Influence of regional-level institutional factors on firm-level innovation in an emerging economy - India

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Abstract

This thesis examines how regional-level factors combined with firm-level factors influence innovation in an emerging economy – India. Past literature has shown that differences in both country contexts and firm-level factors influence innovation. The bulk of this literature tended to focus on developed economies. The handful of studies that have considered contextual differences have studied these at the country-level or within regional blocks such as regions of Europe or Africa. There is a paucity of research, which investigates how differences in state-level factors within a *single* country combined with firm-level factors influence innovation within firms. Therefore, it is an open question whether the findings derived from developed economies and country-level studies apply equally to emerging economies, particularly at the state level within a single country. Thus, there is a gap in the literature regarding our understanding of the impact of combined state- and firm-level factors on innovation within a single country.

This thesis aims to contribute to a better understanding of how state and firm-level factors drive innovation in India, an emerging economy. India is selected because it is a fast-growing emerging economy that is increasingly being integrated into the globalized world economy and thus understanding how these factors influence innovation in an emerging economy would complement the literature that focuses on developed countries. Moreover, India is a huge country with substantial varieties in resources, capabilities, institutions (both formal and informal institutions) as well as ethnic, religious, and cultural varieties. Contextually, these state-level differences are quite different from regions in the developed world where institutional differences tend to be relatively consistent (less varieties). Thus, the insights generated from this study of the Indian context complement prior research by identifying the state and firm factors that combine to drive firm-level innovation. This study also extends the innovation literature by focussing on state-level differences within a single emerging economy, for which there is limited research.

The findings could also have practical managerial and policy implications. From a policy perspective, policymakers in India can get a deeper understanding of the relevant factors that influence firm-level innovation so that they can direct policy and resources to promote innovation in their respective states. From a managerial perspective, managers can also get a better

understanding of strategies and investments they should take to enhance innovation within their firms.

This study is based on data gathered from various sources including the World Bank Enterprise Survey and several sources from within India (Indiastat.com, NCAER State Investment Potential Index, India Innovation Index). The World Bank Enterprise Survey provides firm-level data while state-level data were obtained from the other reputable sources in India. The data were analyzed using logistic regression and multi-level modeling, given that firms are nested within states, thus, we can simultaneously model the micro and macro levels to assess the relevance of the regional context.

The results of this study show that regional factors such as regulatory quality, corruption, and rule of law barriers negatively influence innovation in firms that invest in internal R&D to promote innovation. The results also show that regions that devote a higher proportion of their gross domestic product to innovation achieve higher levels of innovation. Further, regions that have higher levels of human capital stock (more skilled workers) and export technology tend to be more innovative. At the firm level, investments in both internal and external R&D and those that have highly experienced managers are more innovative than their peers.

These results suggest that governments and policymakers can increase innovative activities of firms by providing a highly skilled labor force, invest heavily in R&D, reduce corruption, regulatory quality, and the rule of law barriers. For firm-level managers, this study indicates that higher levels of managerial capability and greater investments in both internal and external R&D can enhance the technical and innovative capabilities (absorptive capacity) of their firms. This may result in a competitive advantage through increased innovation.

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Chapter 1
Introduction

Innovation is generally defined as the development or adoption of new or significantly improved products, processes, marketing methods, and organizational practices (OECD, 2005). The economics literature shows that innovation contributes significantly to a country's economic growth, productivity, and competitiveness (Feldman, 2004; Petrariu, Bumbac, & Ciobanu, 2013; Tebaldi & Elmslie, 2008). Similarly, the management literature shows that innovation provides many benefits to firms such as reduced costs, improved firms performance (e.g., sales), and competitiveness (Aas & Pedersen, 2011; Atalay, Anafarta, & Sarvan, 2013; Azubuike, 2013; Feldman, 2004; Mai, Vu, Bui, & Tran, 2019). Technological innovation can also help firms improve their chances for survival, growth, and expansion at the global level (Azubuike, 2013; Feldman, 2004).

Considering the importance of innovation to firms and countries, numerous studies have been undertaken to identify the factors that drive innovation (Ibrahim & Fallah, 2005; Rajapathirana & Hui, 2018; Zawislak, Gamarra, Alves, Barbieux, & Reichert, 2014) and the link between innovation and firm performance (Artz, Norman, Hatfield, & Cardinal, 2010; Choi & Lim, 2017). The bulk of this literature focused on firm-level factors influencing innovation (Feldman, 2004; Hungund & Kiran, 2019). Additionally, the literature on innovation focuses overwhelmingly on developed economies and relatively less on developing and emerging economies (Albaladejo & Romijn, 2000; Choi & Lim, 2017; Oakey, 1984; D. Wan, Ong, & Lee, 2005).

