable investments like R&D. However, the effectiveness of board in the corporate governance mechanism depends on its independence (Chen & Hsu 2009). It is suggested that boards can be made independent if more independent outsiders are included (Boyd, 1995; Baliga et al 1996). Board members consist of a combination of inside and outside (independent) directors. Agency cost argument supports that boards primarily consisting of independent directors are in better position to monitor management since outsiders are better aligned with shareholder interests (Hillman & Dalziel, 2003), which can stimulate managers to undertake R&D activities. Kor (2006) assert that firms with more independent directors are more likely to develop and maintain innovative

capabilities since they are less risk averse. Independent boards are considered to be more risk averse than insiders since their stake in the ownership is limited which make them pursue investments such as R&D investment (Hernandez et al. 2010). On the other hand, firms with more inside directors may be unwilling to invest in risky investments in R&D due to the fear of reducing firm value (Kor 2006). It can be argued that the unique corporate landscape in India where boards are dominated by insiders (mostly controlling family members and interlocking directorships), independent directors can effectively assess and help management with their *human* and *relational* capital to provision resources for R&D.

2.1.3 Board Interlock: Interlocks arises when board members serve as members of other firms' boards. Resource dependence theory posits that shared board directors can provide information, resources and outside connections (Pfeffer & Salancik 1978; Pfeffer & Salancik 2003). It is not clear in the existing literature whether interlocked directors improve firm performance. There are potential costs and benefits associated with well-connected boards (Larcker et al 2011). Boards with more interlocked directors could be too busy (*over boarded directors*) and are unable to effectively monitor management (Fich and Shivdasani 2006). Given the lack of monitoring by busy boards, it is likely the managers may underinvest in risky investments like R&D. However, busy board members can bring better expertise and insider information about research opportunities. Further, interlock can act as a catalyst in diffusion of new technology as large board interlocks facilitates sharing of resources that support investment in R&D.

2.2 Ownership Structure and R&D

Perhaps among the various dimensions of corporate governance and innovation, ownership concentration is the most important aspect that received considerable empirical attention (Belloc et al 2016). The control of management of firm is either in the form of disbursed or concentrated ownership. Disbursed ownership is associated with efficient capital markets, high disclosure and market transparency standards while concentrated ownership liked to inefficient capital markets, lower disclosure and market transparency standards and take the form of dominant family, business group (BG) affiliation, the state and institutional investors. According the '*share-holder approach*' to corporate governance based on agency theory (Jensen and

Meckling 1976) posit that disbursed ownership leads to lower monitoring due to free riding. With respect to innovation, the misalignment of interests between owners and management makes the managers weary of undertaking risky R&D investments. Therefore, ownership concentration is advocated as solution to agency problem with respect to innovative activities. Ownership concentration may conducive for innovation due to their long-term vision and effective monitoring of management, which is essential for investments in R&D (Minetti et al 2015) On the other hand, ownership concentration is not a preferred mechanism since it may stifle innovative activities due to "asymmetric bargaining" power and expropriation of minority shareholders is easier in investments like new technology which tend to be opaque.

Previous studies, mostly from US and cross-country data have explored the relation between ownership concentration and R&D investment. In a study of U.S. firms, Hill and Snell (1988) provide empirical support of lower R&D spending per employee in firms with less concentrated ownership. Similarly, Francis and Smith (1995) find that firms with dispersed ownership are less innovative. Lee and O'Neill (2003) study the relationship between the ownership structures and R&D investments in agency environment (the U.S.) and stewardship environment (Japan). They find a positive relation only in the U.S. context highlighting the importance of cultural and institutional processes in each country. Di Vito et al. (2010) show that the relationship between ownership structures and R&D investments can be influenced by the wedge between voting and cash-flow rights. However, existing studies do not provide widespread support that concentrated ownership is often beneficial for innovation. The negative effects of ownership concentration is reported by Ortega-Argiles et al (2005) in Spain; Smith et al (2004) in Denmark; Li et al (2010) in China.

