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Impact of prestigious-STEM Education of corporate board members on innovation effort: Evidence from India

Rituparna Kaushik[*], Sourabh Bikas Paul[†], Danilo Spinola[‡]

Abstract

This article studies the innovation effort in India through the education of corporate board members obtained from prestigious STEM higher education institutes known as the Indian Institute of Technology (IITs). Our primary aim is to enquire whether firms with director/s having an IIT-Bachelors' degree in their corporate boards positively impact the firm's innovation effort. To answer this question, we build a novel dataset merging two micro-level databases: CMIE-Prowess (firm innovation) and NSE-Infobase (board of directors' characteristics). Based on the sample of 6151 Indian firms for 2006-2015, we find that overall, having board members with IIT-Bachelor's qualifications do enhance innovation efforts to some extent. However, the positive effect on innovation effort becomes more robust when the director has a research degree over their IIT- Bachelors' degree. The paper highlights that when it comes to innovation efforts, the dominant narrative of relying solely on IIT-STEM elite undergraduate education (IIT-Bachelor's) is insufficient and should also focus on and prioritize research education.

Keywords: Innovation Effort, R&D, STEM Education, Corporate Boards
JEL Classification: O31, G30, I23

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1. Introduction

In India, investing in human capital is a relevant path for families for upward social mobility, as it is also the case in many other emerging economies. Given that education is an essential source of economic and social status, the middle classes, in particular, put an enormous effort into their children to achieve the highest educational attainment (Brown, 2013). In this context, access to prestigious universities can guarantee a privileged entry to the labour market with a better work position and higher income (Haverman & Smeeding, 2006). However, entering a prestigious university in India is highly competitive, primarily through its national exams. The more prestigious, the more competitive it is to access a particular institution, as the university's reputation is critical in defining a student's future career. In Indian society, relevant authors have argued that education has operated in the past as an essential gatekeeper of socioeconomic mobility (Cheney et al., 2005; Subramanian, 2009). For the rising middle classes of post-1985 India, however, STEM education has played an important role and is a gateway for reaching higher social status (Saxena et al., 2010; Nambissan, 2009). Though there are various STEM education institutes in India, the most reputable are the Indian Institutes of Technology (IIT), which comprises 23 nationwide universities. Regarding STEM education, IITs are highly preferred by every engineering and science degree aspirant (Leslie & Kargon, 2006), given the perception that IIT students are trained and given ample opportunity to acquire technical, business, and leadership skills. Because of their reputation as elite universities, the market highly demands IIT graduates.

The need to train (and supply) graduates from elite schools matches the demands of firms in a competitive market environment. Following the classical perspective of Edith Penrose (Penrose, 1959), firms are a collection of assets. Among those assets, the capacity of the labour force and the competence of leaderships are crucial for the growth of firms that are always looking to recruit the most talented graduates to increase their stock of human capital.

Regarding human capital, the literature agrees that the leadership capacity to make key decisions is a central aspect of the strategic behaviour of the firms (Nahum & Carmeli, 2020). These decisions involve allocating a strategic amount of innovative effort, such as the R&D budget. Successful leaders are willing to take a step forward in innovation in a system in which innovations guarantee competitive advantages (Borgelt & Falk, 2007). Hence, innovation decisions require high focus, knowledge, and risk-taking behaviour (Borgelt & Falk, 2007). Considering the high uncertainty involved in innovative activities, leadership that can navigate risks and challenges would help the firm increase innovation and productivity (Balsmeier et al., 2017). Therefore, a board of directors that can make bold but calculated decisions are fundamental for innovation effort.

However, most of the focus of those STEM elite schools, in the Indian context, is on undergraduate degrees. Research degrees, such as PhDs and other research activities, receive a much smaller focus. Considering the aim of supplying human capital capable of engaging assertively with innovative activities, the lack of focus on research might harm the potential positive effects of hiring graduate students from top institutions.

Given the abovementioned context, our research question addresses the causal relationship between the presence of graduates from Indian elite schools (IITs) - with and without a research degree - on the boards of directors and their decision to increase innovation efforts. We aim to contribute to the literature by merging elements of corporate governance (leadership), human capital (education and cognitive traits), and innovation (R&D efforts).

One of the critical concerns for India is the lack of a precisely dedicated database containing detailed information about patents or patent citations at the firm level or any other innovation survey to gauge the status of such firm-level innovation[1]. Hence, to answer our research question, we develop a unique database by merging two databases, i.e., the individual-level board of directors' NSE-Infobase dataset, with the firm-level CMIE-Prowess database. The latter provides us with all financial and R&D spending-related information, whereas the former provides information on the personal characteristics of the board of directors.

Furthermore, given the presence of reverse causality, we consider the possibility of endogeneity. We test if boards with more directors with an IIT-Bachelor degree might lead to higher R&D opportunities; however, higher innovation effort can induce a firm to hire more directors with IIT-Bachelor's qualifications. Furthermore, unobservable firm-level heterogeneity might impact the

[1] Like in many emerging nations, India does not have a yearly National Innovation survey. For this reason, extraction of data from Indian patent database is a hard task. When searched in the database for data extraction we found mismatch among innovators, applicants, and address. This made it impossible to map patents back to firms in the CMIE database.

contribution of directors with IIT-Bachelor qualification. We address those issues in the methodology section using fixed effect estimation (FE) and instrumental variable approach (IV).

We organize the rest of the paper into six more sections. Section 2 discussed the literature review followed by Section 3, which focuses on the Research Context. In Section 4 we discuss the data and related descriptive statistics while in Section 5 we focus on the methodology and the empirical model. Section 6 presents the main results of our study. Finally, section 7 presents the policy implications and concluding remarks.

2. Literature review

This review draws primarily from the corporate entrepreneurship literature, linking it with the field of innovation economics. We mainly discuss literature on innovation, competition, leadership, cognitive traits, social mobility, and the role of STEM education in India.

2.a. Innovation and competition

In a market-based economic system driven by a dynamic competitive environment, innovation plays a central role in shaping its direction (Nelson & Winter, 1982). To survive in the market or retain one's monopoly power, firms must constantly focus on upgrading their assets and products, which requires persistence in innovation efforts (Malerba, 2005). Innovation, however, is not an automatic process (Verspagen, 1991). Most firms must engage in innovative activities, primarily R&D, to develop new products and processes and appropriately introduce them to the market (Mairesse and Mohnen, 2004). One crucial element to engaging successfully in innovative activities is the development of absorptive capacity that allows firms to learn and create (Cohen and Levinthal, 1989; Bell, 2009). A central aspect in the generation of absorptive capacity is related to strengthening human capital (Edquist, 2010). In that sense, a sensitive asset for a successful innovative firm is hiring adequate high-skilled workers.

The R&D activities of the firm do not guarantee success (Lhuillery & Pfister, 2009) but reflect innovation efforts and innovative capabilities. To mitigate the possibility of failure and risks associated with R&D, firms require efforts to innovate in a persistent way (Arqué-Castells, 2013). Given the importance of innovation effort, one of the fundamental questions that many researchers or policymakers in innovation economics face are: what is the source of the innovation effort, and what drives it? (Taalbi, 2017; Nieto & Quevedo, 2005) An important aspect is to look at the highest levels of governance inside the firm, which makes crucial decisions concerning R&D or production. In the current corporate structure, leadership is delegated to the board of directors, which defines the short- and long-term firms' strategies (Merendino & Melville, 2019).

2.b. Corporate Governance: Leadership, Cognitive Traits, and Innovation

A central theory in the corporate governance literature is the positivist agency theory (Johnson et al., 1996). The agency theory opens the debate to discuss how the characteristic of board members can affect a firm's performance. Depending on the organization of a firm's leadership, we may see different outcomes happening.

A second theoretical stream regards the Upper echelons theory (Hambrick, 2007, Hambrick & Mason, 1984). This theory asserts that the different individual traits of the managers, such as education level and diversity in terms of gender, age, and tenure, highly determine a firm's innovation decisions and strategies. Notably, the educational background plays a pivotal role in improving one's cognitive abilities (Hambrick, 2007), which later helps the board of directors determine and execute complex corporate strategies (Baysinger & Hoskisson, 1990). The upper echelons' literature focuses on behaviour aspects such as leadership style, entrepreneurship, and technology orientation to affect innovation (Carmeli et al., 2011; Tang, et al., 2012).

Risk-taking and innovative performance

The literature on corporate governance highlights that if a firm lacks risk-taker competent leadership (Oke et al., 2009; Naranjo-Valencia et al., 2011), it tends to choose a more conservative strategy, reducing the efforts allocated to R&D (Baysinger & Hoskisson, 1990). Risk-taking (but competent and calculated) leadership is a fundamental characteristic of innovative firms (Garcia Granero et al., 2015). In principle, directors are more risk-averse than shareholders (Deutsch, 2005). Shareholders should then consider that and invest in improving the board's capability by hiring better-quality, competent, risk-taker directors (Deutsch, 2005; Tylecote & Visintin, 2007).

The time frame also plays a central role in innovative incentives – tolerating early failure and rewarding long-term success is essential (Manso, 2011). González-Uribe & Xu (2014) add the contract horizon to the innovation literature. Long-horizon managers produce more important innovation (on average) in terms of patent citations and increases in R&D. Higher-quality innovation relates to managerial practices, including the abovementioned risky strategies, which have a high opportunity cost in the short run. Another time frame dimension is ownership (Brossard et al., 2013). Firms with ownership dominated by institutional investors have higher R&D ratios, while "impatient" institutional investors (short-term profit seekers) are linked to lower R&D ratios, hindering innovation (David et al., 2001).

Stem education, top institutions, research degree, and innovation

Considering the cognitive enhancing capacity of education, there is a strong defense of STEM education as a way forward for development and innovation strategy (Bybee, 2013). However, few studies in corporate governance and innovation economics indicate the correlation between the type and the level of higher education with innovation (Ackerman et al, 2013) and managerial competencies[2] (Shet and Pereira, 2021).

The literature on diversity suggests that diverse educational backgrounds combined with the heterogeneous work experience of directors can be a vital factor in critical decision-making, promoting a range of perspectives (Khatib et al., 2021; Yang et al., 2019). In opposition to this view on education diversity, another strand of literature (Alderman et al., 2022) argues that high R&D spending firms tend to place more specialized and highly educated STEM-background people in the top management. The argument is that R&D is a scientific activity; hence, essential decisions about innovative efforts require specific in-depth knowledge (Tödtling et al., 2009).

There is consensus in the literature that both levels of education and the educational background of the board of directors play a significant role in determining a firm's innovation effort (Li et al., 2019; Hsieh et al., 2022). The education of the top management acts as a vital proxy not just for its innovation outcomes but also for the intellectual wealth of the firm (Adnan et al., 2016). However, our focus is not only on the overall STEM education, as in Hsieh et al. (2022), but on STEM education obtained from the top institutions. Elite education is a potential element of individual cognition and knowledge that have the power to guide R&D decisions and innovation effort. Education obtained at elite institutes can be connected to the human capital theory (Sweetland, 1996), as students invest in their education and skills, with the incentives to place themselves virtuously in a competitive job market. Those students then focus on developing the technical knowledge fundamental to making relevant decisions related to R&D.

