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R&D MANAGEMENT

R&D investments in emerging market firms: the role of institutional investors and board interlocks

Saneesh Edacherian[1], Vidya Sukumara Panicker[2,*] and Amon Chizema[2]

[1]Department of Strategy & International Business, University of Birmingham, Dubai, United Arab Emirates. s.edacherian@bham.ac.uk
[2]Loughborough Business School, Loughborough University, Loughborough, UK. v.s.panicker@lboro.ac.uk, a.chizema@lboro.ac.uk

Despite the increase in institutional investor shareholdings in emerging market firms, their impact on R&D investments has received scant attention in the literature. By integrating agency and resource dependence perspectives, we examine the role of different types of institutional investors and their interactions with board interlocks in shaping their preference for R&D investment in their portfolio firms. We test our hypotheses on a sample of 2,478 Indian firm-year observations from 2005 to 2019, using various estimation techniques. Our results indicate that different categories of institutional investors have distinct preferences for R&D investment. Specifically, we find that ownership by both foreign institutional investors and mutual fund investors negatively impacts R&D investments in firms. While board interlocks positively moderate the impact of institutional investors such as banks and financial institutions and foreign institutional investors on R&D investments in firms, this moderation is negative in the case of mutual fund investors and R&D investments in firms. We contribute to the understanding of the determinants of R&D investments in emerging market firms, with a specific focus on institutional investor ownership and add to the nascent literature on the interaction between two forms of governance, i.e., ownership and board characteristics, in shaping this firm strategy.

1. Introduction

A firm's ownership structure is recognized as one of the key determinants of its investment in research and development (R&D) activities (Connelly et al., 2010; Chen et al., 2015a; Lopez Iturriaga and López-Millán, 2017). Among the different ownership groups, institutional investors' role in promoting R&D investment has received significant consideration in extant literature (David et al., 2001; Aghion et al., 2013). However, findings on the impact of institutional investors on R&D are mixed. Some studies highlight a positive association between institutional investors and

R&D investment (Boyd and Solarino, 2016), while others show that institutional investors can impede firms' R&D investment activities (Graves, 1988; Chen et al., 2015b). Literature suggests that the heterogenous nature of institutional investors, relating to their investment horizons, quantum of ownership, and abilities to govern managerial actions can partly explain the inconsistencies relating to their impact on R&D investments (Kochhar and David, 1996; Boyd and Solarino, 2016).

Driven by the significant share of institutional investments in their firms, most of the research on the effect of institutional investors on R&D investments has been undertaken in the context of developed economies. However, emerging markets across the world have been showcasing unique trends and patterns of R&D investment, with studies reporting higher growth of R&D expenditure in these countries, as opposed to their developed counterparts (Alam et al., 2019; Adarkwah and Malonæs, 2020; Schwab and Zahidi, 2020). Additionally, firms in emerging economies have also witnessed an increasingly higher share of ownership by institutional investors. For instance, on average, aggregate shareholdings by institutional investors in terms of market value in the 2004–2016 time-period is at 24% in India, 21% in South Africa, and 19% in Brazil (Alvarez et al., 2018; OECD, 2020). Despite the significance of these observations, surprisingly, our understanding of the effects of institutional investors on R&D investments in emerging economy firms is still nascent.

Further, the distinct institutional arrangement in emerging markets culminates in additional governance challenges as well as contrasting patterns in the relationship between institutional investors and R&D investments (Wright et al., 2005; Globerman et al., 2011; Rong et al., 2017). Emerging markets lack robust institutions that support market transactions, offer information, and verify the credibility of participants, thus leading to institutional voids (Khanna and Palepu, 1999; Landau et al., 2016). To mitigate these challenges firms in these markets often resort to concentrated ownership and rely on networks characterized by board interlocks, with same individual occupying board positions in different firms for better coordination or control (Peng, 2002; Manikandan and Ramachandran, 2015; Caiazza et al., 2019). Board interlocks serve as crucial channels for information and relational capital for firms and investors, addressing the absence of robust institutions (Gaur et al., 2014; Ahsan et al., 2023). However, they can also intensify the challenge of overseeing a company and its management independently from dominant owners (Fich and White, 2005; Withers et al., 2012). Extant research in the context of developed economies, predominantly through the lens of agency theory, have emphasized institutional investors' proclivity for less–interlocked directors (McCahery et al., 2016). However, this focus disregards evidence from a large stream of corporate governance research that highlights the relevance of board capital such as relational capital provided by interlocked directors in emerging economies (Gaur et al., 2014; Manikandan and Ramachandran, 2015) and the significance of relational capital in general for R&D investment (Gu et al., 2013; Johnson et al., 2013; Yi et al., 2016).

Drawing on these insights from an integrated institutional agency-resource dependence perspective (Hillman and Dalziel, 2003; Pache and Santos, 2010; Bravo and Reguera-Alvarado, 2017), we attempt to provide clarity on the impact that different types of institutional investors have on R&D investment. We test our hypotheses on a novel panel dataset of publicly listed firms in India, one of the largest emerging economies. Our panel comprises 2,478 firm-year observations between 2005 and 2019. Our results, confirmed by multiple robustness tests, support our main argument that institutional investors' effect on R&D investment varies according to their type. Specifically, we find that ownership by both foreign institutional investors and mutual fund investors negatively impacts R&D investments in firms. Further, the moderating role of board interlocks in this relationship is also not uniform across investor types. While board interlocks positively moderate the impact of institutional investors such as banks and financial institutions and foreign institutional investors on R&D investments in firms, this moderation is negative in the case of mutual fund investors and R&D investments in firms. Additional tests also reveal interesting interactions among different groups of institutional investors as well as the variations between hi-tech and low-tech firms, in these relationships.

Our work contributes to the nascent stream of research investigating the effect of institutional investors on R&D investment in emerging economies. We provide a fine-grained perspective on this relationship by examining the heterogenous groups of institutional investors and identifying how the characteristics of different kinds of institutional investors can affect managerial decisions in firms. Further, by studying how institutional investors interact with board interlocks in emerging economies, we directly respond to calls to explore how different forms of governance such as ownership and boards jointly affect firm outcomes (Connelly et al., 2010; Federo et al., 2020; Hu et al., 2010;

Miroshnychenko and De Massis, 2020). Our insights also contribute to an integrated institutional agency-resource dependence perspective by examining how the effect of institutional investors approached through an institutionalized agency lens interacts to balance the costs and benefits of board interlocks examined from a resource-dependence perspective.

2. Theoretical framework and hypotheses development

Extant literature encompassing different geographic contexts has examined the influence of the corporate governance related determinants on R&D investments in firms, such as their ownership structure (Baysinger et al., 1991; Ashwin et al., 2015), board of director composition (e.g. Dalziel et al., 2011; Bravo and Reguera-Alvarado, 2017), and the market for corporate control (Hitt et al., 1996; Ongsakul et al., 2022). Based on the notion that corporate governance actors of a firm are both resource providers and monitors, recent studies have integrated tenets of agency theory with the resource dependence view to examine how ownership structure, and board characteristics influence firm strategies (e.g., Hillman and Dalziel, 2003; Hillman et al., 2009). Traditional agency theory, nevertheless, overlooks the role of institutional embeddedness in examining corporate governance in firms (Aguilera and Jackson, 2003), and therefore, is often considered ineffective in accounting for the influence that the institutional environment has over managers, owners, and boards of directors in emerging markets (Bao and Lewellyn, 2017; Melis and Rombi, 2021). However, developments toward an institutionalized agency perspective offset these shortcomings and examine corporate governance practices within firms as an outcome of institutional factors that define and represent the behavior of actors (Aguilera and Jackson, 2003; Jain, 2020). Therefore, in our study, we combine an institutionalized agency lens with a resource dependence view to account for the institutional environment in influencing the monitoring and resource provisioning roles of different kinds of owners and their engagement with board interlocks to affect R&D investments in the context of emerging market firms.