Family Ownership: Family owned firms is a widely known form of business across the globe especially in developing countries that quiet often uses control-enhancing mechanisms. It is argued that firm under family ownership have low motivation to invest in innovative activities which are uncertain and risky. Family owned firms are more interested to transfer ownership and wealth to subsequent generations and prefer regular income, which makes them tread cautiously and discourage investment in innovation (Claessens et al 2002; Gomez-Mejia et al. 2010). In the context of emerging markets, it is argued that agency theory cannot provide convincing

explanation in understanding the relationship between family ownership and R&D. Developing economies are often characterized by underdeveloped institutions like weak capital markets, lower disclosure, weak corporate governance and absence of regulation. Family ownership in emerging markets is found to foster technological innovation by obtaining external resources through their links with government agencies (Lodh et al 2014). However, empirical evidence mostly find family ownership to be negatively associated with R&D investments in Canada (Munoz-Bullon and Sanchez-Bueno, 2011); in the U.S. (Chrisman and Patel, 2012), in Western Europe (Munari et al., 2010), in Germany (Matzler et al. 2014) and in Taiwan (Chen and Hsu, 2009).

Business Groups: A unique feature of emerging markets like India is the extensive prevalence of large number of firms affiliated to business groups. BG enables firms to overcome the agency problems and institutional underdevelopment by playing the role of intermediary institution (Khanna & Palepu, 2000b). In the context of innovation, BGs in emerging markets compensate for '*institutional voids*' by enabling affiliates to acquire valuable resources like financial capital, technology, and scientific talent (Mahmood and Mitchell 2004). BGs due to their reputation is able to obtain external resources by cooperating with institutions outside their internal network to enhance their innovation performance (Hsieh et al 2010).

Institutional Investors: It is well established that investment in R&D substantially improves the firm performance and competitiveness. However, due to the risky and uncertain nature of R&D investment, managers face the dilemma whether to maximize their or shareholder's wealth. Managerial opportunism therefore leads to sacrificing long-term investment like R&D over-short term earnings due to '*myopia*' (Bushee 1998). Various mechanisms, external and internal provides act as a means of defense against opportunistic behavior by the managers. Prior research on ownership structure has probed into the role of external factors like presence of institutional investors and its effectiveness in influencing R&D-firm performance relationship.

As mentioned, institutional ownership is often highlighted as a mitigating mechanism to avoid shareholder conflicts. The institutional shareholders have the financial muscle and the capacity to monitor management (Del Guercio & Hawkins, 1999). It is

pointed out that institutional ownership resort to activist model to discipline managers (Chung & Talaulicar, 2010). Previous studies report that the activism of these institutional investors like pension funds has significantly affected R&D investment (David et al., 2001; Kochhar & David, 1996). Institutional shareholder in developing countries is found play major role in decision making of the organizations stimulating investment process. These institutions act as substitute to the government in providing financial resources for high-risk R&D projects. Institutional shareholders play key role as a regulator and monitoring agency in the financial markets especially in emerging economies (Choi et al 2012).

However, empirical literature testing the significance of institutional investor-R&D relationship is not unambiguous. According to one strand of studies, institutional investors due to their large size force managers to undertake investments with long-term focus like R&D. Institutional sophistication (Baysinger et al., 1991; Hansen and Hill, 1991; Useem, 1993; Kochhar and David, 1996; Zahra, 1996; Wahal and McConnell, 2000; David et al., 2001; Chen et al., 2007; Aghion et al., 2010). On the other hand, another set of studies point out that institutional investors are mainly motivated by the pursuit for short-term returns and do not encourage managers to involve in R&D investments (Drucker, 1986; Mitroff, 1987; Graves, 1988; Graves and Waddock, 1990; Jacobs, 1991; Porter 1992).

3. Data and Methodology

3.1 Sample

We obtained data from PROWESS, a database compiled and maintained by the Center for Monitoring Indian Economy (CMIE). This database contains information for over 6,000 listed firms. The information included in the database is mainly drawn from annual reports and filings to the stock exchanges. This database was previously employed by many corporate governance researchers (Sarkar et al 2008; Johl et al 2016; Black and Khanna 2007). We restrict our sample to listed manufacturing firms with firm level ownership and board information available during the period 2004-2015. While selecting the sample, we excluded firms controlled by the state, since governance practices in these firms are often not driven by economic interests alone. Our final sample consists of 11,264 [2] firm year observations. The sample consists of 1510 firms with an average of 7.46 firm year

[2] This final sample is after deleting 1510 firm year observations with missing lagged scaling variable and/or information on independent variables.

observations. The present study focuses on R&D investment rather than innovation performance as an indicator of innovative efforts of firms (Nieto & Quevedo, 2005; Guzzini & Iacobucci, 2014a). We consider propensity and intensity of R&D as the dependent variables. R&D propensity is defined as a dummy variable equals one if firm's R&D expenditure is greater than zero, whereas R&D intensity measures R&D expenditure as a percentage of total assets[3].