[2] i.e. Ability to keep up with and assimilate the latest technology, acquire, process, evaluate information, and ability to resolve issues caused by problems related with R&D (Bhardwaj & Punia, 2013)

Thus, this ever-present connection of personal cognition and knowledge acquired through STEM education; from specific “prestigious" schools, particularly in STEM, made us question how it could facilitate increases in innovation efforts in a firm. In summary, we argue that STEM education obtained at a highly “prestigious" school is one first potential solid sources of higher scientific cognitive abilities.

A second source of higher scientific ability is higher scientific comprehension. The acquisition of a Ph.D. degree can capture that. While a prestigious undergraduate gives a strong signal about capacity, a Ph.D. degree shows a strong scientific ability to understand how to perform research. Based on works such as Dalziel et al. (2011) and Swift (2018), we then argue that directors who understand how science operates can make better-informed decisions regarding R&D.

2.c. Social Mobility, aspirations, and Elite STEM Institutions in India

Emerging economies present solid opportunities for upward social mobility through education, particularly for low-middle and middle-income families. Families see education as the most relevant legacy for the next generation (Brown, 2013; Marginson, 2018). They aspire to admit their children into the best institutions, which may guarantee a solid career and an upward social and economic shift.

Similarly, in India, the widespread perception is that students who reach the top STEM institutes receive the best STEM education in the country. In that way, they can acquire desired social status, which allows for success, prosperity, prestige, and even opportunity to work in Western developed countries (Varma & Kapur, 2010). Achieving a high educational achievement also results in social status and a strong psychological element. It fosters a strong sense of self-esteem, capacity, and persistence (Srivastava, 2013), fundamental leadership characteristics towards a more risk-taking and innovative mentality (Krueger & Dickson, 1994).

Indian firms, private or government, give the utmost value to the highly reputable Indian Institute of Technology (IIT). Indian firms compete for more IIT graduates in their organizations to symbolize status and merit (Subramanian, 2019). Access to IIT requires students to clear a challenging and competitive science and engineering-based national-level annual entrance examination[3] at the post-secondary level. Clearing the examination allows post-secondary students

[3] The IIT exam happens around May of every year. The subject matters of this exam are physics, chemistry and mathematics. Only 2% of student appearing receive an offer from IIT.

to pursue STEM bachelor's education at the top STEM institution in India[4]. Hence, Indian society regards IITs as a symbol of aspiration and a medium of social mobility[5] (Aygün & Turhan, 2017). The competition for access is so high that more than millions of students sit for this examination and compete for around just 12,000 seats[6] every year. Furthermore, once getting access, graduating from IITs is a challenging task. The subjects studied during undergrad aim to test the students at their most, and many fails and drop out before graduation.

3. Research Context

Given the nature of elite education, IIT graduates tend to be confident in their technical capabilities, which allows them to be risk-takers. This specific profile makes IIT graduates a potentially good match for being part of any firm's board of directors. However, are firms that rely on a higher share of IIT graduates more innovative? Furthermore, can a higher achievement, such as a Ph.D., increase further innovation?

Based on the literature review, the channel through which a board of directors could yield a positive return for a firm's innovation effort is through a strong sense of belief of the members in their strong STEM cognitive abilities to perform better, take the risk, and put more effort in innovation (Deutsch, 2005; Tylecote & Visintin, 2007). We argue that the source of this overpowering belief in own cognitive abilities for yielding a positive return for the firm's innovation effort comes from the privilege of studying in the premier STEM institutes of the country at an early age. Those who, as teenagers, successfully graduate from IITs with a STEM degree in India are prone to take more R&D-related risks. These IIT graduates are more inclined towards R&D later in life as corporate board members, thus leading the firm to put more effort and persistence into innovation.

[4] Some feature in the world's top engineering and science institutions list, such as IIT Delhi and IIT Mumbai.

[5] There is even a far-fetched perception that the "Campus Placement" offers – made by firms recruiting IIT graduates - are highly lucrative; with attractive positive and salary, and sometimes possibility of being placed in reputed firm in OECD countries.

[6] Parents and student's aspirations to join IITs are so high that some parents start preparing their kids for IIT from as early as grade 6. This has led to mushrooming of a huge coaching business across different cities of India whereby classes are offered to help clear the IIT-Bachelor's examination. The city of Kota in India is famous for IIT coaching classes, where students join them as early as grade 6-10 onwards. The whole craze about the IITs lead to a business which is estimated to be worth of more than 30 million Rupees. See https://www.dailymail.co.uk/indiahome/indianews/article-2313660/Inside-Kotas-Rs-300-crore-coaching-industry-How-students-aiming-crack-IIT-JEE-join-mushrooming-institutes.html

As discussed in the previous section, a firm's human resources possess the capacity not just to influence the firm's performance but also to determine the innovation effort. In a framework of an agency relationship, the foundation of corporate governance consists of the firm's different management levels, and the board of directors is the highest and prime importance. In this respect, the top management of the firm, where the personal characteristics and behaviour of the board members play an essential role, makes the majority of the decisions concerning production or R&D.

On a similar note, resource dependence theory asserts that the individual characteristics of the directors, including their education, affect a firm's R&D effort and its value (Dalziel et al., 2011; Hillman et al., 2009). Hence, the board of directors' organizational values and cognitive abilities are critical in key corporate decisions. Features such as tenure, age, and educational background then play important roles in decision-making.

Therefore, following the above mechanism of top-STEM education and cognitive abilities, we hypothesize the following relationship for the structure of corporate governance and innovation effort:

Hypothesis: Firms having director/s with an IIT-Bachelors' degree in their corporate boards should have a significant positive relationship with the firm's innovation effort.

We also explore the broad array of related questions, such as the importance of incremental education attainment over IIT-Bachelors' degree.

4. Data and Descriptive Statistics

We use three different datasets. The first one, which gives us the indicators of the innovation effort, is the CMIE-Prowess[7] dataset. It provides financial details of 20,000 firms listed on the Bombay Stock Exchange (BSE), of which 5,000 firms belong to the manufacturing sector. CMIE collects the financial details of those firms through the firm's published annual reports. The broad spectrum of firms in the database constitutes 70% of the economic activity of the organized industrial sector

[7] Prowess classifies industries as per the National Industrial Classification provided by the "Ministry of Statistics and Program Implementation", Government of India at the website (http://mospi.nic.in).

in India. To classify firms by industry affiliation, we sort them into industries at a level equivalent to a two-digit standard industrial classification (SIC) and use categories for 32 distinct industries[8].

The second dataset is the NSE-Infobase, which consists of the firm's board of director-level details. This dataset provides all of the detailed personal information at the director level of the firm listed at the National Stock Exchange (NSE). The database offers details on the personal demographic characteristics, all education details, and the history of directorial positions.

The third dataset is the one we use to address our endogeneity issue, which is based on the data on post-secondary education enrolment. The data has been collected and compiled from the Ministry of Human Resource Development, India (HRD)[9].

This paper covers ten years (2006-2015). The year 2006 is chosen as starting year because the WTO's TRIPs agreement became binding from 2005 onwards as India has a ten-year transition period (1995-2005) to make the domestic legislation compatible with TRIPs. Apart from that, NSE-Infobase, i.e., the board of directors' dataset, is only available from 2006. Concerning the CMIE database, and specifically the R&D[10] figures and categories, several papers like Kathuria and Das (2005), Aggarwal (2018), Nair & Bhattacharyya (2019), and Jose et al. (2020), among others, use the CMIE database. It is the only available firm-level database covering different financial details, including most of the R&D activities, widely used in the stated context. Concerning NSE-Infobase, the information is available at the director/individual level. Given that our analysis is at the firm-level, we converted this directorial/individual level dataset by aggregating them to the board level and ultimately to the firm-level.

The final dataset consists of an unbalanced panel of 6151 firms belonging to 32 different two-digit manufacturing industries spanning ten years, from 2006 to 2015.[11] This broad dataset has a

[8] There are a total of 94 two-digit categories of industries in the standard industrial classification. But not all of the 94 industry-classifications are present in the CMIE dataset. Thus, we end up with only 32 different industrial classifications.

[9] We collected the data from two reports, i.e. Statistics of Higher and Technical Education and All India Survey on Higher Education (AISHE). For few of the years data was not broken down into different educational streams; so we extrapolated them and predicted them based on the previous information.

[10] There were certain abnormalities observed in terms of R&D spending to sales for certain firms which might have occurred due to human errors. We avoided those errors by excluding the R&D expenditure exceeding more than 3S.D (standard deviation) of the R&D expenditure to sales ratio.

[11] For the purpose of our final analysis, we drop the anomalies observed in our dataset in order to maintain the consistency of our dataset as well as our analysis. Thus, whenever any anomalies are observed, we keep dropping or correcting them to keep our dataset as robust as possible.

combination of all firms that engage in R&D. Given, the nature of the dataset, the majority of the firms engage in some sort of R&D.[12]

4.a. Descriptive Statistics

Table 1. Distribution of directors with IIT-Bachelor's degree and their other education qualifications

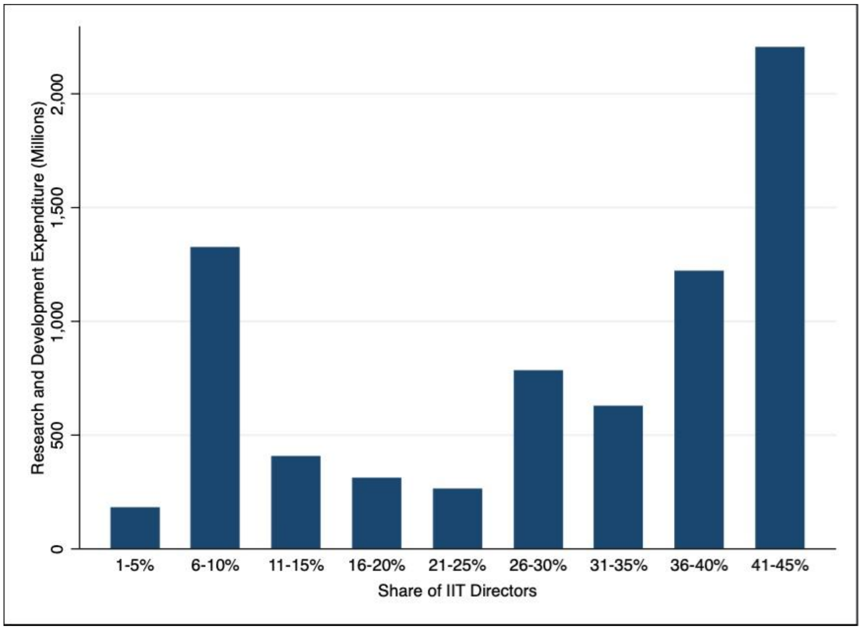
Directors	Total numbers	% of total
All Directors	15140	
IIT-Bachelor's qualification	2372	15.67%
IIT and Postgraduate	2309	15.25%
IIT and IIM	541	3.60%
IIT and PhD	762	5.03%
IIT and Foreign Degrees	825	5.45%

Source: Author's calculations

Table 1 presents the primary distribution of directors with IIT-Bachelor's qualifications (IIT Undergraduate Degree). Directors with IIT-Bachelor's qualifications comprise 16% of the total. Many directors with IIT undergraduate qualifications have a postgraduate degree, and around 5% have a Ph.D. over IT-Bachelor's qualification. Most of these directors obtained their Ph.D. abroad, mainly from different top universities in the US, Canada, Europe, and Australia. 5.45% of directors with an IIT degree have a degree from a foreign country (mainly from the abovementioned countries) over their IIT-Bachelor's degree.