2.1. Institutional investors and R&D investment

R&D investment is a high-risk strategy with potential long-term returns (Wolfe, 1994) and contradicts managerial motivation to allocate resources to low-risk, high-return projects (Stein, 1988). However, while the managerial preference to increase short-term gains results in their avoiding risky long-term projects such as R&D investment (Ferreira et al., 2014), institutional investors can either augment or alleviate this managerial myopia (Wahal and McConnell, 2000). Institutional investors could encourage R&D investment in firms by shielding managers from the pressure of retail investors who are interested in short-term gains (Aghion et al., 2013). They can also exacerbate managerial myopia by aligning themselves with the short-term view of managers in targeting short-term gains (Kochhar and David, 1996).

A common categorization of institutional investors involves classifying them into pressure-resistant investors who do not hold any business relationship with the firm and pressure-sensitive investors who usually maintain business relationship with the firm (Ferreira and Matos, 2008; Connelly et al., 2010). In the context of emerging market firms, pressure-sensitive institutional investors consist of domestic investors such as banks, financial institutions, and insurance companies (Ramaswamy et al., 2002; Douma et al., 2006), who are linked to the firm as investors and through business transactions (Ferreira and Matos, 2008). On the other hand, the predominant categories of pressure-resistant institutional investors in emerging markets include investor groups such as foreign institutional investors and domestic mutual funds (Filatotchev et al., 2007; Alvarez et al., 2018). Owing to their unique attributes as international investors, foreign institutional investors are often considered a distinct entity in terms of their expertise, capabilities, and control (Huang and Zhu, 2015; Panicker et al., 2019). Hence, in this study, we separately consider foreign institutional investors and domestic mutual funds.

2.2. Pressure-sensitive institutional investors (PSII) and R&D investments

PSIIs such as banks and insurance companies have been identified as 'gray' or 'passive' institutional investors due to their business relationships with the invested firms (Douma et al., 2006; Ferreira and Matos, 2008; Connelly et al., 2010). However, PSIIs are not necessarily passive players in the institutional context of emerging markets such as India (Panicker et al., 2019), where owing to the relatively less developed capital markets, they are predominant sources of debt financing, providing capital for investments and growth of firms (Dwivedi and Jain, 2005). The resulting

dual relationship that PSIIs have with the firms, as both lenders and investors (Jiang et al., 2010; Chava et al., 2019), can alter the PSII behavior in different ways. First, in emerging economies, PSIIs often hold a nominated board seat in lieu of their lender relationship, giving them access to firm-level inside information and increasing their potential to actively monitor and influence strategic decisions in these firms (Byrd and Mizruchi, 2005; Chauhan et al., 2015). Second, their role as lenders will ensure that PSIIs have incentives to monitor firm's actions and through the board representation, they also have the potential to influence strategic resource allocations by the managers. Finally, complex and multiplex creditor–owner relationship between PSIIs and firms will escalate the cost of exit for PSIIs (Pan and Tian, 2015), resulting in a long-term relation between PSII and the firm. This ongoing relationship that PSIIs hold with firms can result in them being active participants in firm-level strategic decisions.

We also argue that PSIIs view long-term investments such as R&D in firms positively. Most PSIIs in emerging markets receive support from their respective governments as they often act as agents of social development (Khanna and Palepu, 1999; Douma et al., 2006). They are also governed under strong and well-developed regulations, ensuring protection of returns for invested capital for the investors (Kumbhakar and Sarkar, 2003; Bhatt, 2011). Further, owing to their status as trusted avenues for investments (Sahi et al., 2013; Arora and Marwaha, 2014), PSIIs such as banks and insurance firms in emerging markets face relatively less pressure for showing short-term gains from their portfolios.

Therefore, given that PSIIs face less pressure for short-term gains, have long term relation with firms and access to firm-level insider information, and actively participate in monitoring, we hypothesize the following:

> **Hypothesis 1** In emerging economy firms, ownership by PSIIs is positively associated with R&D investments.

2.3. *Pressure-resistant institutional investors and R&D investments*

2.3.1. Foreign institutional investors (FII)

FIIs are often identified as independent, pressure-resistant institutional investors who are active monitors, who voice their preferences through exit or investor activism (Gillan and Starks, 2003; Huang and Zhu, 2015). Owing to their expertise and information advantage (Dvořák, 2005; Shi and Li, 2023), FIIs motivate managers to invest in risky projects such as R&D that can potentially generate high returns in the longer term (Aghion et al., 2013). However, the behavior of FIIs can be influenced by the institutional environment, regulations, and governance mechanisms that exist in the host country (Lee, 2007; Johnson et al., 2010). We argue that FIIs prefer short-term gains over long-term high-risk investments such as those related to R&D in emerging markets for the following reasons. First, in emerging economies, despite the surge in FII inflows, the regulations governing the relationship of FIIs to firms are still emerging, giving significant power to controlling owners to interfere in the monitoring role of institutional investors including FIIs (Huang and Shiu, 2009; Chen et al., 2013). Hence, the threat of appropriation of gains by large controlling shareholders can make FIIs to focus on areas that provide immediate gains compared to R&D investments that generate returns in the long term (Kim et al., 2008). Second, emerging economy firms, compared to firms in developed economies, are relatively less experienced in R&D investments for innovative projects (Choi et al., 2011; Chen et al., 2014). Thus, the firm's lack of internal capability to manage R&D projects will add uncertainty on returns to FIIs. Hence, considering the uncertainty in returns from R&D investments due to institutional and firm-level factors we hypothesize the following:

> **Hypothesis 2** In emerging economy firms, ownership by FIIs is negatively associated with R&D investments.

2.3.2. Mutual fund institutional investors (MFIIs)

MFIIs are categories of domestic institutional investors, designed for liquidity and considered to be 'independent' institutional investors with a short-term focus in their portfolio investments (Borensztein and Gelos, 2003; Brossard et al., 2013). Due to this inherent organizational design, investors in MFIIs are entitled to redeem their shares at any point, and consequently, the performance of MFIIs and their managers are evaluated on a short-term (usually quarterly) basis (Chaganti et al., 1993). Therefore, MFIIs as professional fund managers face pressure from fund owners to showcase investment choices with higher returns in the short term (Douma et al., 2006; Agarwal et al., 2018). Hence, they can accentuate managerial myopia and route investments away from R&D projects. Moreover, MFIIs are dubbed as players with quick-entry-and-exit strategies and low commitment in firms, resulting in limited interest in risky

R&D investments that typically have a long payback period (Lee, 2007). Additionally, domestic MFIIs, unlike their international counterparts, are found to lack financial sophistication and skills in information technology (Fortin and Michelson, 2005), limiting their ability to assess or effectively monitor firm investments. Further, the inclination of MFIIs to lean toward market-based measures of performance also results in them selling off shares and exiting the firm in cases of poor short-term performance by firms, often resulting in ineffective monitoring (Douma et al., 2006; Muniandy et al., 2016).

In summary, we argue that MFIIs are investors focused on short-term turnover, who possess relatively lower levels of information advantage and expertise and can aggravate managerial myopia. Therefore, we hypothesize the following:

> **Hypothesis 3** In emerging economy firms, ownership by domestic MFIIs is negatively associated with R&D investments.

2.4. *Role of board interlocks in the institutional investors–R&D investments*

We further examine the impact that board interlocks can have on the preferences of institutional investors toward R&D investment. Given the heterogeneity among institutional investors and their increasing influence on board governance, including preferences for board characteristics such as composition and structure, board interlocks can act as an important board characteristic that defines how institutional investors affect firm outcomes including R&D investment. Literature on board interlocks has highlighted both the benefits and challenges that board interlocks bring to board governance and thereby to firm outcomes (Edacherian et al., 2023). Board interlocks can affect board governance by increasing social cohesion among directors to reduce independence, and interlocks can increase director busyness and lead to ineffective monitoring (Fich and White, 2005; Withers et al., 2012). In contrast, literature has also highlighted the potential relational capital interlocked director can bring to the firms (Hillman et al., 2009).

Institutional investors in general hold a diversified investment portfolio, making their interests and opportunities in acquiring firm-specific knowledge limited. Given this, these investors might rely more on-board interlocks, a key source of external knowledge for firms particularly in emerging economy context, to assess and influence firm R&D investment. Additionally, institutional owners have been observed to influence the selection of directors based on the director's capital (David et al., 2001; Westphal and Bednar, 2008), including relational capital determined by the board interlocking positions they hold. Hence, director interlocks can determine the institutional investors' nature of engagement with the board and in turn their influence on managerial myopia that determines R&D investments.