However, in the recent times, the rapid growth of emerging economies like India and China and their increasing integration into the global economy via supply chains have resulted in greater scholarly attention to innovation in these countries (Dahlman, 2007; Khanna, 2007; Reddy, 2010; Srinivasan, 2006). Unfortunately, the research is still in its infancy and much more needs to be learned about innovation in these countries (Jing Li, Chen, & Shapiro, 2010; Srinivasan, 2006). Further, it is noted that much of this literature is dominated by studies on China and less on India (Jun Li & Chen, 2006; Srinivasan, 2006). However, India has been pursuing a more innovation-based development path, thus making it an interesting context for this study (Nair, Guldiken, Fainshmidt, & Pezeshkan, 2015).

More recently, scholars have been recognizing the context within which innovation takes place as important in providing unique insights into innovation dynamics, even at the firm-level (Arendt & Grabowski, 2019; Broekel & Boschma, 2017; Sternberg & Arndt, 2001). The recognition of contextual varieties has led to studies that combine institutional level factors with firm-level factors to study firm-level innovation dynamics (Arendt & Grabowski, 2019; Autio, Kenney, Mustar, Siegel, & Wright, 2014; Sternberg & Arndt, 2001). However, much of this literature is based on the contexts of developed economies (Arendt & Grabowski, 2019; Sternberg & Arndt, 2001), where there are more consistencies at the institutional level compared to emerging economies like India and China where there is substantially greater diversity (Cuervo-Cazurra & Ramamurti, 2014; Nair et al., 2015). In this regard, Hoskisson, Wright, Filatotchev, and Peng (2013) argue that even within the encompassing label of emerging economies, significant diversity of initial conditions, transition paths, and competitive outcomes have made it crucial to make distinctions among them i.e. they are not homogenous. Hoskisson et al. (2013) showed empirical differences between China and India, two emerging economies. Indeed, there is scant research about emerging economies, especially those focussing on comparing regions or states within a single country (Crescenzi, Rodríguez-Pose, & Storper, 2012; Crescenzi & Rodríguez-Pose, 2017). Hence, there is a gap in the literature regarding our knowledge about the drivers of innovation in emerging economies, especially in terms of contextual factors within a single economy.

Commenting on the relevance of contextual factors, Gumbau-Albert and Maudos (2006), Tödtling and Trippl (2005) and Wakelin (2001) argued that it seems reasonable to affirm that if the rate of technical progress differs among nations, industries and firms, it will also differ among regions due to variations in productive structures, diversity of firms, regional differences in market relationships, forms of regulations, and so on, which could lead to divergences in the organization of production and the capacity to innovate. Thus, our understanding of the combined effects of institutional and firm level factors on firm-level innovation in an emerging economy like India is still incomplete. This study aims to contribute to filling the gap in the literature by examining the influence of firm- and regional-level factors in India.

India is chosen as the context for this study for several reasons. First, it is the second-most populous country in the world with a population of about 1.3 billion, which represents a huge marketing opportunity for all types of products, services, and technologies from around the world. Second, it is a huge and diverse country with substantial varieties in resources, capabilities, and institutions (both formal and informal institutions) as well as ethnic, religious, and cultural varieties (Cuervo-Cazurra & Ramamurti, 2014; Nair et al., 2015). To underscore the diversity of India, Lahiri and Yi (2009) noted that the population of few states in India exceeds the total population of Pakistan and Nigeria, which are the sixth and seventh-most populated countries in the world. This diversity could result in different patterns of innovations across regions for which little is currently known (Chaminade, 2011).

Third, India is a fast-growing emerging economy that is increasingly being integrated into the global economy and thus, its importance as a global player is growing (Dahlman, 2007; Trichet, 2007). For instance, increasing integration into the global economy not only means the opening of its huge market for foreign products but also enables local Indian firms to acquire foreign technologies, develop skills and capabilities to use advanced technologies, and produce higher value-added innovations for both its domestic and foreign markets. Fourth, the diversity of its many different regions in terms of formal and informal institutional context presents a unique opportunity to better understand how this diversity influences firm-level innovation across India, which is important to managers, policymakers, and researchers. To the best of our knowledge, there are no prior studies on this topic and this study empirically investigates how firm- and regional-level factors combine to influence firm-level innovation.