[12] Firms that rarely do R&D are operating in the food processing sector, furniture or wood and wooden products sector etc.

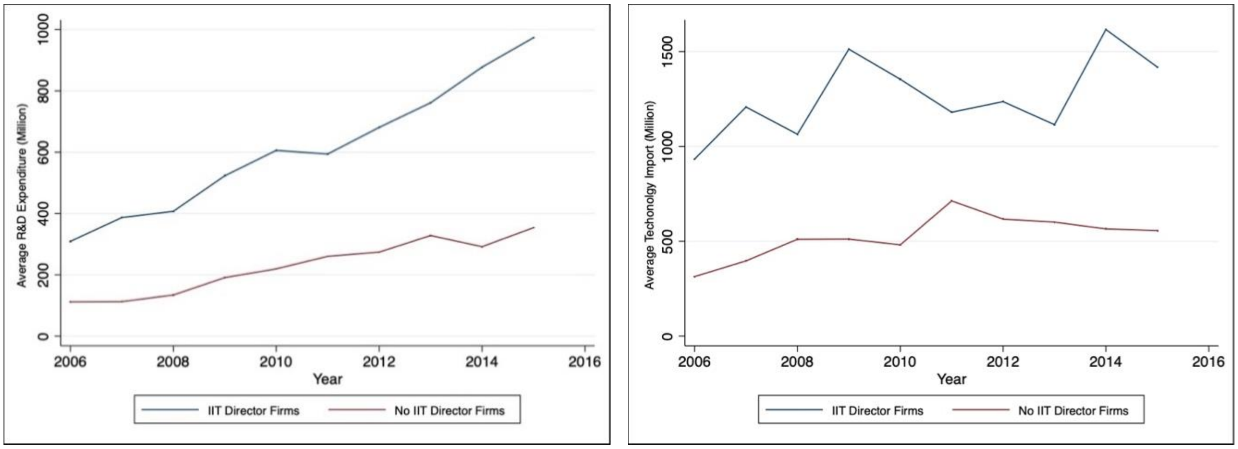
Figure 1: Share of the board of directors of firms having IIT-Bachelor's qualification and R&D expenditure



Source: Author’s calculations

Figure 1 shows the share of firms' board of directors with IIT-Bachelor’s qualification and their respective average R&D expenditures. Boards with 41-45% of directors with an IIT qualification spend the most on R&D, followed by 6-10%. In the 26-45% range, most of the R&D-oriented firms with “IIT and Ph.D.” directors are concentrated. For the 11-25% range, less R&D-oriented firms with no or fewer directors with “IIT and PhD" degrees are concentrated. This finding, specifically the relationship between high “IIT and PhD" and R&D expenditure, carries important implications for results obtained from the regression analysis.

Figure 2: Comparison of R&D expenditure and Technology imports of firms with IIT-Bachelor's qualification and with no IIT-Bachelor's qualification from 2006 to 2015.



(a) R&D expenditure of firms with IIT-Bachelor's directors and with no IIT-Bachelor's directors

(b) Technology imports of firms with IIT-Bachelor's directors and with no IIT-Bachelor's directors

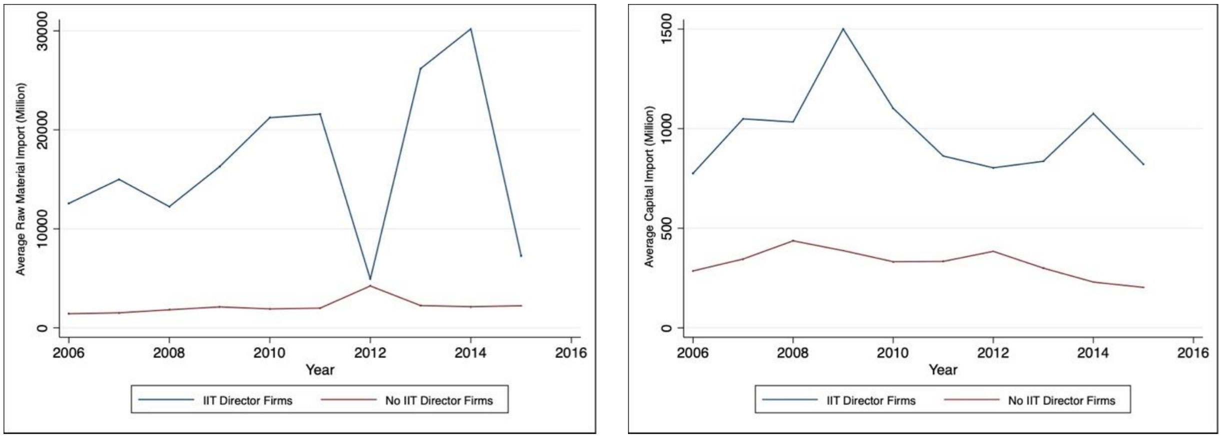
Source: Author's calculations

Figure 2 combines the firm-level R&D information with the board of directors of firms having IIT-Bachelor's qualifications. Over ten years, firms with directors with IIT-Bachelor's qualifications tend to put more effort into innovation by spending in R&D. In terms of the expenditure in R&D, firms with directors having IIT-Bachelor's qualification in their boards tend to spend more in R&D compared to other firms.

For most emerging economies, technology import is the primary source of technology transfer and innovation effort. Regarding technology imports, firms with directors with IIT-Bachelor's qualifications on their boards tend to import more than others. Though there are a few ups and downs, the technology imports of firms with directors having IIT-Bachelor's qualifications remained higher than the firm with no IIT-Bachelor's directors.

In emerging economies, many firms face budget constraints to carry out innovation, which forces them to import raw materials or capital, limiting the resources to invest in R&D (Naude et al., 2011). In the case of India, the relevance of the import of capital and raw material increased post-1991 reform, as firms became free to import capital or raw materials without any hindrance (Sasidharan & Kathuria, 2011).

Figure 3: Comparison of Raw material imports and Capital imports of firms with IIT-Bachelor's director and with no IIT-Bachelor's directors from 2006 to 2015.

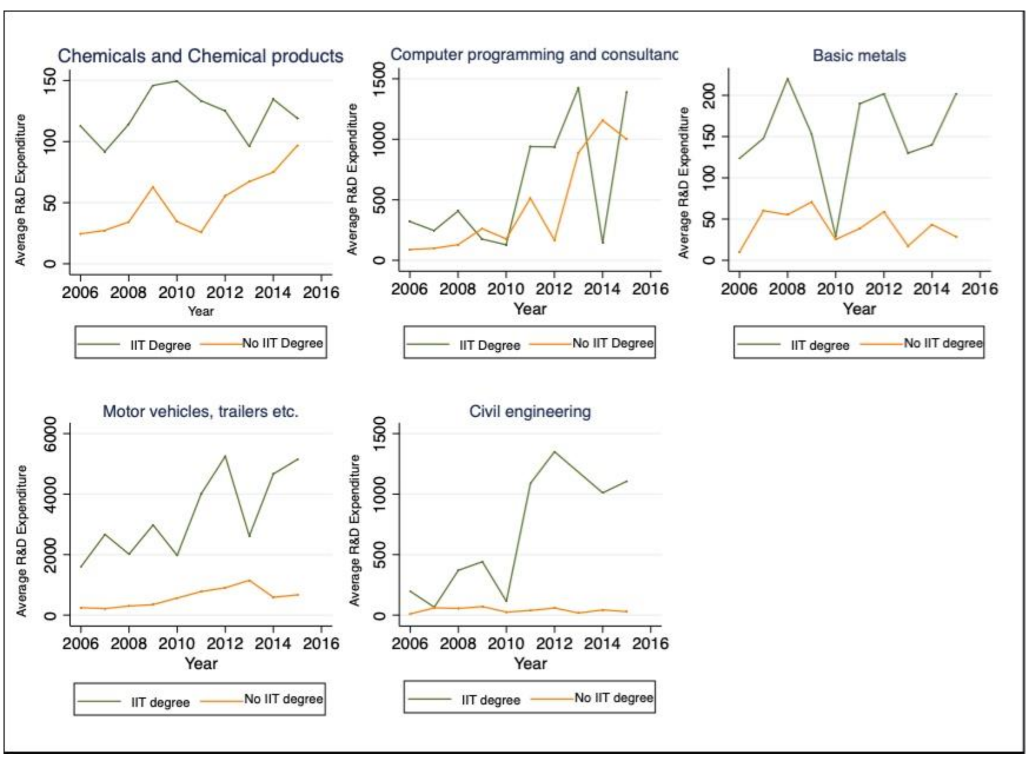


(a) Raw material imports of firms with IIT-directors and with no IIT- Bachelor's directors

(b) Capital imports of firms with IIT-Bachelor's directors and with no IIT-directors

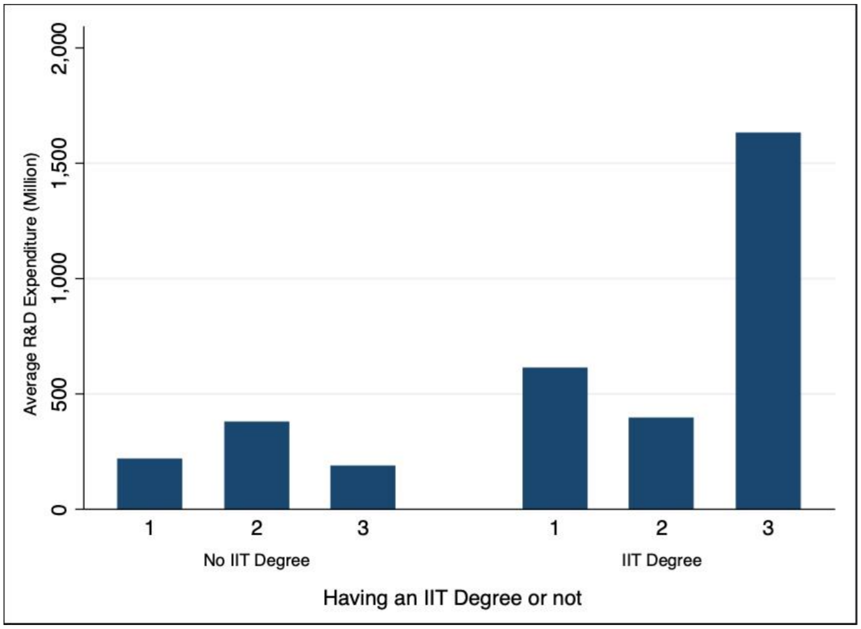
Figure 3 compares the extent of raw material imports and capital imports for firms with and without directors having IIT-Bachelor's qualifications in their boards. Overall, the raw material and capital imports for the firms with directors with IIT-Bachelor's qualifications on their boards have remained high compared to others.

Figure 4: Comparison of R&D expenditure for the top five R&D spending industries on the basis of having a director with IIT-Bachelor's qualification and with no IIT-Bachelor's qualification from 2006 to 2015.