2.4.1. *Board interlocks and PSII–R&D investments relationship*

In the case of PSIIs which often hold the dual roles of creditor–owner in firms, we hypothesized a positive association between these owners and R&D investments. We argue that board interlocks will strengthen this positive relationship. PSIIs with their position in boards and effective business involvement with firms have access to firm-level inside information (Kroszner and Strahan, 2001). Since an interlocked board can ensure access to external resources as well, the board is then a source of both internal firm level information as well as relevant external information. Through their representation on the board, the PSIIs, consequently, can have access to both these sources of information, which will enable them to evaluate the R&D projects more effectively and holistically. While the risks involved in R&D investments is a challenge for any investor to support firm investment in this strategy, availability of information from internal as well as external sources will help PSIIs calibrate their perception of risk within firm investments (Sitkin and Pablo, 1992; Pablo et al., 1996). Further, with positions on boards PSII would be able to manage ineffective monitoring that could result from director busyness and social cohesion. Hence, we hypothesize the following:

> **Hypothesis 4** In emerging economy firms, board interlocks moderate the relationship between PSIIs and R&D investment in such a way that at higher levels of board interlocks, PSIIs are more positively related to R&D investments.

2.4.2. *Board interlocks and FIIs–R&D investments relationship*

The predicted negative relationship between FIIs and R&D investments is attributed primarily to institutional-level factors prevalent in emerging markets, such as relatively less-developed regulatory mechanisms supporting FII investments, concentrated firm-level ownership and potential expropriation and suspicions pertaining to the firm's capability to succeed in R&D activities. An interlocked board can help assuage some of these concerns.

Institutional voids and under-developed labor markets in emerging markets result in firms facing challenges relating to resource acquisition (Black and Khanna, 2007; Ayyagari et al., 2015). Therefore, emerging economy firms are highly dependent on board of directors as a critical source of external knowledge (Singh and Gaur, 2013) and this culminates in relational capital through director interlocks acting as a critical source of external resources to the firm (Khanna and Rivkin, 2001; Singh and Delios, 2017). Interlocks also facilitate information diffusion which is critical for these firms due to the environmental uncertainty and information asymmetry prevailing in emerging markets (Hillman et al., 2009; Khanna and Thomas, 2009). Therefore, interlocked boards will enhance the confidence of FIIs with regards to the capability of a firm to prudently invest in and derive benefits out of an R&D investment. In emerging economies, FIIs will therefore be more supportive of managerial decision to invest in R&D, when the board is well connected through interlocks.

It is to be noted that despite the information benefits provided by board interlocks, these can also result in 'board busyness' due to the membership of individuals in multiple boards, resulting in limited attention to their board duties (Ferris et al., 2003; Jackling and Johl, 2009). However, due to their experience in handling board independence and busy directors in multiple contexts (Miletkov et al., 2014; Ljungqvist and Raff, 2017), FIIs can transfer best practices and mitigate some of the challenges that arise due to director busyness. Therefore, on balance, FIIs as an investor group would be able to derive the best out of board interlocks as a resource provider, lowering the perception of risk that they attach to R&D investments in firms. Hence, we hypothesize the following:

> **Hypothesis 5** In emerging economy firms, board interlocks moderate the relationship between FIIs and R&D investment in such a way that at higher levels of board interlocks FIIs are less negatively related to R&D investments.

2.4.3. Board interlocks and MFII–R&D investments relationship

We posited that the lack of experience and short-term horizon for returns on investment among MFIIs result in a negative association between MFIIs and R&D investments. Unlike FIIs who are international players, MFIIs do not have the experience of engaging with firms in innovative, developed countries (Fortin and Michelson, 2005) and hence cannot decipher or take advantage of the external knowledge provided by board interlocks. Further, the ongoing pressure by fund owners to show gains by superior investment in the short term can often act as distraction for MFIIs and affect their monitoring effectiveness (Muniandy et al., 2016; Liu et al., 2020). Distracted MFIIs are less likely to handle the challenges faced by boards with interlocked directors who are excessively busy and probably compromise their independence. Given that busy directors are overly committed with several engagements, unless monitored effectively by institutional investors, they will not advise against managerial myopia to invest in R&D projects. Hence, we hypothesize the following:

> **Hypothesis 6** In emerging economy firms, board interlocks moderate the relationship between MFIIs and R&D investment in such a way that at higher levels of board interlocks MFIIs are more negatively related to R&D investments.

3. Data and methods

3.1. Empirical context

We test our hypotheses in the context of India, a country which is often classified as an emerging economy (Chari and David, 2012; Sahasranamam et al., 2020). India's gross expenditure on R&D has been consistently increasing, tripling between 2008 and 2018, and as of 2020, is at 0.86% (Department of Science and Technology, 2020). A key characteristic of ownership in India since the post-liberalization era of 1990s is the steady increase in shareholding by institutional investor groups (OECD, 2020). In Figure 1, we present the shareholding trends among different groups of institutional investors in Indian listed firms. We find that while PSIIs were the dominant categories of institutional investors in early 2000s, over the next two decades, FIIs have demonstrated their dominance in the Indian stock market.

Further, the underdeveloped labor markets and immature financial markets in India make interlocked directors' social capital a critical source to access external resources (Estrin and Prevezer, 2011; Singh and Delios, 2017). However, with regulatory efforts to strengthen the governance exercised by boards in India (Helmers et al., 2017), an increase in board interlocks can potentially challenge the overall efforts to increase effectiveness of boards. This tension between regulatory efforts and firm's needs to address resource scarcity makes India an ideal context to investigate the relationship between ownership structure, interlocks, and R&D investment.

3.2. Sample

The primary data source for this study is the Prowess database from the Centre for Monitoring

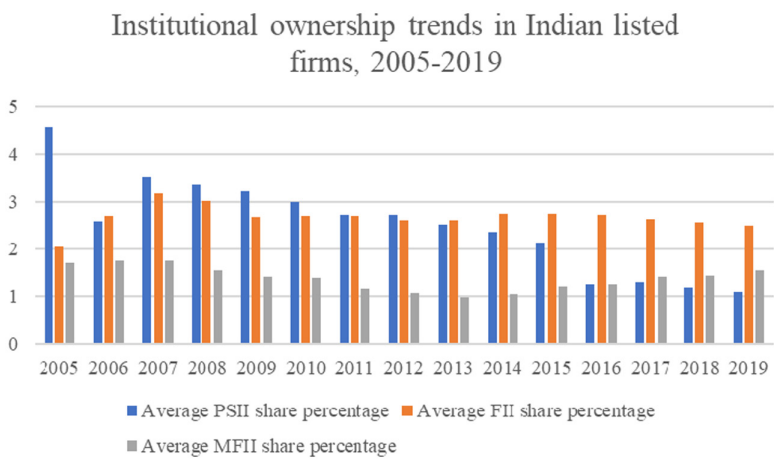

Figure 1. Ownership trends in institutional investment in listed Indian firms, 2005–2019. *Source*: Generated by the authors based on the data from CMIE Prowess database.