Table 1 provides sample distribution by industry and year. The sample has representation from the sixteen industry groups with one fourth of sample observations belonging to high technology intensive sectors (Chemical and Pharmaceuticals). Moreover, there is no major spike or drop in the sample during the study period as all the twelve years represent more than thousand firm year observations.

Table 1 Sample Distribution

Panel A: Sample distribution by industry		
No.	Industry	No. of firm years
1	Food and food products	859
2	Beverages	165
3	Smoke	41
4	Textiles and apparel	1690
5	Wood and furniture products	75
6	Paper and paper products	339
7	Petroleum & Chemicals	1712
8	Pharmaceuticals and medical equipment	931
9	Rubber and plastics	881
10	Non-metallic	598
11	Basic metals	1161
12	Fabrics	337
13	Computers and Electronics	319
14	Electrical products	617
15	Machinery	720
16	Motor vehicles & Transport equipment	819
	Total	11264

[3] We measure R&D expenditure as the sum of both capital and current expenditure. Prowess database obtains this information from the annexure to the board of director's report. Information on R&D expenses is normally reported by manufacturing companies as per section 217 of the Indian Companies Act 1956.

Table 1 Panel B: Sample distribution by calendar year			
	Year	Number of firms	
1	2004		517
2	2005		652
3	2006		761
4	2007		855
5	2008		950
6	2009		1,017
7	2010		1,044
8	2011		1,109
9	2012		1,139
10	2013		1,136
11	2014		1,104
12	2015		980
	Total	11,264	

3.2 Estimation Methods

We investigate the relationship between sample firms' corporate governance and their investment in R&D using the following specifications.

$$R\&D\ dummy_{it+1} = f(CGMeasure_{it}, Controls_{it}, \delta_t, \alpha_d) \quad (a)$$

$$R\&D\ Intensity_{it+1} = g(CGMeasure_{it}, Controls_{it}, \delta_t, \alpha_d) \quad (b)$$

The control variables include size, cash flow, leverage, age, defined previously. We use lagged values to mitigate the effect of potential endogeneity. Above models also include time (δ_t) dummies, industry (α_d) effects. Above functional forms can be specified as follows:

$$d_{it+1} = \boldsymbol{z}_{it}\gamma + u_{it} \quad (1)$$

where d_{it} is the R&D decision of firm *i* in period *t* and $\boldsymbol{z}_{it}$ is the vector of firm specific variables that may impact d_{it}.

$$y_{it+1} = \boldsymbol{x}_{it}\beta + e_{it} \quad (2)$$

where y_{it} is the R&D intensity of firm *i* in period *t* and $\boldsymbol{x}_{it}$ is the vector of firm specific variables that may impact y_{it}. We follow the standard Heckman (1979) two-step procedure to estimate the above equations. This involves Probit estimation of the selection equation (equation 1) which permits computation of inverse Mills ratio[4] (λ) used later in the estimation of the R&D intensity equation (equation 2).

$$\left(y_{it+1} | \boldsymbol{x}_{it}, d_{it+1} = 1\right) = \boldsymbol{x}_{it}\beta + \delta\lambda_{it} + \upsilon_{it} \quad (3)$$

[4] See Greene (2003) for further details.

The above described estimation method accounts for the correlation among the error terms and assumes those error terms of equation1 and 2 follows a standard bivariate normal distribution. An added advantage of Heckman's method is that it corrects for the sample selection bias that may be arising due to non-reporting firms[5]. Further, sample selection models require valid '*exclusion restriction*', i.e., variables that determine R&D propensity but do not affect the outcome of interest, R&D intensity. Following Munari et al (2010) and Honore et al (2015), we use lagged value of average industry R&D intensity as the selection variable. This variable captures the level of technological opportunities within an industry that can be considered a major determinant of decision to undertake R&D.