We also looked at the top five R&D spending industries (Figure 4) to see whether the above-stated trend is visible. For most of the years across the industries presented, overall, firms with directors having IIT-Bachelor's qualifications on their boards tend to spend more on R&D.[13]

Figure 5: Firm Ownership, directors with IIT-Bachelor's qualification and corresponding R&D expenditure.



Note: Domestic firm= 1, Foreign firm=2, and Government-owned firms=3

Though initial statistics show that IIT-Bachelor's seemed to be an essential factor in the innovation effort, we look at the ownership pattern of firms to observe what type of firms place IIT-Bachelor's qualifications as directors. Figure 5 shows that irrespective of the ownership patterns, R&D spending of firms is lower if they do not have any directors with IIT-Bachelor's qualifications. Among those, government-owned firms tend to have more of them, and directors with IIT-Bachelor's qualifications are generally in high demand among Indian firms, be they private or domestic, compared to foreign firms. Figure 5 shows that government-owned firms with directors having IIT-Bachelor's qualifications on their boards tend to spend more on R&D compared to other types of firms.

[13] We found that the dataset has few anomalies, probably occurring from omission at the data recording stage which lead to few erratic trends visible in the figure.

4.b. Dependent variable

As stated earlier in the sections, we use R&D as the primary indicator to capture the innovation effort. In R&D, we use three measures; R&D expenditure[14] (Fu and Gong, 2011; Santos et al., 2014), R&D intensity (R&D_Sales_Ratio) (Driver and Guedes, 2012; Chen et al., 2013; Hwang et al., 2013; Schmid et al. 2014; Kuo et al., 2018), and R&D investment ratio (R&D_Total_Asset_Ratio) (Hwang et al., 2013; Singh and Gaur, 2013; Kuo et al., 2018). Following the above stated literature, R&D expenditure variable is constructed by combining firm's capital and current expenditures on R&D activities and CMIE database directly reports these two variables. The final R&D expenditure variable has been deflated using the CPI values provided by the Reserve Bank of India (RBI)[15]. The R&D intensity variable is constructed by taking the ratio of R&D expenditure variable to total sales of the firm. Finally, the R&D investment ratio is constructed by taking the ratio of R&D expenditure to total assets of the firm. The total asset of the firm is calculated by adding firm's owner's equity to its labilities.

4.c. Variables of interest

The prime variable of interest is directors with IIT-Bachelor's qualifications in a firm's board. We use two variables under our primary variable of interest. We use, first, IIT-Bachelor's directors as a dummy variable, which assigns a value of 1 if the board of that firm has any directors with IIT-Bachelor's qualification and 0 otherwise. Second, we use the share of IIT-Bachelor's directors in a board, which is IIT-Bachelor's directors in a board divided by the total size of the board in a specific year.

4.d. Control variables

Based on the literature, our control variables may influence a firm's composition of the board, corporate governance, and other critical firm-level characteristics. We consider three essential variables influencing firm performance and innovation effort at the board level: board size, composition, and gender. The board size of a firm may determine the extent of its performance and valuation. Yermack (1996) stated that board size negatively affects the firm's valuation, and

[14] Even after correcting for all anomalies related to R&D expenditures, dropping unusual values, and controlling for firm size, there might be some concerns still left with regards to R&D expenditure. So, we scale it again by taking logarithm of R&D expenditure. The results with and without log show similar outcome.

[15] The widely accepted financial values and deflators can be accessed through: https://www.rbi.org.in/

a small board of directors is more effective. We define fraction of insider-outsider as the number of outside directors and independent directors, scaled by board size. Fich and Shivdasani (2012) used board composition to indicate the extent of outside directors. They found that a higher fraction of outside directors positively impacts the firm's performance and return on assets. Furthermore, the literature argues that gender diversity has a positive impact on firm performance; radical innovation; patent outcome; and reduction of fraud (Adams and Ferreira, 2009; Díaz-García et al., 2013; Chen et al., 2013; Cumming and Leung, 2021).

At the firm level, we consider the traditional control variables, i.e., firm size, firm age, ROA (return on total assets), debt ratio, free cash flow, number of segments, sales growth, and ownerships. We measure firm size by the firm's total financial valuation and sales (Kumar and Aggarwal, 2005; Kuo et al., 2018). Many previous studies argue that the firm's age can play an important role in determining R&D capabilities, positively affecting the number of innovations it brings up (Hansen, 1992). Different market and firm-level factors act as complementary factors in the spectrum of influence of age on innovation efforts (García-Quevedo et al., 2014).

Following Bhagat (2017), we measure profitability by the return on total assets (ROA), calculated as the median return on total assets for all firms listed under the Indian National Industrial Code (two-digit NIC). Though mixed, most previous studies found a negative relationship between ROA and R&D (Hitt et al., 1991). This outcome supports the prospect theory (Kahneman and Tversky, 1979), in which the managers take a more risk-averse stance as firms' performance and R&D capacity improve.

To address the impact of a firm's capital structure, we incorporate a financial leverage variable in our model measured as a ratio of debt to total assets (Block, 2012; Munari et al., 2010). Debt financing generally requires a stable stream of cash flows, which affects the fund diversion of innovation projects and the firm's financial wealth. Also, we include cash flows (the ratio of cash flows to equity to the dividend to the total book value of assets) to account for the firm's liquidity status. The elasticity of ordinary and R&D investments concerning cash flow is generally positive, but there could be variation from country to country (Hall, 1992).

We also try to capture the extent of business diversification of firms in terms of their products using the number of business groups in which a firm operates within the specified two digits NIC in India (Khanna and Palepu, 2000). The impact of business diversification on innovation in the larger body of literature is inconclusive. Baysinger and Hoskisson (1989) argued that business diversification strategy consistently impacts R&D intensity in diverse and multiproduct firms. However, Hsieh et al. (2010) contended that diversification based on the business group positively affects firm-level innovation (context of Taiwan). The positive relationship between diversification and innovation stems from the logic of knowledge sharing (Cohen and Levinthal, 1990).

We use the net sales growth rate following Kuo et al. (2018) to measure firm-level growth. Recent studies (Fich and Shivdasani, 2012; Bhagat and Bolton, 2013) state that firm growth is essential while considering the firm's performance. But concerning R&D, Kuo et al. (2018) found that growth proxied by sales growth tends to affect the R&D performance of the firm.

We use ownership data to control whether a domestic/foreign, private or government entity owns the firm. Park et al. (2018) suggested that foreign ownership does not matter for R&D intensity in Japan. Still, overall foreign ownership may boost the chances of carrying out R&D[16]. For the context of India, Aggarwal (2018) suggested that most foreign-owned firms tend to spend less on R&D rather than focus on cheap technology transfer. In India, most of the R&D performing firms used to be only foreign rather than domestic firms[17], but it has changed since the last decade. We may expect that with foreign ownership, the probability of carrying out R&D activities may increase compared to domestic firms (Sasidharan and Kathuria, 2011), but not necessarily high R&D.

4.e. Summary Statistics

Table 2 presents the summary statistics for the main variables and board and firm-level control variables. We have 6151 observations considered for the final analysis after eliminating irregularities from the dataset. The summary statistics below display the values before taking logarithms.

[16] They suggested that if a foreign corporate group from a technologically advanced nation establishes a subsidiary firm in a country, this may lower the average R&D intensity of firms in the local economy.

[17] In many developing nations such as India and China the situation has been changing, specifically in the post-liberalization period. Many Chinese firms such as Huawei, ZTE, etc., and Indian firms such as TATA, Hero, etc., undertake R&D activities regularly.

Table 2: Summary statistics of dependent and explanatory variables

Variables	Mean	P25	Median	P75	SD	Min	Max
Board Level							
Board Size	11.57	8	10	14	5.12	3	25
Share of IIT-Bachelor's	3.89	2.24	0.91	6.67	7.50	0	50
Share of IIT-qualification-PhD	1.45	0.92	0.86	2.67	2.04	0	25
Share of IIT-qualification -Foreign Degree	1.04	0.52	0.77	1.89	2.53	0	42
Share of Female Directors	5.10	2.22	2.10	9.50	7.01	0	50
Share Independent Director	53.58	46.15	54.54	61.53	12.86	0	100
Share Insider Director	46.41	38.46	45.45	53.85	12.86	0	100
Term Length	7.66	3.49	5.95	10.34	5.74	0.04	42.58
Firm level							
R&D Expenditure (Million Rupees)	372.32	8	33.33	148.1	1451.51	0	22043
R&D intensity (in %) (R&D_Sales_Ratio)	5.00	0.02	0.04	3.21	1.12	0	54.09
R&D Investment Ratio (in %) (R&D_Total_Asset_Ratio)	1.10	0.28	0.62	1.68	1.2	0	2.1
Age	31.04	14.76	26.00	36.10	19.34	5	49.69
ROA (in %)	93.07	45.78	83.63	95.66	60.07	5	98
Size (Million Rupees)	2519.09	1145.53	1517.4	2875.7	14758.6	8.72	3298.95
Debt Ratio (in %)	34.67	7.22	31.48	38	31	3.33	201.74
Cash Flow Ratio (in %)	1.79	0.23	0.50	3.26	0.14	-0.30	46.33
Business Diversification	1.52	1	1	3	0.76	1	8
Growth	178.18	0	8.05	22.90	635.058	-99.99	304.60
Number of observations	6151						

Figures in Table 2 indicate that the average R&D expenditure is 372.32 million rupees, whereas the average R&D intensity and investment ratio is 5 and 1.1 percent. Firms in our dataset have, on average, around 4 percent of their directors with an IIT-Bachelor’s qualification. At the same time, boards have only 5 percent of female directors. In terms of firms operating in different business segments, most firms are operating in at least one business segment/s. The average firm age in our dataset is around 31 years.

Table 3 below presents the Pearson correlations among variables. Correlations are consistent with our hypothesis that a higher fraction of the board of directors with IIT-Bachelor degrees positively correlates with innovation effort. The table indicates that the extent of correlation among the variables is low. The correlation matrix points toward the direction of our predictions; however, correlation does not control causality and shows an association. It cannot capture the genuine causal relationship (John, 1995). Hence, in the next section, we discuss the empirical results in more detail, exploring the nature of the proposed relationship between innovation efforts and IIT-Bachelors.