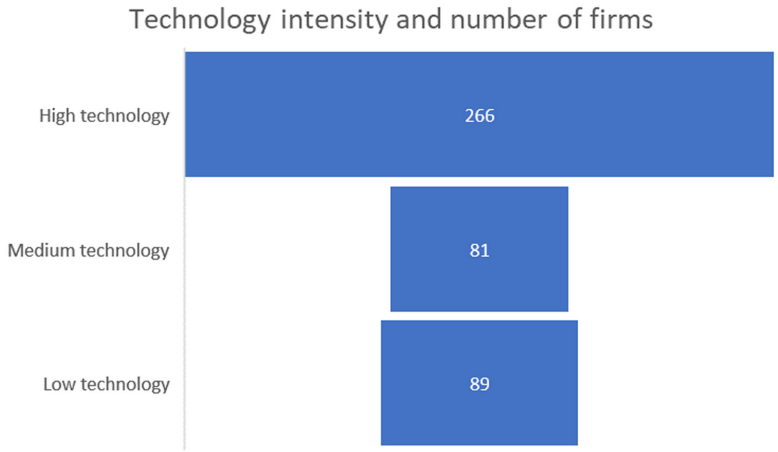

Figure 2. Technology intensity of firms in the sample.

of Indian Economy (CMIE), extensively used by studies that have been published in leading journals (Ashwin et al., 2015; Chittoor et al., 2009). Since Indian corporate governance reforms in 2005 ensured that the disclosures of firm level details are standardized (Afsharipour, 2011), we chose 2005 as the starting point of our sampling period. From the sample, we identified 436 firms for which the details of institutional investments, board interlock details and R&D investment details were available in one or more years of this time-period. After removing missing data and applying a one-year lag between the dependent and independent variables, we were left with a final sample of 2,478 firm-year observations from 436 unique firms between 2005 and 2019. To assess the technological intensity of industries to which our sample firms belong to, we apply the classification provided by OECD (Galindo-Rueda and Verger, 2016). For example, high technology industries include aircraft, computers, information technology, and pharmaceuticals, medium technology industries include rubber, plastics, basic metals, and ship construction, and low technology industries include food processing, textiles, clothing, insurance, and footwear. Based on this classification as presented in Figure 2, we identify that our sample has 266 high technology firms, 81 medium technology firms and 89 low technology firms.

3.3. Variables

3.3.1. Dependent variable

The primary dependent variable of this study is *R&D intensity*, which is measured as the ratio of R&D investment to total annual sales of the firm. R&D intensity is one of the most widely used measures in studies that investigate R&D investments in firms (Zhang et al., 2007; Liu et al., 2017; Xie et al., 2019).

3.3.2. Explanatory variables

Our primary explanatory variables are the share of ownership by different groups of institutional investors. As identified from the review of the literature, we examine three groups of institutional investors in this study, namely *PSII ownership, FII ownership, and MFII ownership*. We measured the percentage shares held by each of these ownership categories within the firm, since shareholding represents the participation and influence of different ownership groups (Bebchuk et al., 2017; Nofsinger et al., 2019). While the ownership by FIIs and MFIIs is reported as such in the CMIE database, we use the shareholding by banks, financial institutions, and insurance companies in firms as representative of PSII ownership (Panicker et al., 2019).

Next, we measure director interlocks as the degree of centrality, which is the total number of firms that the focal firm has interlocks with through the board of directors (Ruigrok et al., 2006). To adjust for board size of the firm, we refined the board interlocks measure by dividing the degree of centrality by total number of directors (Ortiz-de-Mandojana et al., 2012).

3.3.3. Control variables

From the extant literature, we identify several variables that could potentially impact our hypothesized relationships. The details of all these variables and the literature which supports their inclusion in our model are presented in Table 1.

3.4. Estimation technique

To examine the relation between ownership groups and R&D investments, we employ random-effects models by using the generalized least squares estimator. Hausman test statistic (P-value = 0.853) shows that our assumptions for random effects are not violated. Further, we also lagged all independent and control variables by one year to minimize potential

Table 1. Control variables, computation and reason for inclusion

Variable name	Reason for controlling	Variable computation
Family ownership	Influence the resource availability as well as the willingness of the firms to take risks influence R&D (Ashwin et al., 2015)	Percentage shareholding by family owners
Business group affiliation	Specialized organizational form which can influence resource availability (Purkayastha et al., 2018)	Dummy variable, value = 1 if a firm is group affiliated, 0 otherwise
Board size	Ineffective monitoring and the lack of cohesiveness of larger board impacts R&D (Kor, 2006)	Total number of directors on the board
Board independence	Offer expertise, reputation, experience and networks, supporting R&D (Kor, 2006)	Number of independent directors as a ratio of board size
CEO duality	Promote R&D investments by enabling better decision making and monitoring (Chen and Hsu, 2009)	Dummy variable, value = 1 if CEO and Chairperson is the same person, 0 otherwise
Advertising intensity	Asset of the firm that reflect consumer orientation and influence R&D (Golovko and Valentini, 2011)	Total advertising investments as a ratio of total sales
Exports sales ratio	Improve demands, learning and knowledge base and promote R&D investments (Purkayastha et al., 2018)	Total exports as a ratio of total sales
Debt to equity ratio	Capital structure of the firms affects managerial choice and investment discretion (Munari et al., 2010)	Ratio of total debts to total equity
Firm size	Influence competencies in firms, impacting R&D (Lee and Sung, 2005)	Total assets of the firm
Firm age	Younger firms are found to invest more in R&D (Coad et al., 2016)	Age of the firm since inception
Profitability	Higher profitability encourages R&D (Geroski et al., 1993)	Return on assets (ratio of net profits to total assets)
Industry code	Controlling the industry level impact on R&D investments	2-digit NIC code representing the primary activity of the firm
Industry munificence	Resource availability and its abundance in industry environment, which can influence firm R&D (Dess and Beard, 1984)	Regression coefficient of time on annual industry sales average divided by the mean value of sales
Industry dynamism	Instability and volatility of the environment which can influence R&D investments (Dess and Beard, 1984)	Standard deviation on industry sales over years
Year of R&D	Incorporate the temporal disparities in macro-economic variations	Year in which the R&D investment was made

endogeneity (Greene, 2010). All the models with moderators include mean-centered independent variables, for ease of interpretation (Aiken et al., 1991).

4. Results

The descriptive statistics and correlation matrix are presented in Table 2. To address potential concerns of multicollinearity, we computed variance inflation factors (VIF) of all our variables and find that the average VIF is 1.23 and none of the variables had a VIF greater than 1.5, both of which are well below the most conservative threshold values of 4 (O'brien, 2007). Further, we find from Table 2 that firm size and profitability have high standard deviation; therefore, we use the logarithms of these variables in our models.

Table 3 presents the outcomes of random-effects panel estimation regression. The models are tested hierarchically, with the initial models estimating direct results and the interactions being added one by one. In all cases, we have estimated and reported robust standard errors. We also control for 2-digit industry codes and year effects in all our estimations.

In hypotheses 1, we predicted that ownership by PSIIs is positively related to R&D investments. From Table 3, model 1, contrary to our assumptions, we find this relation to be insignificant ($\beta = 0.005$, $P = 0.804$). Therefore, hypothesis 1 is not supported. From Table 3, model 1, we find that ownership by FIIs ($\beta = -0.008$, $P = 0.032$) and MFIIs ($\beta = -0.043$, $P = 0.000$) is negatively and significantly related to R&D investments in firms. Therefore, we find support for hypotheses 2 and 3.

As seen in Table 3, the direct effect of our moderator, board interlocks, on R&D investment is negative across models. As discussed in hypotheses development section, literature has documented both positive and negative effects of board interlocks; however, in our context, we find that the effect of board interlocks on R&D investments in firms is consistently negative. For our study, in hypotheses 4 to 6, we predicted the moderating effect of board interlocks on the relationship between ownership by various groups of institutional investors and R&D investments. Hypothesis 4 gets support from results in model 2 in Table 3, which shows that board interlocks have a positive moderating effect on the PSII ownership–R&D investment relationship ($\beta = 0.012$, $P = 0.012$). Further, the results in model 3 of Table 3 show that the moderating effect of board interlocks on FII ownership–R&D investment relationship is positive and significant ($\beta = 0.004$, $P = 0.047$), thereby supporting hypothesis 5. Finally, from model 4 in Table 3, we find that board interlocks have a negative and significant moderating effect on the MFII ownership–R&D investment relationship ($\beta = -0.004$, $P = 0.026$), thus supporting hypothesis 6.

We also use the marginal effects approach to interpreting how a main effect is informed by the presence of a moderating variable (Busenbark et al., 2022). We use the *margins and marginsplot* commands in Stata for making predictions and plotting the relationships visually. We use the values of board interlocks at different percentiles (0, 25, 50, 75, and 90th percentiles) to represent different ranges of board interlocks in firms.