In the empirical analysis, we focus on various board characteristics such as board size (*BSIZE*), board independence (*BIND*), board interlocks (*BINTER*). The empirical model incorporates several other control variables including cash flow, leverage, size, and age along with time and industry fixed effects (refer to Table 2 for definition of variables used). Previous studies highlight the influence of financial factors on R&D (Hall & Lerner, 2010). Following earlier studies (Sasidharan et al 2015), *cash flow*, defined as sum of profit after tax, depreciation, amortization, and R&D expenses (scaled by total assets) is considered as a proxy for firms' financial constraints. Gugler (2001) gives a detailed account on why debt financing is not suited for investment in R&D. A number of empirical studies like Bradley *et al.,* (1984), Czarnitzki and Kraft (2009) shows negative relationship between firms' leverage and R&D intensity. In the present study, we define *leverage* as ratio of total borrowing to total assets. *Firm size*, measured as natural logarithm of total assets is expected to have positive influence on R&D since larger firms appropriate more benefits from R&D investments (Nelson & Winter, 1982). Previous studies based on India have reported a positive relationship between firm size and R&D (Kumar & Saqib, 1996); while other studies reported U-shaped (Siddharthan, 1988) and S-shaped (Kumar & Aggarwal, 2005) relationship. We control for *Age*, computed based on the year of incorporation. Age is expected to influence R&D activities positively

[5] In our data set, missing values of R&D cannot be treated as zero investment in R&D, since firms need to report R&D expenses only if it is greater than one per cent of sales revenue. Therefore, including only sample firms with non-zero R&D values will lead to biased estimates due to sample selection.

as experienced firms may have comparative advantage in exploiting the benefits of R&D efforts.

Table 2. Variable Description

Variable	Description
Dependent Variables	
R&D Dummy	Equals 1 if R&D expenditure is greater than zero and 0 otherwise
R&D Intensity	R&D expenditure including current as well as capital expenses as a percentage of total assets
Independent Variables	
Board Size (BSIZE)	Natural logarithm of total number of directors on board
Board Independence (BIND)	Number of independent directors /Total number of directors
Board Interlocks (BINTER)	Average number of outside board directorships held by board members
Leverage (LEV)	It is the ratio of total borrowing to total assets
Size	Natural logarithm of total assets
Cash Flow (CF)	It is the sum of profit after tax, depreciation, amortization, and R&D expenditure
Age	It is computed based on the firm's corporation year

Table 3 summarizes the descriptive statistics for dependent variables, governance variables and other controls. On an average, firms in our sample spend 0.44 percent of their assets on R&D and only forty percent of the sample firms are reporting (engaging) R&D expenditure. The variables relating to board structure are available only for 80-92 percentage of the sample firms and are comparable to previous studies (Johl et al 2016; Sarkar et al 2008). The median sample firm has a board with six members with fifty percent of them are independent. Further, on average board members hold 3.44 outside directorships. The median asset size of our sample firms is 2470 million Indian rupees. Leverage of the sample firms is moderate with a mean (median) of 32.38 (32.95) percent.

Table 3 Summary Statistics

Variable	N	mean	p25	p50	p75	sd
Total Assets	11264	1475.50	84.73	246.83	786.30	9340.80
LEV	10676	0.3238	0.1823	0.3294	0.4564	0.1828
Size	11264	5.5827	4.4394	5.5087	6.6673	1.6884
CF/TA_t-1	10334	0.0952	0.0425	0.0818	0.1367	0.0853
AGE	11264	33	20	27	41	20
Proportion_R&D	11264	0.4456	0.0000	0.0000	1.0000	0.4971

RD /Sales (%)	10334	0.4482	0.0000	0.0000	0.3267	1.1122
RD Modified/Sales (%)	11264	0.4798	0.0000	0.0000	0.2852	1.3771
Corporate governance variables						
Ln Board size	11264	1.76	1.39	1.79	2.08	0.45
BINDEP	11264	0.52	0.43	0.50	0.60	0.16
BINTER	11264	3.44	1.33	2.73	4.75	2.93

Table presents the summary statistics of the variables considered in the empirical investigation. All the ratio variables included are winsorized at one as well as at ninety nine percentile to eliminate the effect of extreme values. The definition of the variables is provided in Table 2.