Table 3: Correlations among the variables in consideration

	R&D expenditure	R&D intensity (R&D_Sales_Ratio)	R& D investment (R&D_Total_Asset_Ratio)	Fraction of IIT graduates	Only IIT	Board Size	Ownership	Fraction of outside director	ROA	Age	Firm size	Debt ratio	FCF	Business diversification	Growth	Gender
R&D expenditure	1															
R&D intensity (R&D_Sales_Ratio)	0.52	1														
R& D investment (R&D_Total_Asset_Ratio)	0.57	0.54	1													
Fraction of IIT graduates	0.70	0.65	0.67	1												
Only IIT	0.70	0.62	0.68	0.82	1											
Board Size	0.23	0.02	0.01	0.60	0.24	1										
Ownership	-0.002	0.009	-0.01	0.07	0.04	-0.11	1									
Fraction of outside director	0.16	-0.02	0.07	0.06	0.14	0.46	0.02	1								
ROA	0.03	-0.08	0.04	-0.06	-0.07	-0.02	-0.04	0.02	1							
Age	0.09	0.07	0.09	0.07	0.12	0.24	-0.18	0.09	0.02	1						
Firm size	0.39	0.11	0.03	0.18	0.27	0.48	-0.12	0.23	0.22	0.27	1					
Debt ratio	-0.041	-0.01	0.18	-0.06	-0.03	-0.06	0.15	-0.02	0.09	-0.12	-0.09	1				
FCF	0.006	0.002	0.009	0.03	0.007	-0.02	-0.007	0.09	-0.08	0.04	-0.02	-0.007	1			
Business diversification	-0.04	-0.02	-0.05	0.09	0.1	0.15	-0.07	0.038	0.009	0.15	0.18	0.02	-0.01	1		
Growth	0.002	0.03	0.02	-0.03	0.008	0.01	0.01	-0.07	0.02	-0.04	0.11	0.02	0.01	0.05	1	
Gender	-0.3	0.06	0.01	0.05	-0.05	-0.26	-0.023	-0.03	-0.02	-0.03	0.023	0.02	-0.01	-0.04	0.05	1

5. Methodology and empirical econometric model

We apply three different models to investigate the relationship stated in our hypothesis. First, we apply OLS as baseline specifications. Second, we use the fixed effect regression to correct for firm-level heterogeneity since the analysis includes both cross-sectional and time series data. Finally, we employ 2SLS (IV) approach to correct for the endogeneity. We specify our model as follows:

$$Innovation\_Effort_{it} = \beta_0 + \beta_1 IIT\_Bachelors_{it} + \gamma X_{it} + \zeta Z_{it} + F_i + T_i + I_i + e_{it}$$

Our outcome variable is innovation effort ($Innovation\_Effort_{it}$), which we proxied by $R\&D\_expenditure$, $R\&D\_Intensity$ (R&D_Sales_Ratio), and $R\&D\_Investment\_Ratio$ (R&D_Total_Asset_Ratio)

The main independent variable of interest is $IIT\_Bachelors_{it}$. We initially use $IIT\_Bachelors\_Dummy$, a dummy variable, which assigns 1 if the board of the firm has director/s with IIT qualification. Later, to check whether more directors with IIT-Bachelor's qualification on the board is better or not for the innovation effort, we use $IIT\_Bachelors\_Share$. X_{it} includes all of the board-level important control variables, whereas Z_{it} includes all of the firm-level important control variables. Apart from them, F_i is the firm-level fixed effect, T_i is the industry trend, and I_i is the industry fixed effect; and e_{it} is an error term.

Endogeneity

Other unobserved variables likely influence the proposed relationship between directors with IIT-Bachelor's qualifications and the innovation effort of a firm. For the above specification, corporate governance and entrepreneur literature highlight the issue of endogeneity[21] which might create bias in our analysis. We argue that having more directors with IIT-Bachelor's qualification on the boards might lead to high R&D opportunities, which in turn might enhance the productivity (performance) of the firm. Furthermore, the possibility of reverse causality also exists" higher innovation effort might induce a firm to hire more directors with IIT-Bachelor's qualification. Enhanced productivity will open more opportunities and scopes for R&D activities which, in turn, will attract or create more opportunities through campus placements after graduation for IIT

[21] Triana and Garcia (2009); McGuirk and Jordan (2012); Parrotta et al. (2010); Kuo et al. (2018); Cumming and Leung (2021); Bolli et al. (2018) etc. pointed to the existence of endogeneity in this context.

graduates to join the firms. Thus, we contend that the variable $IIT\_Bachelors_{it}$ is endogenous, and there could be certain unobservable firm-level heterogeneity (firm's performance related) which will affect $IIT\_Bachelors_{it}$.

To address the potential endogeneity issue, we adopt two alternative methods. First, we use the fixed effect model to address the issue of unobserved time-invariant heterogeneity by depending on within-firm variation over time. Second, we use the IV-2SLS approach to address the potential endogeneity of our interest variable. Cumming and Leung (2021) contended that, in the case of China, regional demographics play an important role in determining the R&D of a firm with its board of directors having STEM qualifications. Following Triana and Garcia (2009), regions of a country with higher technological and pure science graduates tend to have higher proportions of graduates with such degrees. Regions with a higher number of social science graduates should have a higher share of social science graduates on boards of those regions. If the boards of regions deviate from their graduate demographic characteristics, such changes are reflected in biased appointments and could exacerbate the agency cost attached to boards. If the firm's board's diversity in terms of education, expertise, etc., reflects the region's demographic characteristics, then there is a lower likelihood of severe agency problems within the firm. Following that logic, and up to a lesser extent following McGuirk and Jordan (2012), Parrotta et al. (2010), we instrument the "IIT_Bachelor's" on the total enrolment of students in STEM undergraduate degree in state/s that base firms having directors with IIT qualifications. We extracted all post-secondary school enrolment data from the Statistics of Higher and Technical Education and the All India Survey on Higher Education (AISHE). We then arranged the enrolment of post-secondary school STEM qualification by gender and each state of India from 2006-2015. Finally, we calculate total enrolment numbers and total enrolment ratios of STEM qualifications by state and gender-wise. Using an instrumental variable in this setting has three key benefits. First, complementing the fixed effect estimation with the instrumental variable allows us to test the robustness of the identification strategy by evaluating the stability of estimates based on two types of unrelated variations (Bolli et al., 2018). Second, the instrumental variable approach addresses endogeneity concerns caused by unobserved heterogeneity and reverse causality (Bolli et al., 2018). Third, apart from addressing unobserved heterogeneity issues, it will also address potential measurement error issues, as our data for the instrumental variable approach relies upon surveys/census.

Nevertheless, we also scan through different media stories of big and medium corporate firms and others for our instruments. The use of instruments is consistent with the view that R&D-driven firms do not appoint diverse boards and prefer people from STEM backgrounds from a top college (Cumming and Leung, 2021). Consistent with statements of appointment in practice[22], we infer that regional educational demographics can directly influence board appointments. Still, they do not directly affect the innovativeness of the firm. That is, the diversity of the board in terms of education strongly reflects the current regional demographic characteristics as it influences the supply of available pool of directors in the present and future times.

Highly educated STEM board directors are always short in supply and high in demand (Gillan, 2006). Within each region of a country as diverse as India, there are differences in the general population regarding gender, educational attainment, STEM environment, and experience. For example, in some areas of the country, such as the South, where educational attainment is higher, focus on science-based education and scientific training is prevalent. In turn, it is natural to expect that the board of directors from these regions will comprise a higher number of people with STEM or advanced STEM degrees with specializations (Carter et al., 2010). But the regional educational demographics generally do not have a direct causal impact on the innovation capacity of a firm, and prior studies have not recognized a causal effect on regional educational demography and innovation effort.

Our dataset shows little connection between the regional STEM qualification and innovation effort. But while looking at all top STEM institutes, states with more STEM graduates tend to have firms that also reflect those characteristics in their boards. Thus, the regional STEM educational enrolment could be an exogenous instrument to predict the extent of the IIT-Bachelor's director's influence in the innovation effort. Still, it is uncorrelated with the innovation effort. Hence, we specificy our first stage regression as follows;

$$IIT\ Bachelors_{it} = \beta_0'\ STEM\_Enrolment_{sit} + \delta X_{it} + S_i + e_{it}' \qquad (2)$$

Here, $STEM\_Enrolment_{sit}$ indicates the Enrolment of undergraduate students in STEM the state S in year t, where the firm i based. X_{it} is the vector of all of the important control variables. Finally,

[22] See examples likes of https://careers.microsoft.com/us/en/diversityandinclusion; https://www.bmo.com/main/about-bmo/corporate-governance/board-of-directors/board-diversity/; https://diversity.google/annual-report/ etc.

S_i is a vector of fixed effects indicating all of fixed effects such as the state fixed effect, firm fixed effect, and industry fixed effect; and e'_{it} is an error term. The crucial identifying assumption in this model is that, conditional on the controls, the Enrolment of undergraduate students in STEM courses in all states of India is orthogonal to the error term in (1). Hence, under this identification assumption, our estimate of β in (1) will be interpretable as the causal impact of having IIT-Bachelor's degree holders in the board on innovation effort of the firm.

6. Results and Discussions

6.a. Main Results: Innovation effort and Directors with IIT-Bachelor's qualification

To test hypothesis 1, we first run the OLS as a baseline; then, we run our fixed effect panel data estimates. In our first specification, we use the dummy variable of IIT-Bachelor's, and later we use the share of IIT-Bachelor's. Table 4 presents the results of baseline OLS and Fixed effect regressions on three indicators for innovation effort, i.e., R&D expenditure, R&D intensity, and R&D investment ratio.

Table 4: Baseline OLS and Fixed effect Regression of Innovation Effort and directors with IIT-Bachelor's qualification

	Panel A *R&D Expenditure*		**Panel B** *R&D Intensity* *(*R&D_Sales_Ratio)		**Panel C** *R&D Investment Ratio* (R&D_Total_Asset_Ratio)	
Dependent variables	***OLS***	***FE***	***OLS***	***FE***	***OLS***	***FE***
IIT-Bachelors_Dummy	143.9*** (60.93)	135.58*** (49.87)	0.042 (0.059)	0.043 (0.62)	0.008*** (0.0003)	0.001*** (0.0004)
Log(Board_size)	106.5 (87.27)	40.67 (87)	0.12 (0.084)	0.12 (0.09)	-0.002 (0.0004)	0.003 (0.0004)
Frac_Insider_Outsider	117.62*** (30.84)	147.47** (71.99)	0.026 (0.029)	0.03 (0.03)	0.00005 (0.0001)	0.00009 (0.0002)
Board_Gender_Dummy	-291.17** (133.62)	-267.79 (204.59)	0.068 (0.123)	0.08 (0.14)	0.0007 (0.0006)	0.0005 (0.0005)
Ownership_Dummy	194.47** (102.26)	166.06*** (69.03)	-0.031 (0.099)	-0.03 (0.1)	0.0005 (0.0006)	0.00008 (0.00050
ROA	-1.08 (0.97)	-0.84* (0.5)	-0.00006 (0.0009)	0.0002 (0.0004)	0.0002*** (5.47E-06)	0.0004*** (4.24E-06)
Ln(Age)	63.05 (51.28)	60.17 (48.94)	-0.092* (0.049)	-0.094* (0.05)	-0.0004** (0.0002)	-0.0004 (0.0003)
Log(Size)	408.98*** (23.12)	417.37*** (63.82)	0.12*** (0.022)	-0.13*** (0.024)	0.0006*** (0.00009)	0.0004*** (0.0001)
Debt_Ratio	0.718 (1.37)	2.36 (1.6)	-0.002 (0.001)	-0.002 (0.0016)	0.0002*** (4.89E-06)	2.37e-0.8 (6.36E-06)
Cash_Flow_Ratio	-0.0002 (0.004)	0.00003 (0.0018)	-1.70E-07 (4.71E-06)	-7.11E-08 (5.00E-06)	-2.31E-09 (2.24E-08)	1.43e-08*** (6.43E-09)

Business_Diversification	-94.78*** (37.82)	-86.78*** (23.99)	0.02 (0.03)	0.02 1 (0.038)	0.00003 (0.0002)	-0.00004 (0.0001)
Growth	-1.29 (0.81)	-1.48*** (0.65)	0.002** (0.00080)	0.001** (0.0008)	-4.77E-09 (2.27E-08)	-4.42E-09 (3.20E-09)
Intercept	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Industry Fixed Effect	Yes	No	Yes	No	Yes	No
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	No	Yes	No	Yes	No	Yes
Industry Trend	No	Yes	No	No	No	No
Number of Observations	6151	4837	6151	4837	6151	4837
Adjusted R^2	0.251	0.16	0.261	0.16	0.1145	0.17
F value	16.87	8.66	11.38	5.21	11.6	12.05

(a) Note: The coefficients and p-values (in parentheses) are reported. Heteroscedasticity robust standard errors are shown in brackets. *, **, and *** indicate a significance level of 10%, 5%, and 1%, respectively. Industry dummies include 32 industrial categories, and time dummies include nine time periods. In panel A we have R&D expenditure as the dependent variable, in panel B, we have R&D intensity (R&D_Sales_Ratio), and in panel C, we have R&D investment ratio (R&D_Total_Asset_Ratio) as the main dependent variable to indicate the extent of the innovation effort.