We illustrate in Figure 3 that the relationship between PSII and R&D investments in firms is positive and statistically significant when board interlocks is 0 (hence the significant coefficient for interaction in Table 3, model 2) and that this relationship is statistically significant after the average board interlocks reaches about 2.5. The marginal effects in Figure 3 also demonstrate that the relationship between PSII ownership and R&D investments clearly increases as board interlocks increases. Next, we illustrate in Figure 4 that the relationship between FII and R&D investments in firms is statistically significant and positive until the average board interlocks reaches about 4.5. Finally, we illustrate in Figure 5 that the relationship between MFII and R&D investments in firms is statistically significant and negative after the average board interlocks reaches about 0.5.

4.1. Tests of endogeneity

Our main models can have potential concerns of endogeneity, including ones related to sample selection bias, simultaneity bias and omitted variable bias. Sample selection bias may occur when values of a study's dependent variable are missing because of another process (Sartori, 2003). In our case, this could result in selecting a sample of only those firms which have a greater propensity to have a more interlocked board, resulting in a non-random sample and a possibly biased estimation (Aghion et al., 2013). The estimation, therefore, requires a two-step procedure, where the first stage determines whether an observation in an overall population appears in the final representative sample and the step two consists of modeling the relation between the dependent and independent variables of the final sample (Wooldridge, 2010; Certo et al., 2016). Therefore, we apply the Heckman model, a two-step process (Heckman, 1976), in which the first stage uses a Probit model to analyze the determinants of interlocked directors with

Table 2. Descriptive statistics and correlation matrix

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1. R&D intensity	4.15	121.23	1										
2. PSII ownership	1.69	4.95	0.007	1									
3. FII ownership	2.67	6.65	0.011	−0.04*	1								
4. MFII Ownership	1.36	3.59	0.006	−0.04*	0.42*	1							
5. Interlocks	2.46	2.26	−0.019	−0.03*	0.28*	0.24*	1						
6. Family ownership	24.96	23.80	−0.016	−0.08*	−0.14*	−0.10*	−0.22*	1					
7. Board size	6.98	3.69	−0.03*	−0.06*	0.32*	0.27*	0.42*	−0.09*	1				
8. Board independence	0.28	0.25	0.004	−0.02*	0.07*	0.05*	0.43*	−0.06*	0.42*	1			
9. Advertising intensity	0.04	0.98	0.44*	−0.006	0.011	0.004	−0.006	0.004	−0.012	−0.011	1		
10. Export sales ratio	9.49	33.82	0.06*	−0.004	−0.002	−0.002	0.053*	0.002	0.007	0.005	0.01*	1	
11. Debt equity ratio	6.03	286.79	−0.002	0.04*	−0.01*	−0.01*	−0.007	−0.01*	−0.01*	−0.01*	0.003	−0.0002	1
12. Firm size	127.59	1,116.1	0.03*	0.006	0.23*	0.10*	0.11*	−0.09*	0.17*	0.05*	−0.001	0.0001	0.0003
13. Firm age	24.09	27.55	−0.03*	−0.006	0.04*	0.10*	0.18*	−0.11*	0.21*	0.16*	−0.007	0.003	−0.01*
14. Profitability	−289.6	20,764	−0.19*	−0.02*	0.004	−0.01*	0.004	0.009	0.007	0.003	−0.07*	0.0001	0.0001
15. Industry munificence	−4.48	60.35	0.016	−0.010	0.01*	0.003	0.06*	−0.01*	0.03*	0.11*	0.002	0.003	−0.004
16. Industry dynamism	0.53	3.09	0.005	−0.006	0.02*	0.02*	−0.01*	−0.007	0.001	−0.04*	−0.002	−0.001	0.002

	12	13	14	15	16
12. Firm size	1				
13. Firm age	0.04*	1			
14. Profitability	0.001	0.003	1		
15. Industry munificence	−0.01*	0.02*	0.001	1	
16. Industry dynamism	0.14*	−0.01*	−0.001	−0.43*	11

*Correlation is significant at the 0.05 level (2-tailed).

Table 3. Results of random effects GLS regression estimation of the relation between institutional investors, board interlocks and R&D investments

	Model 1			Model 2			Model 3			Model 4			Model 5		
	β-value	SD	***P***-value	***β***-value	SD	***P***-value	***β***-value	SD	***P***-value	***β***-value	SD	***P***-value	***β***-Value	SD	***P***-value
PSII ownership	0.005	0.019	0.804	−0.007	0.021	0.730	0.005	0.019	0.785	0.005	0.019	0.799	0.007	0.021	0.740
FII ownership	−0.008	0.009	0.032	−0.008	0.009	0.033	−0.019	0.010	0.072	−0.008	0.009	0.040	−0.022	0.011	0.037
MFII ownership	−0.043	0.012	0.000	−0.043	0.012	0.000	−0.043	0.012	0.000	−0.034	0.015	0.020	−0.029	0.015	0.053
Board interlocks	−0.133	0.029	0.000	−0.122	0.030	0.000	−0.172	0.036	0.000	−0.118	0.033	0.000	−0.144	0.039	0.000
Family ownership	0.006	0.005	0.019	0.006	0.005	0.019	0.006	0.005	0.012	0.006	0.005	0.015	0.006	0.005	0.210
Board size	−0.017	0.022	0.426	−0.017	0.022	0.422	−0.016	0.022	0.451	−0.018	0.022	0.394	−0.018	0.022	0.398
Board ind	−0.007	0.380	0.986	0.000	0.380	0.999	0.009	0.381	0.982	0.012	0.381	0.976	0.046	0.381	0.904
CEO duality	−0.019	0.142	0.895	−0.021	0.142	0.885	−0.041	0.143	0.774	−0.024	0.142	0.867	−0.055	0.143	0.699
BG affiliation	−0.524	0.337	0.119	−0.524	0.337	0.120	−0.525	0.333	0.115	−0.523	0.336	0.119	−0.520	0.334	0.119
Advertising int	0.073	0.040	0.069	0.074	0.040	0.068	0.069	0.041	0.088	0.073	0.040	0.071	6.789	4.066	0.095
Export sales ratio	0.003	0.003	0.313	0.003	0.003	0.308	0.003	0.003	0.317	0.003	0.003	0.346	0.003	0.003	0.373
Debt equity ratio	0.000	0.004	0.896	−0.001	0.004	0.861	0.000	0.004	0.908	0.000	0.004	0.890	−0.001	0.004	0.862
Firm size	0.267	0.101	0.008	0.270	0.101	0.007	0.281	0.101	0.005	0.265	0.101	0.008	0.286	0.101	0.004
Firm age	−0.008	0.007	0.270	−0.008	0.007	0.266	−0.008	0.007	0.296	−0.008	0.007	0.260	−0.008	0.007	0.284
Profitability	0.039	0.032	0.220	0.041	0.032	0.199	0.041	0.032	0.205	0.039	0.032	0.225	0.042	0.032	0.189
Ind munificence	−0.002	0.005	0.969	−0.002	0.005	0.974	−0.001	0.005	0.985	−0.002	0.005	0.963	0.000	0.000	0.982
Ind dynamism	−0.004	0.037	0.924	−0.003	0.037	0.928	−0.002	0.037	0.950	−0.004	0.037	0.914	−0.003	0.037	0.944
PSII × Interlocks				0.012	0.009	0.012							0.005	0.002	0.030
FII × Interlocks							0.004	0.002	0.047				0.007	0.004	0.011
MFII × Interlocks										−0.004	0.004	0.026	−0.012	0.009	0.019
F-value	147.55		0.000	148.94		0.000	152.51		0.000	148.99		0.000	156.31		0.000
R squared	20.4			21.3			22.1			21.2			21.8		
N	2,478			2,478			2,478			2,478			2,478		

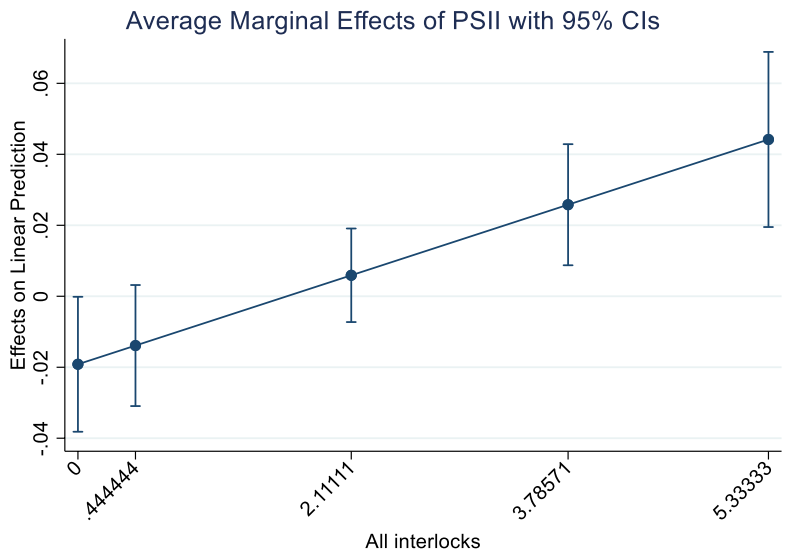

Figure 3. Marginal effect of board interlocks on the relationship between PSIIs and R&D investment.