4. Results and Discussion

As discussed earlier, a two-step Heckman selection model is employed to correct for the potential selection-bias. Column 1 Table 4 reports the estimation results of the first stage using probit model. These estimates provide the likelihood of being an R&D spender based on the full sample. Our selection variable, lagged value of average industry intensity is significantly correlated with R&D propensity. As expected firm size, cash flows, and age are positively related to the probability of undertaking R&D. Consistent with previous studies, leverage is found to be negatively associated with firms' decision to engage in R&D. Turning to the board characteristics, board size and board interlock are positively related to R&D propensity and intensity. Contrary to the findings of Yermack (1996), we find that large boards are better in supporting R&D investments. This finding is similar to Jackling and Johl (2009) and indicate that larger boards provide better intellectual capital and encourage R&D. However, board independence is unrelated to innovative efforts. One plausible reason is the unique feature of the India - many of the independent directors serve as board member with the same company for a long period[6]. This long tenure of the independent directors may lead to acquaintance and promoters could influence directors a lot more and thus Independence may get impacted. Board Interlock (BINTER) is positively associated with innovative efforts of the sample firms. This indicate that directors with multiple board membership positively influence R&D expenditure. Our results supports the resource dependency theory and is not consistent Fich and Shivdasani (2004).

[6] See 'Are long-serving independent directors truly independent?" by Bhuma Shrivastava, Live Mint dated 23rd September 2012 (available at http://www.livemint.com/)

Table 4. Board characteristics and Innovation

	1	2	3	4
Outcome				
LnBSIZE	0.074***			0.093***
	(0.025)			(0.030)
BINDEP		0.069		0.074
		(0.061)		(0.057)
BINTER			0.018***	0.017***
			(0.003)	(0.004)
CF/TA	1.803***	1.867***	1.915***	1.850***
	(0.211)	(0.181)	(0.222)	(0.167)
LEV	0.081	0.085	0.086	0.097
	(0.072)	(0.080)	(0.064)	(0.073)
Size	0.065***	0.074***	0.069***	0.057***
	(0.020)	(0.023)	(0.018)	(0.016)
LnAGE	0.037	0.045	0.056**	0.046*
	(0.026)	(0.034)	(0.026)	(0.027)
Constant	-0.987***	-0.984***	-1.038***	-1.138***
	(0.325)	(0.350)	(0.288)	(0.321)
Selection				
LnBSIZE	0.373***			0.390***
	(0.055)			(0.042)
BINDEP		-0.046		0.096
		(0.107)		(0.129)
BBUSY			0.025***	0.027***
			(0.005)	(0.007)
CF/TA	2.108***	2.263***	2.272***	2.115***
	(0.275)	(0.255)	(0.302)	(0.230)
LEV	-0.670***	-0.646***	-0.617***	-0.636***
	(0.089)	(0.083)	(0.093)	(0.125)
Size	0.276***	0.299***	0.282***	0.256***
	(0.011)	(0.013)	(0.009)	(0.012)
LnAGE	0.420***	0.424***	0.419***	0.414***
	(0.029)	(0.034)	(0.031)	(0.029)
AvgeInd R&D Int	1.209***	1.214***	1.186***	1.178***
	(0.155)	(0.126)	(0.150)	(0.147)
Constant	-4.220***	-3.566***	-3.536***	-4.244***
	(0.161)	(0.167)	(0.134)	(0.176)
Mills Lambda	0.447***	0.476***	0.522***	0.486***
	(0.107)	(0.126)	(0.101)	(0.102)
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
No. of observations	8,790	8,790	8,790	8,790

***,**, and * refer to 1%, 5%, and 10% significance level.

Table presents the findings of estimating equation a and b. We employ Heckman two step procedure and the standard errors have been estimated using the bootstrapping method. The definition of the variables is provided in Table 2.

5. Robustness Checks and Additional Analysis on Impact of Alternate Monitoring Mechanisms

Our result support resource dependent view of board structure in emerging economies, as larger boards and more board interlocks seems to encourage innovation. However, we cannot reject the monitoring role of BoD as the results may manifest the existence of alternate monitoring mechanisms that may undermine the importance of monitoring by board. Therefore, in this section we examine whether presence dominant shareholder, ownership concentration, and institutional ownership could explain our reported results.

First, we examine how institutional ownership affect the relationship between board structure and governance. Our results indicate that institutional ownership above a threshold level of 5% and 10% is associated with higher propensity for R&D. However, institutional ownership above 10% level is only positively influencing the R&D intensity. The interaction variables between board structure and institutional ownership indicate that moderating role of institutional ownership is insignificant in all specifications pertaining to R&D intensity.