Fifth, most of our knowledge and understanding of the influence of institutional factors on innovation is based on research conducted within the context of developed economies where there is generally more consistency and fewer varieties in their institutional contexts. Studies focussing on developing economies have generally focussed on comparing countries rather than examining a single country (Barasa, Knoben, Vermeulen, Kimuyu, & Kinyanjui, 2017; Crespi & Zuniga, 2012; Nichter & Goldmark, 2009). The institutional aspect of innovation within a single country, especially in emerging economies like India, is understudied and thus presents an opportunity to undertake valuable research (Vecchi, Della Piana, & Vivacqua, 2015). Further, Narayanan and

Shin (2019) argued that not all emerging economies are homogeneous, and therefore studying a diverse country like India will add to the innovation literature, where there is a paucity of research. A key objective of this research is to empirically shed light on the role of regional factors on firm-level innovation.

Finally, statistics from several data sources for innovation input indicators such as R&D expenditure in the field of Science, technology and agriculture and number of R&D institutions funded by state; enablers that facilitate innovation such as enrolment in Ph.D., state government expenditure on higher and technical education, and venture capital deals; and lastly output of innovation that include patents filed from the states, number of startups in the state, number of registered GI, and number of publications by state universities show that innovation pattern is not the same for every region accounting for regional variation and different innovation patterns. Hence, we need to understand further on the heterogeneity of innovation activities among regions/states. Figures 1 to 9 in Appendix 7 shows the variations of the innovation indicators for different regions.

The research question addressed in this study is: **what are the firm- and regional-level factors combine to influence innovation in regions[1] across India**? Thus, we collected and analyzed data at two levels: firm-level and regional-level. The firm-level data were sourced from the World Bank Enterprise Survey while the regional-level data were collected from several statistical and research agencies in India. These agencies include IndiaStat.com, India Innovation Index, NCAER State Investment Potential Index, Infrastructure Statistics, and R&D Expenditure Ecosystem. The dependent variable in our study is product innovation. Firm-level variables include firm age, firm size, legal status, industry, internal R&D, external R&D, managerial experience, skilled labor, and external funding. Regional variables include gross state domestic product, regulatory quality, corruption, rule of law, human capital, infrastructure, R&D expenditure, and ICT Exports. We also examined interactions between firm- and regional-level variables. The data were analyzed using logistic regression and multi-level regression. Multilevel modeling allows the micro and macro

[1] In this thesis, regions and regional refer to states within India. Institutional and contextual factors refer to regional or state level factors.

levels to be modeled simultaneously, which is considered a natural way to assess the relevance of the regional context (Hox, 2002).

The findings provide deeper insights into the importance of contextual dimensions driving innovation in firms in India. It would help policymakers to concentrate on improving governance and political stability by reducing corruption, enforcing the rule of law, and strengthening regulatory quality. By improving governance, differences in innovative output in different states can be reduced to a great extent. The overall improvement in institutional quality can promote a healthy business environment encouraging innovation and entrepreneurship at the firm-level. Additionally, firm resources like research and development (R&D) and human capital can be more valuable to the firm with the presence of strong regional institutional conditions. Policymakers must explore how to strengthen the bonds among institutions (Nair et al., 2015). In terms of managerial implications, the findings can help executives develop innovation and investment strategies once they get a better understanding of the key drivers and context of firm-level innovation.

The remainder of the thesis is organized as follows. Chapter 2 presents a review of the relevant literature, which not only highlights the context of the study but also helps to identify key variables for the analysis. Chapter 3 presents a theoretical model and hypothesis along with the research question. Chapter 4 describes the data collection and methodology. Chapter 5 describes the results. Chapter 6 provides the discussion. Chapter 7 presents a conclusion and highlights the limitations and future research for our study.