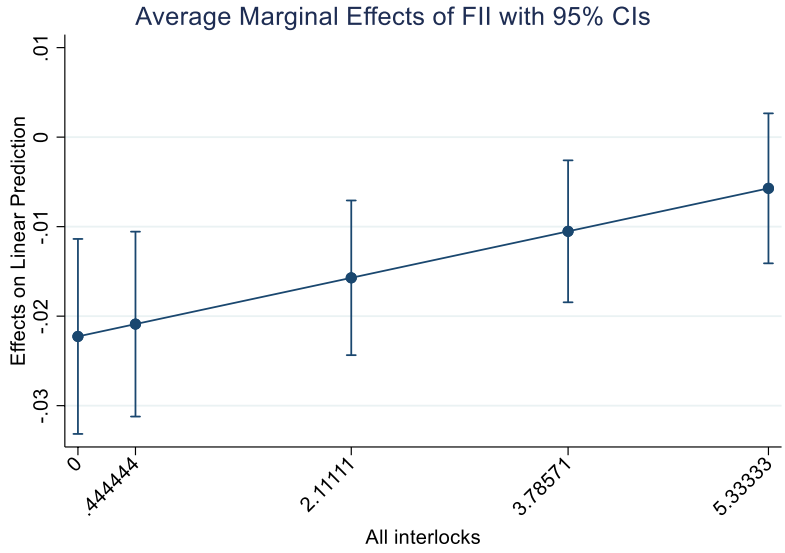

Figure 4. Marginal effect of board interlocks on the relationship between FIIs and R&D investment.

all the dependent variables of our main study as explanatory variables. The non-selection hazard (i.e., the inverse Mills ratio) generated by the first stage selection model was then included in the second-stage regressions to address potential sample selection biases. The results of this two-stage model, presented in Table 4, are aligned with the main findings, suggesting that our estimation was not biased due to selection issues.

Next, we test for simultaneity bias that refers to cases where the regressors could be correlated with error terms, resulting in incorrect estimations. To test for this source of endogeneity, we employed Durbin–Wu–Hausman test (Durbin, 1954; Wu, 1973; Hausman, 1978). In line with the standard practice, we instrumented different types of institutional ownership with their lagged variables (Gujarati et al., 2012). We predicted the residuals of the first stage and included them in the second-stage model. We performed exclusion restriction tests to examine the validity – the instrument does not relate to the dependent variable except through endogenous variable of interest – of the instruments (Semadeni et al., 2014). We find that the *P*-values for all our ownership variables were insignificant, confirming the exogeneity of our instruments (*P*-values are 0.247, 0.492 and 0.558 respectively for PSII, FII and MFII). Next, we compared the coefficients of the original model and the two-stage models.

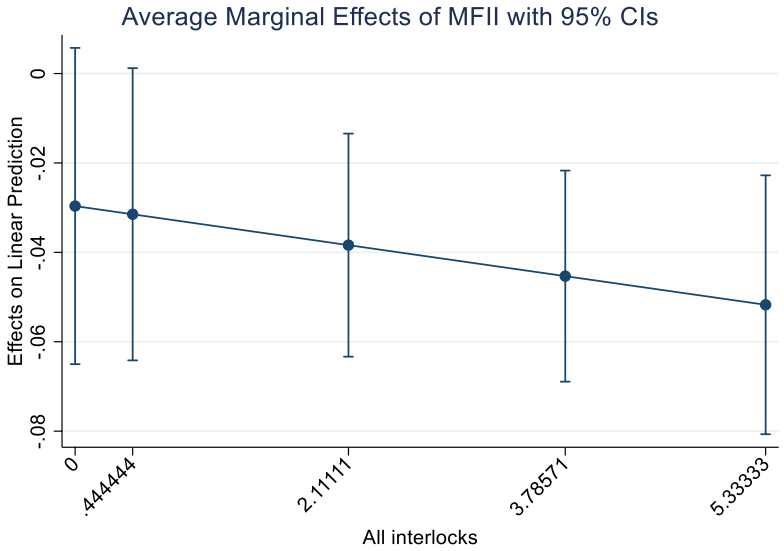

Figure 5. Marginal effect of board interlocks on the relationship between MFIIs and R&D investment.

The results of Durbin–Wu–Hausman test demonstrates that the variable for FII ownership is endogenous (Prob > F=0.002), while the other two ownership variables, MFII and PSII (Prob > F=0.105 and 0.665), are not endogenous. Subsequently, we performed two-stage model estimation with residuals (Crossland et al., 2014), and the results of second stage of the two-stage models with FII agree with our main results (Table 5).

The next potential source of endogeneity in our model relates to omitted variable bias, where the non-inclusion of some variables in a model might result in biased coefficient estimations (Certo et al., 2016). We test the robustness of our results against potential omitted variable bias through the Coefficient Stability Approach (Oster, 2019). The test is performed with the assumption that the relationship between the treatment and unobservable elements in a model can be captured through the association between the treatment and observable components (Mavis et al., 2020). To perform this test, we first run two regressions, one with only the dependent and independent variables and the other being a full model including all the controls. Therefore, incorporating omitted variables in the model may lead to a maximum R-squared (R_{max}) assumed to be equal to 1.3 times the estimated R-squared with controls (Oster, 2019). Next, β coefficients are estimated with assumed values of δ=1 (δ being the relative degree of selection on observed and unobserved variables) and if this bias-adjusted β are in line with our original outcomes, then omitted variable bias has not impacted our results. Further, we calculate δ when β=0 for the computed R_{max}. For any value of δ>1, the model is confirmed to be free of omitted variable bias. A negative value of δ, while being uninformative, also indicates that the addition of chontrols has strengthened the original model and the inclusion of further variables would not probably alter the results (Gorodnichenko and Weber, 2016). In the case of all our models with explanatory variables and interactions, we find that the value of δ at β=0 and R_{max} are either less than 0 or greater than 1. We also find that the estimated adjusted β aligns with the β values from the full model with controls. Our results of test for omitted variable bias in Table 6 offer evidence to the extent that our model does not suffer from omitted variable bias. Notably, fixed-effects models of estimation are also more effective in managing omitted variable bias, and therefore, the outcomes of fixed-effects estimation, fixed at year and firm level, are presented in Table 7.

4.2. Additional tests

In addition to these, we perform a set of additional tests to ensure the robustness of our findings and to have a more nuanced understanding of the various relationships. Due to space constraints, the details of these tests are presented in the supplementary material.