Table 5. Institutional Ownership and Board characteristics- Innovation Relationship

	1		2	
Outcome				
LnBSIZE	0.094*	(0.053)	0.098**	(0.048)
BINDEP	0.108	(0.103)	0.058	(0.073)
BINTER	0.013**	(0.007)	0.020***	(0.005)
Dum (INST>5%)	0.192	(0.124)		
Dum (INST>5%)*ln_BSIZE	-0.036	(0.047)		
Dum (INST>5%)*BINDEP	-0.046	(0.144)		
Dum (INST>5%)*BINTER	0.002	(0.008)		
Dum (INST>10%)			0.222*	(0.132)
Dum (INST>10%)*ln_BSIZE			-0.072	(0.050)
Dum (INST>10%)*BINDEP			0.072	(0.110)
Dum (INST>10%)*BINTER			-0.010	(0.008)
Controls & Constant	Included		Included	
Selection				
LnBSIZE	0.425***	(0.063)	0.463***	(0.059)
BINDEP	0.263*	(0.141)	0.257*	(0.146)
BINTER	0.016	(0.011)	0.023***	(0.009)
Dum (INST>5%)	0.495**	(0.204)		
Dum (INST>5%)*ln_ BSIZE	-0.093	(0.079)		
Dum (INST>5%)*BINDEP	-0.593***	(0.214)		
Dum (INST>5%)*BINTER	0.015	(0.015)		

Dum (INST>10%)			0.868***	(0.240)
Dum (INST>10%)*ln_ BSIZE			-0.227***	(0.080)
Dum (INST>10%)*BINDEP			-0.809***	(0.224)
Dum (INST>10%)*BINTER			0.004	(0.014)
Controls & Constant	Included		Included	
Mills Lambda	0.423***	(0.146)	0.381***	(0.126)
Year, Industry	Yes		Yes	
No. of observations	7,505		7,505	

***,**, and * refer to 1%, 5%, and 10% significance level.

Table presents the findings of estimating equation a and b. We employ Heckman two step procedure and the standard errors have been estimated using the bootstrapping method. The sample firms are classified as business group affiliated firms and stand-alone firms using the CMIE-Prowess classification. The definition of the variables is provided in Table 2.

In the next step we examine whether insider ownership is strengthening or weakening the board structure-innovation relationship. Concentrated ownership prevalent in India (Chakrabarti et al 2008) enables high risk taking behavior (Wright et al. 1996). Since R&D investment is perceived as risky long-term investment strategy, large shareholding by promoters may enhance innovation effort. We have used two additional variables to capture the insider ownership- promoters holding and family holding. The capital market regulator SEBI defines a promoter as any person who directly or indirectly control the company. We obtained promoters ownership data from prowess. Following Aswin et al (2015) we define a subcategory of promoters holding as family holding in the firm. Family holding is the sum of promoter holding in the capacity of individuals and body corporate. Model 1 in table 6 reports results with promoters holding and Model 2 reports results with family ownership. Promoter ownership positively affect R&D intensity, but it weakens the positive relationship between board structure variables and innovation.

Table 6. Promoter Ownership and Board characteristics- Innovation Relationship

	1		2	
Outcome				
LnBSIZE	0.212**	(0.093)	0.201**	(0.088)
BINDEP	0.489*	(0.270)	0.203	(0.292)
BINTER	0.039***	(0.011)	0.036***	(0.013)
promoters	0.006*	(0.004)		
c.promoters#c.ln_bsize	-0.002	(0.001)		
c.promoters#c.bindep	-0.008*	(0.005)		
c.promoters#c.bbusy	-0.000*	(0.000)		
family_own			0.003	(0.005)
c.family_own#c.ln_bsize			-0.001	(0.002)
c.family_own#c.bindep			-0.002	(0.006)
c.family_own#c.bbusy			-0.000	(0.000)