Chapter 2
Literature Review

2.1 Firm-level drivers of innovation

There is an extensive literature on many aspects of innovation such as the drivers of innovation (Ibrahim & Fallah, 2005; Rajapathirana & Hui, 2018; Zawislak et al., 2014), the link between innovation and firm performance (Artz et al., 2010; Choi & Lim, 2017), the types of innovation (Gunday, Ulusoy, Kilic, & Alpkan, 2011; Oke, Burke, & Myers, 2007; Zhou, Shu, & Gao, 2016), the role of advanced technology adoption on innovation (Arduini, Belotti, Denni, Giungato, & Zanfei, 2010; Evangelista, Sandven, Sirilli, & Smith, 1998; Plewa, Troshani, Francis, & Rampersad, 2012), and international comparisons of innovation (Barasa et al., 2017; Crespi & Zuniga, 2012; Nichter & Goldmark, 2009). Barasa et al. (2017) observed that previous studies have often investigated product innovation more than other types of innovation because product innovation enhances firm performance, competitiveness, and survival.

An examination of the literature reveals a long list of factors, which seem to influence innovation (see Table 1 of Appendix 1). Rather than creating a laundry list of firm-level factors, it is probably more effective to highlight the most widely used theories that have been employed to study firm-level innovation and then to link the individual factors to these theories. The most commonly used theories include the resource-based theory of the firm (Barney, 1991; Wernerfelt, 1984), dynamic capabilities (Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997), absorptive capacity (Cohen & Levinthal, 1990), resource orchestration (Sirmon, Hitt, & Ireland, 2007), competitive strategy (Bayraktar, Hancerliogullari, Cetinguc, & Calisir, 2017; Weerawardena & Mort, 2012; Yamin, Mavondo, Gunasekaran, & Sarros, 1997), and more recently the institutional theory (Barasa et al., 2017; Butkiewicz & Yanikkaya, 2006; Santarelli & Tran, 2018; Tran, 2019).

The resource-based theory (RBT) of the firm emphasizes the ownership and attributes of the internal resources of the firm as a source of innovation and strategic competitive advantage (Barney, 1991; Wernerfelt, 1984). According to RBT, resources that are valuable, rare, imperfectly imitable, and non-substitutable (VRIN) are considered strategic resources, which can be used to create differential performance in terms of competitive advantage and value creation (Barasa et al., 2017). Using this theoretical approach, many studies have identified several resource-related variables that influence innovation. Examples of these variables include firm size, sales, internal R&D expenditure, skilled labor, patent applications (Artz et al., 2010; Choi & Lim, 2017), investment in and use of ICT, organizational changes (Arendt & Grabowski, 2019), and the use of advanced technology (Baldwin & Audretsch, 1996). These studies have generally reported positive associations between these variables and innovation.

Studies that have used dynamic capabilities (Eisenhardt & Martin, 2000; Helfat & Martin, 2015; Teece et al., 1997), resource orchestration (Helfat & Martin, 2015; Sirmon et al., 2007) or absorptive capacity (Cohen & Levinthal, 1990) focus mainly on the capabilities of the organization to configure continually and reconfigure its resources and processes to achieve its goals (Eisenhardt & Martin, 2000; Teece et al., 1997). In these studies, the major focus is on variables such as managerial experience and capabilities, managerial decision-making, managerial support, and availability of a highly-skilled worker force (Helfat & Martin, 2015; Sirmon et al., 2007; Teece et al., 1997). For example, Barasa et al. (2017) investigated and found a positive relationship between managerial experience and innovation. Similarly, Artz et al. (2010) found that firms' technological competency, which influences its absorptive capacity, is mainly based on internal R&D capabilities.

Studies that employ a competitive strategy approach focus on the role of the external environment on innovation (Indris & Primiana, 2015; Tian, Zhang, Yu, & Cao, 2019; Weerawardena & Mort, 2012). In these studies, the focus is on the competitiveness of the firm's environment, the extent and speed of technological and marketing changes or turbulence within the industry, government policies, and application of information technology (Z. Wang, 2007). For instance, Vega-Jurado, Gutiérrez-Gracia, Fernández-de-Lucio, and Manjarrés-Henríquez (2008) study of Spanish manufacturing firms found that the factors that influence product innovation vary across industrial sectors. Further, Barasa et al. (2017) argue that a firm may not necessarily innovate even when it possesses the required resources because the extent to which it can extract value from its resources depends on the environment of the firm.