5. Discussion

Given the abundant evidence that institutional investors and boards of directors are both critical mechanisms of a firm's governance (Connelly et al., 2010; Federo et al., 2020), the lack of

Table 4. Result of second stage of Heckman 2-stage analysis, with inverse mills ratio included as an independent variable

	Model 1			Model 2			Model 3			Model 4			Model 5		
	β-value	SD	***P***-value	***β***-value	SD	***P***-value	***β***-value	SD	***P***-value	***β***-value	SD	***P***-value	***β***-Value	SD	***P***-value
PSII ownership	0.003	0.019	0.865	0.009	0.021	0.679	0.004	0.019	0.832	0.003	0.019	0.856	0.008	0.021	0.703
FII ownership	–0.005	0.008	0.047	–0.005	0.008	0.525	–0.014	0.010	0.169	–0.005	0.008	0.531	–0.017	0.010	0.098
MFII ownership	–0.042	0.012	0.000	–0.043	0.012	0.000	–0.042	0.012	0.000	–0.034	0.015	0.022	–0.029	0.015	0.054
Board interlocks	–0.121	0.028	0.000	–0.110	0.029	0.000	–0.153	0.035	0.000	–0.106	0.032	0.001	–0.125	0.038	0.001
Family ownership	0.006	0.005	0.253	0.006	0.005	0.255	0.006	0.005	0.271	0.006	0.005	0.258	0.005	0.005	0.284
Board size	–0.025	0.021	0.221	–0.025	0.021	0.218	–0.024	0.021	0.235	–0.026	0.021	0.207	–0.026	0.021	0.212
Board ind	0.073	0.389	0.851	0.082	0.389	0.833	0.075	0.389	0.847	0.094	0.390	0.809	0.118	0.390	0.762
CEO duality	0.055	0.142	0.698	0.053	0.142	0.710	0.038	0.143	0.792	0.050	0.142	0.725	0.023	0.143	0.873
BG affiliation	–0.239	0.320	0.455	–0.235	0.320	0.463	–0.246	0.318	0.440	–0.241	0.320	0.452	–0.246	0.318	0.440
Advertising int	8.329	4.007	0.038	8.350	4.007	0.037	7.967	4.007	0.047	8.269	4.007	0.039	7.801	4.010	0.052
Export sales ratio	0.005	0.003	0.056	0.005	0.003	0.055	0.005	0.003	0.058	0.005	0.003	0.068	0.005	0.003	0.078
Debt equity ratio	–0.001	0.004	0.861	–0.001	0.004	0.825	–0.001	0.004	0.873	–0.001	0.004	0.854	–0.001	0.004	0.826
Firm size	0.227	0.097	0.019	0.231	0.097	0.017	0.233	0.097	0.016	0.229	0.097	0.018	0.242	0.097	0.012
Firm age	–0.021	0.006	0.001	–0.021	0.006	0.001	–0.021	0.006	0.001	–0.021	0.006	0.001	–0.021	0.006	0.001
Profitability	0.045	0.030	0.132	0.046	0.030	0.119	0.047	0.030	0.119	0.045	0.030	0.129	0.049	0.030	0.100
Ind munificence	0.001	0.005	0.837	0.001	0.005	0.835	0.001	0.005	0.820	0.001	0.005	0.849	0.001	0.005	0.830
Ind dynamism	–0.015	0.028	0.593	–0.015	0.028	0.597	–0.015	0.028	0.603	–0.015	0.028	0.589	–0.015	0.028	0.605
Inverse mills ratio	0.264	1.505	0.861	0.294	1.505	0.845	0.164	1.502	0.913	0.399	1.511	0.792	0.389	1.509	0.797
PSII × Interlocks															
FII × Interlocks				0.011	0.009	0.022							0.004	0.002	0.059
MFII × Interlocks							0.003	0.002	0.013				0.006	0.004	0.014
										–0.004	0.004	0.042	–0.012	0.009	0.020
F-value	62.26			64.82			63.16			63.76			68.47		
R squared	41.9			40.8			40.1			41.6			46.1		
N	2,478			2,478			2,478			2,478			2,478		

Table 5. Results of stage 2 estimation with residuals of FII

	Model 1			Model 2		
	β-value	SD	***P***-value	***β***-value	SD	***P***-value
PSII ownership	0.019	0.021	0.363	0.013	0.024	0.596
FII ownership	−0.017	0.014	0.018	−0.042	0.016	0.007
FII residual	−0.048	0.015	0.001	−0.047	0.015	0.002
MFII ownership	−0.042	0.013	0.002	−0.045	0.017	0.008
Board Interlocks	−0.089	0.033	0.007	−0.240	0.055	0.000
Family ownership	0.010	0.005	0.051	0.003	0.006	0.029
Board size	−0.029	0.024	0.217	−0.027	0.024	0.250
Board independence	−0.592	0.464	0.202	−0.517	0.464	0.266
CEO Duality	−0.168	0.163	0.302	−0.185	0.163	0.258
BG Affiliation	−0.690	0.332	0.037	−0.650	0.331	0.050
Advertising intensity	0.104	0.045	0.015	0.109	0.045	0.016
Export sales ratio	−0.011	0.003	0.001	−0.011	0.003	0.000
Debt equity ratio	−0.001	0.005	0.784	−0.001	0.005	0.812
Firm size	0.248	0.113	0.028	0.273	0.113	0.016
Firm age	−0.012	0.007	0.083	−0.012	0.007	0.091
Profitability	0.033	0.037	0.369	0.033	0.037	0.378
Industry munificence	0.001	0.001	0.790	0.002	0.001	0.969
Industry dynamism	0.001	0.016	0.936	0.003	0.016	0.842
PSII × Interlocks				0.007	0.009	0.046
FII × Interlocks				0.009	0.003	0.001
MFII × Interlocks				−0.002	0.005	0.041
Chi-squared	196.79		0.000	213.55		0.000
R squared	20.85			21.79		
N	1,951			1,951		

Table 6. Outcomes of coefficient stability approach

Variable	***β*** with controls	Estimated adjusted ***β***	***δ*** for ***β*** = 0, given $\boldsymbol{R}_{max}$ [a]	Reject H_0 [b]
PSII	0.003	0.009	6.752	Yes
FII	−0.005	−0.011	−55.26	Yes
MFII	−0.042	−0.044	13.11	Yes
PSII × Interlock	0.011	0.01	2.9	Yes
FII × Interlock	0.003	0.012	−1.07	Yes
MFII × Interlock	−0.004	−0.008	18.87	Yes

[a] R_{max} is 1.3 times the R^2 of the model with all controls.
[b] H_0 = Omitted variables bias the results of estimation.

adequate research to understand how these interact with each other to influence firm outcomes is a surprising void in extant literature. We remedy this omission in dynamically changing landscape of institutional ownership in firms, which suggest the potential variability in institutional investors' preferences and their interaction the board (Johnson et al., 2010; Oehmichen et al., 2021). We study the institutional ownership pattern and its impact on R&D investment in a sample of Indian firms between 2005 and 2019 and find that the type of institutional investors determines the nature of their relationship with the firm and the subsequent preference for R&D investments. Further, board interlocks moderate this relationship differently across groups of institutional investors. These findings have several theoretical and empirical implications for research on firm governance and institutional ownership in the context of emerging economies.