Panel A of Table 4, where we take R&D expenditure as a dependent variable, reports that $IIT - Bachelors\_Dummy$ is positive and significant at a 5% level. This indicates that firms that have directors with IIT-Bachelor's qualifications tend to spend more on R&D compared to other firms that do not have any of them on their boards. Similar to R&D expenditure, the coefficients are positive for R&D intensity in panel B and R&D investment ratio in panel C. But, in panel B, $IIT - Bachelors\_Dummy$ is insignificant, whereas, in Panel C, $IIT - Bachelors\_Dummy$ is positive and significant at a 1% level. While our main interest variable in Panel B is insignificant, the overall results indicate a positive association between IIT-Bachelor's qualifications of directors and innovation effort indicated by R&D. Thus, Hypothesis 1 is supported. We find a similar outcome in our Fixed effect result. Though the signs and significance level are similar to OLS, their intensity is smaller than OLS since fixed effect regression controls for the firm-level unobserved heterogeneity.

Apart from OLS in panel C, board size has a positive sign, but it is not significant in any of the specifications. These results add to the literature's existing mixed response to board size. In both OLS and fixed effect, $Frac\_Insider\_Outsider$ is positive, but only significant in panel A. The gender dummy is negative and significant at 5% in panel A, adding to a few debates where researchers argue that gender diversity is attributed to risk aversion, affecting R&D effort (Barber and Odean, 2001; Byrnes et al., 1999). The ownership estimator is only positive and significant in panel A (OLS and fixed effect), showing that Indian firms tend to spend more than foreign firms. The firm size estimator is positive and significant (as in Bolli et al., 2018, and Kumar and Aggarwal, 2005) in all specifications (except for the fixed effect part of panel B). While the firm's age does not have much impact on the R&D expenditure, it negatively affects both R&D intensity and the R&D investment ratio. It indicates that in old firms, organizational rigidities, and rent-seeking behaviour causes lower firm performance (Fich and Shivdasani, 2012; Loderer and Waelchli, 2010). The coefficients are negative in panel A in the business diversification variable, measured by the firm's presence in different business segments. In the rest of the panels, they are insignificant, though signs may vary. A negative sign of this variable may indicate the fact that higher diversification takes out the attention from innovation effort and performance too, similar to outcomes contented by Baysinger and Hoskisson (1989), Hitt et al. (1991), and Fich and Shivdasani (2012).

5.a. Innovation effort and many directors with IIT-Bachelor's qualification, the better?

In this section, rather than taking the primary interest variable as a dummy variable, we take it as a continuous variable. We define a new interest variable, which is $IIT - Bachelors\_Share$. We define it as the total share of directors in a firm's board that has an IIT-Bachelor's degree in a given year. This section checks if having a higher percentage of directors with an IIT-Bachelor's degree has any significant positive impact on the innovation effort of the firm. The idea is here to confirm the prevalent narrative in the Indian corporate scenario, which believes that more directors with IIT-Bachelor's degrees can positively enhance the firm performance[23].

Table 5: OLS and Fixed effect regression of innovation effort and share of directors with IIT-Bachelors qualification

Dependent variables	**Panel A** *R&D Expenditure*		**Panel B** *R&D Intensity* *(*R&D_Sales_Ratio)		**Panel C** *R&D Investment Ratio* (R&D_Total_Asset_Ratio)	
	OLS	***FE***	***OLS***	***FE***	***OLS***	***FE***
IIT-Bachelors_Share	7.9** (4.12)	7.95** (3.83)	0.0032 (0.004)	0.0031 (0.0042)	0.00003* (0.000018)	0.00004*** (0.00001)
Log(Board_size)	127.09 (87.03)	59.65 (84.4)	0.122 (0.84)	0.13 (0.899)	0.00016 (0.0004)	0.0002 (0.0003)
Frac_Insider_Outsider	118.70*** (30.85)	148.67*** (71.69)	0.026 (0.29)	0.026 (0.33)	0.00006 (0.0001)	0.0001 (0.0002)

[23] https://www.livemint.com/companies/news/iits-in-delhi-mumbai-churn-out-most-tech-entrepreneurs-1568652902193.html

Board_Gender_Dummy	-290.34** (133.68)	-267.29 (205.24)	0.069 (0.129)	0.00003 (0.00007)	0.0007 (0.0006)	0.00058 (0.0005)
Ownership_Dummy	197.52** (102.37)	166.52** (69.63)	-0.033 (0.099)	-0.029 (0.0.1)	-0.0005 (0.0006)	0.0001 (0.0002)
ROA	-1.09 (0.97)	-0.87* (0.5)	0.00005 (0.0009)	0.0002 (0.0004)	0.000018*** (5.47E-08)	0.00003*** (4.22E-06)
Ln(Age)	64.6 (54.49)	61.73 (48.03)	-0.092* (0.049)	-0.094* (0.052)	-0.0003 (0.0002)	-0.0004 (0.0003)
Log(Size)	410.35*** (23.12)	418.69*** (62.96)	-0.12*** (0.02)	-0.13*** (0.024)	0.0006*** (0.00009)	0.0004*** -0.0001)
Debt_Ratio	0.803 (1.37)	2.5 (1.62)	0.0019 (0.0013)	0.0024 (0.0016)	0.00002*** (4.89E-06)	-1.11E-07 (6.40E-06)
Cash_Flow_Ratio	-0.0002 (0.004)	0.00004 (0.0017)	-1.83E-07 (4.71E-06)	-8.06E-08 (5.00E-06)	-2.05E-09 (2.24E-08)	1.47e-08** (6.51E-09)
Business_Diversification	-96.93*** (37.88)	-88.63*** (24.05)	0.022 (0.037)	0.02 (0.38)	0.00003 (0.0001)	-0.00004 (0.00015)
Growth	-1.27 (0.81)	-1.44** (0.64)	0.0016** (0.0007)	0.0017** (0.0008)	-4.98E-09 (2.27E-08)	3.67E-09 (3.24E-09)
Intercept	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Industry Fixed Effect	Yes	No	Yes	No	Yes	No
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	No	Yes	No	Yes	No	Yes
Industry Trend	No	Yes	No	No	No	No
Number of Observations	6151	2267	6151	2267	6151	4837
Adjusted R^2	0.25	0.1594	0.139	0.16	0.1245	0.598
F value	16.81	10.95	5.95	11.65	11.52	13.11

(a) Note: The coefficients and p-values (in parentheses) are reported. Heteroscedasticity robust standard errors are shown in brackets. *, **, and *** indicate a significance level of 10%, 5%, and 1%, respectively. Industry dummies include 32 industrial categories, and time dummies include nine time periods. In panel A we have R&D expenditure as the dependent variable, in panel B, we have R&D intensity (R&D_Sales_Ratio), and in panel C, we have R&D investment ratio (R&D_Total_Asset_Ratio) as the main dependent variable to indicate the extent of the innovation effort.

Results in Table 5 indicated that in all specifications except for panel B, the $IIT - Bachelors\_Share$ variable is positive and significant at various levels. In panel A, in both OLS and FE, $IIT - Bachelors\_Share$ is positive and significant at 5 percent, whereas in panel B, though it is positive but insignificant. In Panel C, though it is positive and significant at 10 and 1 percent in OLS and FE, the extent of the positive impact is small. Most board and firm-level control variables follow the signs and significance levels observed in previous results in the preceding sections. The results indicate that firms with a higher share of directors with an IIT-Bachelor’s degree seem to have higher R&D expenditure and R&D investment ratio but not R&D intensity.

Thus, we contend that a higher share of IIT-Bachelor's directors in a firm put relatively more effort into their innovation effort by making more coherent, scientific, and informed R&D decisions.

6.b. Innovation effort, directors' IIT-Bachelor's qualification, and incremental educational attainment

In this section, we test whether the positive effect of IIT directors is solely coming from IIT-Bachelor's qualification or the advanced degree above IIT-Bachelor's undergraduate qualification. We contend that incremental educational attainment beyond a bachelor's degree could foster and ignite IIT students' research ability and mindset. Thus, we segregate the IIT-Bachelor's directors based on educational attainment into a total of 4 categories. First, directors with only an IIT-Bachelor's degree. Second, directors who have an IIT-Bachelor's degree and a postgraduate degree. Third, directors with IIT-Bachelor's degree as well as a Ph.D. degree. Last, directors with an IIT-Bachelor's degree and an advanced degree from aboard[24]. We report the results for incremental educational attainment in Table 6.

Table 6: OLS and Fixed effect regression of Innovation Effort, directors with IIT-Bachelor's and advanced qualifications

Dependent variables	**Panel A** *R&D Expenditure*		**Panel B** *R&D Intensity* (R&D_Sales_Ratio)		**Panel C** *R&D Investment Ratio* (R&D_Total_Asset_Ratio	
	OLS	***FE***	***OLS***	***FE***	***OLS***	***FE***
IIT-Bachelors(only IIT graduates)	74.93 (69.97)	99.08* (51.23)	0.19 (0.06)	0.023 (0.07)	-0.0007** (0.0003)	-0.001** (0.0004)
IIT-Bachelors_PG	-84.78 (168.69)	-6.17 (229.45)	-0.05 (0.167)	-0.062 (0.17)	0.0006 (0.0009)	0.00067 (0.001)
IIT-Bachelors_PHD	744.42*** (128.03)	800.47*** (330.26)	0.31 (0.12)	0.014 (0.13)	0.0014* (0.0007)	0.0018* (0.001)
IIT-Bachelors_FORGN	258.39** (103.66)	260.17 (206.55)	0.06 (0.1)	0.062 (0.1)	0.0005 (0.006)	0.0008 (0.0006)
Log(Board_size)	99 (86.21)	39 (84.27)	0.11 (0.08)	0.12 (0.09)	-0.00013 (0.0004)	0.00002 (0.0003)
Frac_Insider_Outsider	98.95*** (30.53)	129.41* (70.26)	0.023 (0.09)	0.027 (0.033)	0.00005 (0.0001)	0.00009 (0.0002)
Board_Gender_Dummy	-279.70** (131.93)	-262.67 (195.3)	0.07 (0.13)	0.079 (0.14)	0.0007 (0.0006)	0.0005 (0.0005)
Ownership_Dummy	181.2* (101.04)	157.57*** (63.69)	-0.31 (0.09)	0.024 (0.033)	-0.0005 (0.0006)	6.15E-06 (0.0006)

[24] Almost all of the IIT-Bachelor's directors in this category have an advanced degree from prestigious universities of OECD countries, mainly USA, EU, Canada and Australia.