2.2 Institutions and Innovation

Recently, scholars have started to devote greater attention to better understand how the institutional environment or context of the firm influence firm-level innovation (Barasa et al., 2017; D'Agostino & Scarlato, 2014; Martín-de Castro, Delgado-Verde, Navas-López, & Cruz-González, 2013). Innovation is the driving force of economic change and institutional factors influence the way in which innovative efforts impact economic growth (Kim & Loayza, 2019; Roper & Love, 2006; Santarelli & Tran, 2018; Silve & Plekhanov, 2018; Tojeiro-Rivero & Moreno, 2019; Vecchi et al., 2015). According to D'Agostino and Scarlato (2014), technological capabilities (i.e. knowledge and skills that the firm needs to acquire) are the outcome of complex interactions between individuals, firms, and organizations, and this happens within specific socioeconomic and institutional contexts (Iammarino, Piva, Vivarelli, & Von Tunzelmann, 2012; Malerba & Orsenigo, 1995).

According to Vecchi et al. (2015), institutional theory, which refers to the rules of the game (North, 1990), emphasizes the effect of the law and the judicial system as well as socio-cultural norms and values on organizational structure and behavior (North, 1990). Formal institutions include political rules, economic rules, and contracts while informal institutions include codes of conduct, norms of behavior, and convention. Both formal and informal institutions regulate economic activities and human behavior, but informal institutions are embedded in a culture and play a role when formal constraints fail (North, 1990). Therefore, the national institutional context has a significant impact on the rules of competition, firm strategy, and firm performance since institutions impose rules for legitimacy, serve as a source of knowledge, and allocate incentives and resources for innovation (Vecchi et al., 2015). Generally, a more efficient institutional context favors market exchanges and the growth of the national economy (North, 1990; W. P. Wan & Hoskisson, 2003).

Similarly, Silve and Plekhanov (2018) argue that countries with stronger economic institutions characterized by more secure property rights, better business environment, and effective rule of law provide greater incentives for businesses to make long-term, risky investments. For instance, poor institutions and corruption reduce foreign direct investment (Javorcik & Wei, 2009) and undermine incentives for domestic firms to reinvest their earnings (Cull & Xu, 2005).

Additionally, a difficult business environment impedes the entry of new firms to the market (Bruno, Bytchkova, & Estrin, 2011; Silve & Plekhanov, 2018). Also, a high incidence of corruption, weak rule of law or burdensome red tape can drive up the costs of introducing new products and make returns to innovation much more uncertain (Silve & Plekhanov, 2018). Hence, risk-adjusted returns to innovation are likely to look less attractive in countries with weak economic institutions. Essentially, poor economic institutions are likely to discourage innovation while strong economic institutions encourage innovation (Rodríguez-Pose & Di Cataldo, 2015; Tebaldi & Elmslie, 2008). Empirical evidence indicates a negative relationship between corruption and innovation (Habiyaremye & Raymond, 2013; Mahagaonkar, 2008) while higher quality institutions lead to higher patent output (Rodríguez-Pose & Di Cataldo, 2015).

According to M. W. Peng, Wang, and Jiang (2008), institutional perspective is the most widely deployed theoretical lens strategy that scholars use when studying emerging economies, especially when seeking to better understand the unfolding competition in these economies. Further, Lu, Tsang, and Peng (2008) argued that the institutional environment in the Asia–Pacific region plays a multi-faceted role behind firms' knowledge management and innovation strategy. They believe that future research drawing on the institution-based view would possess significant potential to advance understanding of innovation strategy in Asia–Pacific firms. However, Tojeiro-Rivero and Moreno (2019) contend that the mechanism by which the regional context shapes the innovative performance of firms is still poorly understood. Essentially, innovation may vary depending on the regional environment in which the firm is located. This thinking is aligned with the idea of Van Oort, Burger, Knoben, and Raspe (2012) who noted that the characteristics at the regional level are not automatically reproduced at the firm level because information on the variance between firms is lost when data at an aggregated regional level are used.

2.3 Innovation Studies in India

Today, many Western scholars have recognized the importance of innovation in emerging economies (Kafouros & Forsans, 2012). Most of the literature on emerging economies focus on technological product and process innovation. Brazil, Russia, India, and China (BRIC) are regarded as the largest emerging economies (Nieto, 2012). Among them, particularly, India and

China are often known as the economies that are more likely to challenge the developed economies of the United States (US) and the European Union (EU) (Crescenzi & Rodríguez-Pose, 2017). Innovation in emerging economies contributes to the global innovation output thus showing that emerging economies are increasingly integrated with developed economies (Reddy, 2010). Several studies have been conducted to understand the ICT Exports of both China and India even though there is more research on China relative to India (Srinivasan, 2006). Even though India's manufacturing sector is not as strong as China, the country finds its potential in IT-enabled services attributed to the advantage it has in the English language when compared to China (V. Kumar, Mudambi, & Gray, 2013). India's Tata Consultancy Services (TCS) and Infosys are two of India's most innovative and successful global IT services companies (V. Kumar et al., 2013).