Controls & Constant	Included		Included	
Selection				
LnBSIZE	0.563***	(0.120)	0.406***	(0.131)
BINDEP	0.975***	(0.373)	0.583*	(0.341)
BINTER	0.074***	(0.020)	0.084***	(0.020)
promoters	0.016***	(0.006)		
c.promoters#c.ln_bsize	-0.003	(0.002)		
c.promoters#c.bindep	-0.016**	(0.007)		
c.promoters#c.bbusy	-0.001**	(0.000)		
family_own			0.009	(0.007)
c.family_own#c.ln_bsize			0.001	(0.003)
c.family_own#c.bindep			-0.011	(0.007)
c.family_own#c.bbusy			-0.001***	(0.000)
Controls & Constant	Included		Included	
Mills Lambda	0.533***	(0.091)	0.827***	(0.115)
Year, Industry	Yes		Yes	
No. of observations	8,741		7,398	

***,**, and * refer to 1%, 5%, and 10% significance level.

Table presents the findings of estimating equation a and b. We employ Heckman two step procedure and the standard errors have been estimated using the bootstrapping method. Promoter refers to the promoter ownership and 'Family' refers to the family ownership. The Family ownership is the sum of the holdings of Indian individual promoters and Indian corporate bodies. The definition of the variables is provided in Table 2.

Finally, we examine an important firm-level characteristic-affiliation to a business group (BG), which has a significant influence on the financial and other organizational resources required for R& D expenditure. Prior literature has shown that BG affiliation positively influences R&D investment is emerging markets (Chang et al 2006, Komera et al 2016). BGs are often characterized by internal capital markets and sharing of various other resources including technology, management talent etc. (Elango and Patnaik, 2007). Thus BG affiliates strategic choices are not only influenced by the board, but also by the other affiliates. Therefore, we bifurcate the sample into BG affiliates and stand-alone firms and the results are given on Table 5. Though board interlock is significant among the subsamples, board size is not significant. Further, the influence of board structure is similar across the two subsamples.

Table 5. Sample split: Ownership, Board characteristics and innovation

	Business group affiliates				Stand-alone			
	1	2	3	4	5	6	7	8
Outcome								
LnBSIZE	-0.011			-0.011	0.086			0.092
	(0.045)			(0.038)	(0.061)			(0.061)
BINDEP		0.101		0.093		-0.002		-0.013
		(0.072)		(0.068)		(0.098)		(0.096)
BINTER			0.017***	0.015***			0.016**	0.018***
			(0.005)	(0.005)			(0.006)	(0.006)
Control Variables	Included	Included	Included	Included	Included	Included	Included	Included
Constant	-0.410	-0.771**	-0.834**	-0.428	-0.590	-0.216	0.021	-0.456
	(0.437)	(0.307)	(0.340)	(0.398)	(0.661)	(0.611)	(0.563)	(0.698)
Selection								
LnBSIZE	0.382***			0.381***	0.358***			0.387***
	(0.062)			(0.054)	(0.061)			(0.062)
BINDEP		-0.173		-0.035		-0.014		0.145
		(0.160)		(0.136)		(0.152)		(0.145)
BINTER			0.018**	0.019*			0.016	0.022**
			(0.009)	(0.010)			(0.012)	(0.011)
Control Variables	Included	Included	Included	Included	Included	Included	Included	Included
AvgeInd R&D Int	1.114***	1.136***	1.136***	1.109***	1.154***	1.146***	1.124***	1.130***
	(0.141)	(0.172)	(0.186)	(0.166)	(0.214)	(0.231)	(0.235)	(0.288)
Constant	-3.583***	-2.826***	-2.932***	-3.575***	-4.395***	-3.782***	-3.745***	-4.461***
	(0.229)	(0.237)	(0.185)	(0.226)	(0.258)	(0.211)	(0.228)	(0.223)
Mills Lambda	0.354**	0.482***	0.533***	0.328**	0.312*	0.236	0.175	0.286
	(0.159)	(0.134)	(0.152)	(0.153)	(0.182)	(0.183)	(0.188)	(0.206)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	4,370	4,370	4,370	4,370	4,420	4,420	4,420	4,420

***,**, and * refer to 1%, 5%, and 10% significance level.

Table presents the findings of estimating equation a and b. We employ Heckman two step procedure and the standard errors have been estimated using the bootstrapping method. The sample firms are classified as business group affiliated firms and stand-alone firms using the CMIE-Prowess classification.The definition of the variables is provided in Table 2.

6. Conclusions

In this paper, we examined the relationship between board characteristics and R&D investment by Indian firms. Our empirical results based on 11264 firm year observations during the period 2004-2015 show that board size and board interlock are positively associated with R&D investments. Institutional ownership and BG affiliation have no influence on this relationship.

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