ROA	-0.9 (0.96)	-0.79* (0.47)	-0.0006 (0.0009)	0.0002 (0.0004)	0.00002 (5.47E-06)	0.0003*** (4.27E-06)
Ln(Age)	59.18 (50.61)	56.66 (47.04)	-0.092* (0.049)	-0.095* (0.050)	-0.0003 (0.0002)	0.0004 (0.0003)
Log(Size)	386.73*** (22.98)	392.64*** (59.12)	0.122*** (0.022)	-0.127** (0.024)	0.0005*** (0.00009)	0.00038*** (0.001)
Debt_Ratio	0.933 (1.34)	2.62* (1.56)	-0.002 (0.001)	-0.0024 (0.016)	0.0002*** (4.89E-06)	-1.64E-08 (6.63e- 06)
Cash_Flow_Ratio	-0.0002 (0.004)	9.61E-06 (0.001)	-1.58E-07 (4.27E-06)	-6.93E-08 (5.00E-06)	2.53E-09 (2.24E-08)	1.44e-08** (6.55E-08)
Business_Diversification	-84.53** (37.43)	-75.32*** (24.97)	0.02 (0.03)	0.02 (0.39)	0.00004 (0.0001)	-0.00002 (0.0001)
Growth	-1.55** (0.8)	-1.76*** (0.66)	0.0016** (0.0008)	0.0017** (0.0008)	-3.71E-09 (2.27E-08)	5.20E-09 (3.97E-09)
Intercept	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Industry Fixed Effect	Yes	No	Yes	No	Yes	No
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	No	Yes	No	Yes	No	Yes
Industry Trend	No	Yes	No	No	No	No
Number of Observations	6151	2267	6151	2267	6151	2267
Adjusted R^2	0.271	0.18	0.293	0.16	0.115	0.598
F value	17.53	6.95	12.25	11.65	11.11	10.21

(a) Note: The coefficients and p-values (in parentheses) are reported. Heteroscedasticity robust standard errors are shown in brackets. *, **, and *** indicate a significance level of 10%, 5%, and 1%, respectively. Industry dummies include 32 industrial categories, and time dummies include nine time periods. In panel A we have R&D expenditure as the dependent variable, in panel B, we have R&D intensity (R&D_Sales_Ratio), and in panel C, we have R&D investment ratio (R&D_Total_Asset_Ratio) as the main dependent variable to indicate the extent of the innovation effort.

After incorporating different types of incremental educational attainment over IIT-Bachelor's qualification, only having an IIT-Bachelor's limits the effect of the innovation effort. IIT and PhD combined is strongly positive in all of the panel and is significant except for panel B. We could infer from this outcome that simply having an IIT-Bachelor's degree is important. However, to ignite the innovation potential of a firm and put maximum effort towards it, the directors would require a research degree like PhDs. Research degree over IIT-Bachelor's would unlock those IIT-bachelor directors' research mindset and abilities and provide the research aptitude/experience to carry out R&D.

In opposition to the expected results, Panel A $IIT - Bachelors\_Dummy$ is only significant at 10 percent level in the fixed effect part of the panel. Contrary to that, in Panel C, $IIT - Bachelors\_Dummy(only\ IIT graduate)$ is significant in both of the specifications along with IIT-Bachelor's and Ph.D. After iterations, the control variables from Table 6 remain somewhat similar in sign and significance.

Overall, from this experiment, we note that the incremental educational attainment factor, mainly IIT-bachelors and Ph.D., plays a positive and significant role in explaining innovation efforts to some extent. This result holds essential conclusions for the overall narrative of this paper. As we can see that only $IIT - Bachelor's$ is insignificant, we could conclude that merely having an IIT (bachelors) degree is not sufficient for firm's innovation effort. Instead, having a research degree over an IIT-Bachelor's degree increases the effect on innovation. These results allow us to question the Indian firms' obsession with IIT-Bachelor's degrees in private and government sectors while disregarding research degrees. We observe that a good research degree along with an IIT-Bachelor's degree can contribute to a firm's innovation effort. Furthermore, most IIT-bachelor holders with a Ph.D. obtained their PhDs abroad rather than from the IITs. Only very few of the board of directors obtained their Ph.D. from IITs.

It makes sense that directors with a research degree positively affect R&D. We contend that the undergraduate degree holders may be intelligent, confident, and risk-takers but do not have a research-oriented mindset in particular required to make R&D-related decisions. The IIT-Bachelor's degree, however, lays the solid cognitive foundation for future STEM research-oriented degrees. Hence, when these IIT graduates complete their research degrees, they take back their strong research abilities to the firm's decision-making level. Therefore, we contend that this mix of IIT-Bachelor's degree, which provides strong STEM cognitive skills and a complementary STEM research degree, enhances the research abilities, which can positively impact a firm's innovation effort and simultaneously handle all R&D-related risks. Hence, we argue that a research degree alongside an IIT-Bachelor's degree acts as a solid complementary in boosting the innovation potential of the firm.

6.c. Endogeneity concerns and IV estimations

In previous sections, we mentioned the potential endogeneity problem and the solutions to deal with the same. In this sub-section, we present the results from our instrumental variable estimation. We instrument $IIT\_Bachelors$ with the total enrolment of students in STEM undergraduate degree in state/s that locate firms having directors with IIT-Bachelor qualifications. Table 7 presents the results, where we use the same instruments for all three panels.

Table 7: Endogeneity concerns and the results of IV estimations for innovation effort and IIT-Bachelor's qualified directors.

Dependent variables	**Panel A** *R&D Expenditure*	**Panel B** *R&D Intensity* (R&D_Sales_Ratio)	**Panel C** *R&D Investment Ratio* (R&D_Total_Asset_Ratio)
	2SLS-IV	***2SLS-IV***	***2SLS-IV***
IIT-Bachelors _Share	39.03*** (11.6)	0.011 (0.009)	0.0007 (0.0006)
Log(Board_size)	129.78* (73.88)	0.13 (0.105)	-0.0003 (0.0004)
Frac_Insider_Outsider	116.66*** (46.31)	0.27 (0.021)	0.00003 (0.002)
Board_Gender_Dummy	-307.9 (239.95)	0.07 (0.057)	0.0002 (0.0006)
Ownership_Dummy	128.04* (79)	-0.051 (0.04)	-0.0011 (0.001)
ROA	-1.09 (1.17)	-0.0001 (0.0002)	0.00018*** (5.83E-06)
Ln(Age)	47.42 (42.58)	-0.103 (0.077)	-0.00035 (0.0002)
Log(Size)	393.78*** (40.87)	0.134 (0.1)	0.0007*** (0.0001)
Debt_Ratio	1.25 (1.22)	-0.002 (0.0015)	0.0002*** (6.49E-06)
Cash_Flow_Ratio	-0.00096 (0.001)	-2.63E-07 (1.12E-06)	-3.93E-10 (9.90E-09)
Business_Diversification	-113.87*** (29.67)	0.017 (0.017)	0.00002 (0.0001)
Growth	-1.04* (0.56)	0.0017 (0.0018)	-8.44E-09 (2.32E-08)
Intercept	Yes***	Yes***	Yes***
Industry Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Industry Trend	Yes	No	No
Number of Observations	2193	2193	4655
R^2	0.2524	0.29	0.1698
$Wald - Chi^2$	67903.9	21079.33	416.88

(a) Note: The coefficients and p-values (in parentheses) are reported. Heteroscedasticity robust standard errors are shown in brackets. *, **, and *** indicate a significance level of 10%, 5%, and 1%, respectively. Industry dummies include 32 industrial categories, and time dummies include nine time periods. In panel A we have R&D expenditure as the dependent variable, in panel B, we have R&D intensity (R&D_Sales_Ratio), and in panel C, we have R&D investment ratio (R&D_Total_Asset_Ratio) as the main dependent variable to indicate the extent of the innovation effort.

In Table 7, panel A, $IIT - Bachelors\_Share$ variable is positive and significant at a 1 percent level, which suggests that the instrumental variables for IIT-Bachelor's directors have a positive and significant relationship with R&D expenditure. But, in the rest of the panels, the $IIT - Bachelors\_Share$ though positive, is not significant. This may indicate the fact that the impact of having more board members with IIT-Bachelors qualification can affect the R&D expenditure positively but does not necessarily have an effect on other indicators of the innovation effort which are ratios and can get influenced by sales and assets. Overall, we do see a positive and significant impact of IIT-Bachelor's qualification on R&D expenditure which indicates that higher the share of these confident directors in the boards high will be the risk taking beaviour leading more experiments with research and hence, higher R&D expenditure. We contented that this might be since, in India, when it comes to the innovation effort, firms tend to focus on the R&D expenditure more, given R&D tax benefits offered from the government's side.

Table 8: Weak instrument tests for instrumental variables.

Instrument:	Enrolment of STEM undergraduate degree students in state/s, where the firms that have board of directors with IIT-Bachelor's qualifications are situated.		
Tests	**Panel A** *R&D Expenditure*	**Panel B** *R&D Intensity* (R&D_Sales_Ratio)	**Panel C** *R&D Investment Ratio* (R&D_Total_Asset_Ratio)
Durbin	15.74*** (0.0001)	1.41 (0.23)	1.21 (0.27)
Wu Hausman	8.88*** (0.0029)	1.28 (0.25)	1.19 (0.2738)
First-stage F value	72.33*** (0.0000)	NA	NA
Minimum eigenvalue	72.1391***	NA	NA
2SLS Size of nominal 5% Wald test	64.69 -5%	NA	NA
Sargan	27.82 -0.1137	NA	NA
Basmann	27.29 (0. 1273)	NA	NA

(a) Note: In brackets, we report the P values. In the 2SLS size of nominal 5% Wald test, we report the figure at 5% level. *, **, and *** indicate a significance level of 10%, 5%, and 1%, respectively. For detailed discussions about the endogeneity issue, please refer to section 4e.

To avert the problem of exogeneity of the endogenous variable, overidentification, and to test the validity of the instruments, we run a series of post-estimation tests. Table 8 presents the results of the post-estimation tests for all three specifications that lead us to confirm the validity of the instruments.

In Panel A, the endogenous variable satisfies the endogeneity test at a 1 percent level. In Panels B and C, however, the Durbin and Wu-Hausman test rejects the endogeneity, and we can proceed with the result obtained from OLS and Fixed effect regressions. But for Panel A, the IV approach is justified, given the presence of the endogeneity issue. The F value is high and significant at 1 percent in the first regression stage. For the eigenvalue, it is 72.19, and it is higher than the 2SLS size of the nominal 5% Wald test, which is 64.69%. These results justify the validity of our instruments for specification A. We also check for the possibility of over-identifications, which our tests reject. This exercise overall confirms validity of our instrument and results of the table 7 supporting our overall hypothesis.