Several studies have been conducted in the past to understand the link between R&D and innovation in India. Dubey and Dubey (2010) found that even with an increase in investment in R&D, pharmaceutical firms in India did not see a considerable increase in their drug pipeline and approval of new molecular entity (NME) rate (Nair et al., 2015). In another study conducted by Deolalikar and Röller (1989), it was found that the number of patents by Indian firms was linked to the availability of human capital rather than R&D investment, capital, or organization size (Nair et al., 2015). Studies on service innovation found that India has a competitive environment that is directly linked to service innovation (Nair et al., 2015).

Subrahmanya (2005) found that product innovations in India are motivated due to internal factors with the entrepreneurs not searching for external support. However, external factors are also responsible for incremental innovations either due to the expansion of the market or customer demands, thus leading to the improvement of existing products. Gupta and Barua (2016) found four main enablers of innovation in SMEs namely, the traits of the entrepreneur (e.g., excellent technical skills, ability to take risk and make decisions), the entrepreneur's education level and work experience, the extent of networking and collaboration with suppliers, customer, educational institutions and R&D investment of the venture. Singh, Khamba, and Nanda (2017) found that entrepreneurial capability, technology infrastructure, and government actions influence innovation in SMEs. In another study, R. S. Kumar and Subrahmanya (2010) argued that increased innovation can be achieved through greater collaboration between SMEs and large firms, industry-government collaboration in R&D, university-industry R&D collaboration, and the provision of financial and technical aid by state and central governments to SMEs (e.g., subsidies). Along these lines, Gupta and Barua (2016) suggest that the establishment of supportive government policies; allocation of funds for R&D activities; and training unskilled workers at government institutes will positively influence firm-level innovation.

In terms of the institutional dimension of innovation in India, Crescenzi and Rodríguez-Pose (2017) observed that the innovation system in India depends on informal activities and the informal sector and operates under weak institutional conditions. They argue that robust, stable, high-quality institutions are considered key components for generating greater innovation (Crescenzi & Rodríguez-Pose, 2017). These researchers also commented that India is slowly establishing the basis for innovation through selective investment in R&D and human capital that promotes firms and sectors with greater ICT Exports (Crescenzi & Rodríguez-Pose, 2017). This is evident by the recent push towards the growth of human capital and the development of science and technology by increasing research grants for researchers (Crescenzi & Rodríguez-Pose, 2017) and providing tax incentives and loans for firms at a subsidized rate (Crescenzi et al., 2012).

The Indian government has also promoted the rise of venture capitalists as a means of funding opportunities for firms for their innovations (Crescenzi & Rodríguez-Pose, 2017). Additionally, the government has also encouraged the acceptance of foreign technologies in ICT sectors (Crescenzi & Rodríguez-Pose, 2017). However, the unequal geography of innovation among the states is due to path dependency in lines of activities undertaken by the firms which are visible in the case of states like Maharashtra that has a large concentration of pharmaceutical industries (Crescenzi et al., 2012); the establishment of distinguished educational institutions such as the Tata Institute of Fundamental Research (TIFR) and the Indian Institute of Technology (IIT); the existence of auto components industries in the state of Tamil Nadu and highest-ranked engineering colleges in the state of Karnataka and the presence of many entrepreneurs in the state of Gujarat (Crescenzi et al., 2012; Crescenzi & Rodríguez-Pose, 2017). Thus, regions like – Bangalore, Delhi, Hyderabad, and Mumbai have emerged as the center for innovation because of the continuous support from the government and spatial relations (Crescenzi et al., 2012).

In summary, these studies show that state-level factors including government industrial reform policies and other institutional changes have had a positive impact on firm-level innovation.

Chapter 3
Theoretical Background

3.1 Research Question

The research question examined in this study is: What are the firm-level and regional-level factors that influence innovation in firms in India?