Table 7. Results of fixed-effects OLS estimation

	Model 1			Model 2			Model 3			Model 4			Model 5		
	β-value	SD	***P***-value	***β***-value	SD	***P***-value	***β***-Value	SD	***P***-value	***β***-Value	SD	***P***-value	***β***-Value	SD	***P***-value
PSII ownership	0.011	0.020	0.569	−0.002	0.022	0.931	0.012	0.020	0.539	0.012	0.020	0.565	−0.001	0.022	0.953
FII ownership	−0.011	0.009	0.049	−0.011	0.009	0.027	−0.019	0.011	0.090	−0.011	0.009	0.027	−0.026	0.011	0.024
MFII ownership	−0.046	0.013	0.000	−0.046	0.013	0.000	−0.047	0.013	0.000	−0.034	0.016	0.030	−0.032	0.016	0.044
Board interlocks	−0.154	0.031	0.000	−0.141	0.033	0.000	−0.185	0.039	0.000	−0.131	0.035	0.000	−0.216	0.053	0.000
Family ownership	0.011	0.006	0.001	0.011	0.006	0.001	0.010	0.006	0.012	0.011	0.006	0.099	0.004	0.007	0.026
Board size	−0.013	0.023	0.592	−0.012	0.023	0.593	−0.012	0.023	0.621	−0.014	0.023	0.552	−0.012	0.023	0.596
Board ind	−0.191	0.396	0.630	−0.185	0.396	0.640	−0.180	0.396	0.650	−0.167	0.396	0.674	−0.114	0.396	0.774
CEO duality	0.023	0.158	0.882	0.019	0.158	0.904	0.007	0.158	0.962	0.014	0.158	0.929	−0.002	0.158	0.988
Advertising int	0.064	0.049	0.197	0.063	0.049	0.200	0.059	0.049	0.235	0.063	0.049	0.200	0.057	0.049	0.243
Export sales ratio	0.002	0.003	0.622	0.002	0.003	0.606	0.001	0.003	0.648	0.001	0.003	0.694	0.001	0.003	0.854
Debt equity ratio	−0.001	0.004	0.884	−0.001	0.004	0.845	0.000	0.004	0.893	−0.001	0.004	0.874	−0.001	0.004	0.853
Firm size	0.444	0.156	0.004	0.448	0.156	0.004	0.452	0.156	0.004	0.450	0.156	0.004	0.456	0.156	0.003
Firm age	−0.029	0.106	0.781	−0.029	0.106	0.782	−0.029	0.106	0.782	−0.030	0.106	0.777	−0.021	0.105	0.844
Profitability	0.035	0.032	0.274	0.038	0.032	0.245	0.036	0.032	0.263	0.035	0.032	0.280	0.037	0.032	0.259
Ind munificence	0.004	0.001	0.981	0.003	0.001	0.978	0.007	0.001	0.970	0.001	0.001	0.994	0.005	0.001	0.868
Ind dynamism	−0.003	0.037	0.946	−0.002	0.037	0.950	−0.002	0.037	0.967	−0.003	0.037	0.931	0.000	0.037	0.999
PSII × Interlocks				0.013	0.010	0.066							0.016	0.010	0.097
FII × Interlocks							0.003	0.002	0.019				0.005	0.002	0.033
MFII × Interlocks										−0.006	0.004	0.017	−0.007	0.005	0.014
F-value	26.2			26.3			26.5			26.3			26.8		
R squared	16.2			16.8			18			16.1			17.8		
N	2,478			2,478			2,478			2,478			2,478		

A central tenet of our research is the dynamics of interaction between institutional investors and board interlocks as a determinant of institutional investor preference toward risky strategies such as R&D investments. Prior literature on the role that board characteristics play in the relationship between institutional investors and firm outcomes pertain predominantly to the monitoring function of the board and board involvement in the strategy (Federo et al., 2020). Institutional investors have been found to affect board monitoring functions by influencing board characteristics and outcomes such as board independence, executive compensation, CEO duality and board committee composition (Pucheta-Martínez and García-Meca, 2014; Schnatterly and Johnson, 2014). Notably, most research on institutional investors and their impact on R&D investment, draw their arguments from agency theory to highlight the monitoring role of institutional investors in influencing managerial actions such as R&D investment (Boyd and Solarino, 2016), while overlooking the impact of resource provisioning function of board on institutional investor preferences. To address this, we considered the moderating effect of board interlocks, a major source of external resources for firms (Boyd, 1990; Peng, 2002; Hillman and Dalziel, 2003), in the relationship between institutional ownership and R&D investments. Given the strong need for firm-specific information to evaluate the need for R&D investments (Dalziel et al., 2011), existing arguments on monitoring from agency theory do not fully explain how institutional investors influence managerial decisions to invest in R&D. Thus, by examining institutional investors in conjunction with board interlocks specifically for emerging markets, we capture a more granular view of how institutional investors depend on the director's relational capital to influence managers to make strategic decisions on R&D investment. By examining board interlocks and institutional investors – two critical components of firm's governance – together, we complement the arguments drawn from institutional agency theory to explain the monitoring role of institutional investors with perspectives advocated by resource dependence theory (Hillman et al., 2009) on relational capital brought in by board interlocks. Our results also demonstrate that different types of institutional investors vary in their interaction with board interlocks to affect R&D investment by firms.

Second, our findings contribute to research on institutional investors' role in R&D investment in the context of emerging economy firms. Given that most of the research on institutional investors has been conducted in the context of developed economies such as the United States, the findings of this large body of literature may not have potential implications in emerging economies. Indeed, firms in emerging economies witness additional agency problems due to concentrated ownership, hence the behavior of individual institutional investors can vary in this context (Chen et al., 2014). For instance, Rong et al. (2017) showed that institutional investors such as mutual funds are positively related to innovation in Chinese firms. In contrast, our results from the Indian context show that both FIIs and MFIIs are negatively related to R&D investments. Such contrasting findings demonstrate that even among emerging economies, there can be heterogeneity, an observation that underscores the relevance of institutions and institutional environments in firm decisions. In the context of Indian firms, we also estimate the moderating effect of board interlocks, which has contextual relevance in emerging economies because interlocked directors and the external resources they bring to boards can be prone to managerial entrenchment and expropriation in emerging economies.

5.1. Policy and managerial implications

At a policy level, our study highlights the need for a strong legal framework in emerging economies to provide confidence and protection to FIIs to enable them to have a long-term focus in their portfolio. Emerging economies are yet to reach a mature legal system that enables FIIs to maintain long-term time horizons for their investments, making them less interested in investing in risky projects such as R&D. Our study also has managerial implications for firm governance. For managers, our study prescribes an ideal combination of the level of director interlocks depending on the identity of the prominent shareholders of the firm to R&D investments in firms. For instance, we find that in a firm with PSII as the dominant shareholder, the ideal level of board interlocks would be over 2.5, for this investor to tap the benefits of interlocks. Similarly, for a firm with FII as the dominant shareholder, we recommend the average board interlocks to be under 5, before the busyness effects of interlocks set in. If a firm with MFII as a majority shareholder, it is prudent for the firm to maintain a low level of average board interlocks (less than 0.5).

5.2. Limitations and future research

Notwithstanding the relevance and timeliness of our study, it still has limitations that provide scope for future research. First, in our analysis, we did not differentiate the board interlocks depending on the nature of ties, type of industry or firms connected, and the connection of different firms through the

same institutional investor. Future research could extend our analysis to further explore the various dimensions of board interlocks and the connections of firms. Another interesting avenue for research would be to understand the implications institutional investors have for the outcome of innovation such as patents and new product introductions. The involvement of managers in innovation outcomes might vary compared to their interest in R&D investment and thus the engagement of institutional investors. We theorize the impact of PSII on firm R&D outcomes as a culmination of their dual relationship with firm, specifically as lenders and investors; however, the unavailability of data prevents us from establishing which of these two is their dominant characteristics, and this is a limitation of our study. Finally, as observed by previous research, there can exist a difference in institutional investors' behavior across various emerging economies as explained above through the contrasting findings of Rong et al. (2017) and those from this study. Researchers should investigate institutional investor behavior in different contexts for more generalizable findings.

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Conflict of interest statement

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Saneesh Edacherian is an Assistant Professor in Strategy and International Business at the University of Birmingham Dubai, United Arab Emirates. He earned his PhD in Strategic Management from the Indian Institute of Management Ahmedabad, India. His research explores how strategic leadership groups shape strategic outcomes such as innovation and internationalization. His emerging interests lie in extending the scholarly conversation and offering practitioner

insights into corporate governance and responsible business practices. Saneesh's publications include articles in outlets such as International Business Review, Corporate Governance: An International Review and the Journal of Business Research.

Vidya Sukumara Panicker is a Senior Lecturer in International Business, in Loughborough Business School, United Kingdom. Her core research areas include emerging markets, corporate governance, and international business. Her research has been published in journals such as Journal of World Business, International Business Review, Journal of Business Research, Cross Cultural and Strategic Management and Journal of Management and Governance.

Amon Chizema is Professor of International Business and Corporate Governance in Loughborough Business School, United Kingdom. Amon's research explores international corporate governance issues including the impact of corporate governance on internationalization, corporate governance mechanisms and their impact on firm strategic choices, executive compensation, adoption and diffusion of governance practices across countries and dynamics of the board of directors. His research has been published in leading journals such as the Strategic Management Journal, Journal of Management Studies, The Leadership Quarterly, Journal of World Business, Review of Quantitative Finance and Accounting and Corporate Governance: An International Review.

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