7. Conclusion

In this paper, we explored how an extensively competitive examination and degree obtained at the top STEM institutes may affect the innovation effort in India. This particular question and education qualification is essential because it unravels the mix of the board of directors' specific type of STEM educational attainment, India's fixation with that particular STEM education, and its broader implication for innovation. Though various institutions provide STEM education, we looked at only one specific set of top institutions in India, the Indian Institutes of Technology (IITs). Given that IITs are renowned for high-quality education, competitive entry, and entrepreneurship, we explore their contribution to the overall innovation ecosystem in India. Based on the datasets covering ten years from 2006 to 2015 for Indian firms, we determined a positive relationship between IIT-Bachelor's qualification of the board of directors and innovation efforts. Still, the effect is limited, and research training significantly strengthens this relationship.

The overall nexus of the IIT-Bachelor's qualification and innovation is not as simple as it looks. In all cases, the effect on R&D intensity remained insignificant while R&D expenditure and, to some extent, the R&D investment ratio were positive and significant. The positive impact confirms the importance of an IIT-Bachelor's qualification in the innovation effort. However, this positive relationship is not only driven by the IIT-Bachelor’s degree. The research training of the board plays an essential role in determining innovation efforts.

Our results allow us to question the immense Indian focus and corporate and social pride attached to hyper-competitive examinations like IIT-Bachelor’s. When it comes to the issue of the innovation effort, the dominant narrative of valuing IIT-Bachelor’s is sufficient for enhancing the effort but focusing and prioritizing research education should play an equally relevant role. Also, most of those with an IIT-Bachelor’s and Ph.D. degree acquired their PhDs abroad. The lack of IIT graduates with an IIT Ph.D. also allows us to question India’s preferential attitude towards only IIT-Bachelor’s without much focus on enhancing the research infrastructure of the IITs itself.

The general trend in India is that there are more discussions over the IIT-Bachelor’s degree but seemingly less focus on the research degrees and improving the research infrastructures of these premier institutes. Given that innovation requires not just requires confidence and risk-taking behaviour but also strong research aptitude. Hence, building a better research infrastructure should also grasp the government's attention as public. Better research infrastructure shall ignite the research abilities of young minds so that later in life, they can carry the same attitudes and aptitude to boost the innovation potential of the firm and the country.

Following our results, we suggest that first, from the perspective of the innovation effort, a focus should be on the research degree rather than simply on the IIT-Bachelor’s. Second, with each state of India getting at least one IIT, aligning with our overall results, India may hope for better innovation efforts with more IIT-Bachelor’s degree holders and creating more space for research at IITs. Third, determinants for sales/profits differ from innovation, so having an IIT-Bachelor’s degree may enhance sales/profits. Still, for innovation efforts recognizing the importance of a Ph.D. degree, we must be cautious at directly linking both to frame national innovation and STEM education policy.

We recognize that the scope and aim of this research have limitations. There could be many relevant socioeconomic issues, such as Ph.D. and non-IIT education, as well as how caste dynamics can influence social mobility or the skewed gender ratio in STEM education and R&D. We recognize the importance of those elements. Still, we opt to leave them unaddressed in this article. These issues, though very pertaining, are out of the scope of this current research, being a topic for future extensions. The present work sets our base for more studies on the complex dynamics of India's STEM education and innovation.

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Appendices

A1. Descriptions of the Variables

Dependent variables

Dependent Variable	**Descriptions**
R&D Expenditure$_{it}$	Total R&D expenditure, including all capital and current expenditure of the firm *i* the year *t*. The R&D expenditure has been deflated CPI values provide by the Reserve Bank of India
R&D Intensity$_{it}$ (R&D_Sales_Ratio)	Ratio of R&D expenditure to the total sales (deflated) of the firm *i* in the year *t*.
R&D Investment Ratio$_{it}$ (R&D_Total_Asset_Ratio)	Ratio of R&D expenditure to the total assets of the firm *I* in the year *t*.

Instrumental variables

Instrumental Variables	**Descriptions**
STEM Enrolment	Enrolment of undergraduate students in STEM the state *S* in year *t*, where the firm *i* based.
States	A dummy variable defining each state of India.

Independent variables

Independent Variable	**Descriptions**
IIT-Bachelors_Dummy	A dummy variable, which assigns a value 1 if the board of firm *i* has any directors with IIT-Bachelor's qualification and 0 otherwise, in the year *t*.
IIT-Bachelors_Share	Share which indicates the number of IIT-Bachelor's directors in a board divided by the size of the board of firm *i* in the year *t*.
Log(Board_size)	Log of the size of the board, i.e., number of directors of the board of firm *i* in the year *t*.
Frac_Insider_Outsider	The number of outside directors and independent directors, scaled by board size of firm *i* in the year *t*.
Board_Gender_Dummy	Dummy variable indicating the gender status of the board of firm *i* in the year *t*. If the variable takes the value 1 if the board has at least a female director and if the variable is 0, then there is no female director in the board.
Ownership_Dummy	Dummy variable indicating ownership structure. The variable takes the value 0 if the firm *i* is owned by a foreign entity and if the variable is 1 then, it is owned by the Indian entity.
ROA	Indicates return on assets, defined as the ratio of net income before interest, tax and depreciation to total assets of firm *i* in the year *t*.

Ln(Age)	Natural log of how old the firm *i* is in the year *t* based on its incorporation year.
Log(Size)	Log of the size of the firm *i* in terms of its financial valuation and sales in year *t*.
Debt_Ratio	Defined as the ratio of total debts to total assets of firm *i* in the year *t*.
Cash_Flow_Ratio	Defined as the ratio of cash flows to equity to the dividend to total book value of assets of firm *i* in the year *t*.
Business_Diversification	The total number of business groups in which firm *i* is operating within the specified 2-digit NIC in year *t*.
Growth	The percentage of the difference between the net sales of the current year and the previous year divided by the net sales of the previous year for firm *i* in year *t*.

A2. Robustness checks

Table A.2.1. Regressions with log(R&D expenditure)

Dependent variables	**Panel A**$^{\$}$ *Log(R&D Expenditure)*		**Panel B**$^{\$\$}$ *Log(R&D Expenditure)*		**Panel C**$^{\$\$\$}$ *Log(R&D Expenditure)*	
	OLS	***FE***	***OLS***	***FE***	***OLS***	***FE***
IIT-JEE_Dummy	3.224*** (0.72)	0.223*** (0.072)				
IIT-Bachelors Share			3.186*** (0.64)	0.149*** (0.039)		
IIT-Bachelors (only IIT graduates)					0.122* (0.067)	0.126** (0.57)
IIT-Bachelors PG					-0.0153 (0.180)	-0.006 (0.2)
IIT-Bachelors PHD					0.277** (0.109)	0.285** (0.101)
IIT-Bachelors_FORGN					0241** (0.111)	0.236 (0.148)
Log(Board_size)	0.40*** (0.10)	0.335*** (0.112)	0.349*** (0.092)	0.316*** (0.097)	0.346*** (0.092)	0.258*** (0.097)
Frac_Insider_Outsider	0.62*** (0.35)	0.64** (0.34)	0.007 (0.032)	0.002 (0.03)	0.009 (0.032)	0.005 (0.04)
Board_Gender_Dummy	-0.123** (0.59)	-0.111 (0.148)	-0.192* (0.105)	-0.187* (0.1)	-0.202** (0.101)	0.197 (0.155)
Ownership_Dummy	0.47* (0.26)	0.37*** (0.12)	-0.031 (0.102)	0.051 (0.117)	0.229** (0.108)	0.212** (0.102)
ROA	-0.08 (0.07)	-0.05 (0.5)	-0.00001 (0.0001)	-0.0008 (0.0005)	-0.0003 (0.001)	-0.0002 (0.005)
Log(Age)	0.13** (0.058)	0.142** (0.65)	0.151*** (0.054)	0.157*** (0.05)	0.153*** (0.054)	0.158*** (0.056)
Log(Size)	0.91*** (0.068)	0.923*** (0.035)	0.841*** (0.024)	0.852*** (0.036)	0.869*** (0.024)	0.852*** (0.035)
Debt_Ratio	0.003** (0.013)	0.002 (0.002)	0.002* (0.001)	0.0009 (0.0019)	0.002** (0.001)	0.001 (0.02)
Free_Cash_Flow	-0.0002 (0.006)	0.00003 (0.0016)	-0.00003 (0.0005)	0.00002 (0.0005)	-0.00003 (0.0008)	0.00002 (0.0007)
Business_Diversification	-0.85** (0.041)	-0.708* (0.411)	-0.057 (0.04)	-0.019** (0.0007)	-0.061 (0.04)	-0.048 (0.038)
Growth	-0.001** (0.0009)	-0.002*** (0.0009)	-0.001** (0.0008)	-0.047 (0.038)	-0.001** (0.0008)	-0.002*** (0.0006)
Intercept	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Industry Fixed Effect	Yes	No	Yes	No	Yes	No
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes

Firm Fixed Effect	No	Yes	No	Yes	No	Yes
Industry Trend	Yes	No	Yes	No	Yes	No
Number of Observations	6151	4837	6151	4837	6151	4837
Adjusted R^2	0.548	0.426	0.568	0.457	0.576	0.17
F value	56.53	47.95	62.52	86.58	58.81	12.05

The coefficients and p-values (in parentheses) are reported. Heteroscedasticity robust standard errors are shown in brackets. *, **, and *** indicate a significance level of 10%, 5%, and 1%, respectively. Industry dummies include 32 industrial categories, and time dummies include nine time periods. In panel A we have R&D expenditure (deflated) as the dependent variable, in panel B, we have R&D intensity, and in panel C, we have R&D investment ratio as the main dependent variable to indicate the extent of the innovation effort.

$ Panel A: Table 4 of main text with log(R&D expenditure), $$ Panel B: Table 5 of main text with log(R&D expenditure), $$$ Panel C: Table 6 of main text with log(R&D expenditure)

Table A.2.2. IV Regression with log(R&D expenditure)

Dependent variables	R&D_Expenditure
	2SLS-IV
IIT-Bachelors Share	0.44*** (0.016)
Log(Board_size)	0.361*** (0.093)
Frac_Insider_Outsider	0.089** (0.0.41)
Board_Gender_Dummy	-0.181** (0.85)
Ownership_Dummy	0.118 (0.102)
ROA	-0.00002 (0.008)
Ln(Age)	0.181*** (0.05)
Log(Size)	0.835*** (0.033)
Debt_Ratio	-0.0018 (0.0015)
Free_Cash_Flow	0.00009 (0.0003)
Business_Diversification	-0.097*** (0.038)
Growth	-0.001* (0.0008)
Intercept	Yes***
Industry Fixed Effect	Yes

Year Fixed Effect	Yes
Firm Fixed Effect	No
Industry Trend	Yes
Number of Observations	2193
Adjusted R^2	
F value	
R^2	0.5782
Wald - Chi2	86236.82

The coefficients and p-values (in parentheses) are reported. Heteroscedasticity robust standard errors are shown in brackets. *, **, and *** indicate a significance level of 10%, 5%, and 1%, respectively. Industry dummies include 32 industrial categories, and time dummies include nine time periods. Here, we have R&D expenditure (deflated) as the main dependent variable to indicate the extent of the innovation effort.

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