3.2 Theoretical Model and Hypotheses

As noted in the literature review, both firm-level resources and institutional quality influence firm-level innovation. Firm-level resources include both tangible and intangible resources a firm owns (Kamasak, 2013). Additionally, firms must have the managerial capabilities to structure, bundle, and leverage its resources to exploit market opportunities in competitive environments (Sirmon et al., 2007). These unique bundles of resources and capabilities are crucial for value creation and innovation (Sirmon et al., 2007; Teece et al., 1997). Specific firm-level resources that have shown to drive innovation include internal R&D, skilled labor, and managerial experience (Barasa et al., 2017). These three resources are often considered innovation inputs and product innovations and patents are often considered innovation outputs. The link between these three resources and innovation in the regional context of India is examined in this study.

3.3 Firm-Level Variables

i. Innovation

In this study, innovation, the outcome of interest, is captured by the product innovation variable rather than patents since it is the most widely used measure of innovation in developing countries (Kalanje, 2006; Tojeiro-Rivero & Moreno, 2019). In developing countries, patents, as a measure of innovation, are not widely used for several reasons including lack of intellectual property resources and expertise and weak or inefficient intellectual property regulations (Mansfield, 1993; Reichman, 2009). Generally, considerably more firms are likely to develop new products than file patents, and using patents will exclude a large swath of firms. Additionally, Tojeiro-Rivero and

Moreno (2019) argue that this measure accounts for the actual amount of innovations made and higher numbers of product innovations may lead to improvements in a firm's market share, market value, and even its survival.

According to the OSLO manual (OECD, 2005), the premier global reference guide on innovation, product innovation refers to the introduction of new or significantly improved products by firms. The Enterprise Survey, the source of our firm-level data, asks respondents whether their firm introduced any new or significantly improved products or services over the last three years. We use a dichotomous variable to describe product innovation, where "1" indicates that the firm introduced any new or significantly improved products/services within the last three years, and 0 otherwise.

ii. Internal R&D and Innovation

Investments in R&D are often considered an indicator of innovation input that is considered pivotal for firm-level innovation (Arundel, Bordoy, & Kanerva, 2008; Arundel, Huang, & Hollanders, 2010; Arundel, Kanerva, Van Cruysen, & Hollanders, 2007). Generally, it is widely accepted that firms that invest in R&D are more likely to develop new products, adopt new processes and technologies, and improve their technical and managerial capabilities or absorptive capacity (Tojeiro-Rivero & Moreno, 2019). Essentially, R&D is positively associated with innovation output. Despite this, Barasa et al. (2017) cited several studies on developing countries that indicate a mixed relationship between internal R&D and innovation. For example, positive relationships between internal R&D and innovation were observed in Asia (K. Lee & Kang, 2007; C. C. Wang & Lin, 2013), Tanzania (Goedhuys, 2007), Kenya (Kamau & Munandi, 2009) but negative relationships were observed in Chile and Mexico (Crespi & Zuniga, 2012).

Previous empirical studies have shown that internal R&D coupled with external R&D significantly influences innovation by firms (Ceccagnoli, Higgins, & Palermo, 2014; Rehman, 2015). External networks benefit firms by sharing risks and costs and exploiting economies of scale (Rehman, 2015). By conducting in-house R&D, firms can improve their absorptive capacity (Rehman, 2015). External R&D can help firms reorganize their internal resources and improve their technological capabilities (Tojeiro-Rivero & Moreno, 2019). Firms can improve their innovation performance by overcoming the obstacle of resource constraint (Rehman, 2015). Past research on external R&D has shown that inter-firm collaborations for R&D influence product innovation (Mukherjee, Gaur, Gaur, & Schmid, 2013; Rehman, 2015). In the case of India, both internal R&D and external R&D are known to influence product and process innovations (Rehman, 2015). Thus, we expect both internal and external R&D to positively influence innovation and propose the following hypotheses:

H1a. Internal R&D will be positively related to innovation
H1b. External R&D will be positively related to innovation

iii. Skilled Labor and Innovation

Skilled labor at the firm-level refers to the quality of the workforce generally in terms of the level of formal education, training, and expertise. Highly skilled workers are more likely to contribute to innovation (Al-Laham, Tzabbar, & Amburgey, 2011; McGuirk, Lenihan, & Hart, 2015) because they significantly enhance the absorptive capacity of the firm (Liu & Buck, 2007; Roper & Love, 2006). Absorptive capacity contributes to innovation through a highly skilled workforce because workers are better able to identify, assimilate, and exploit external sources of knowledge (Cohen & Levinthal, 1990). Several studies of developing countries (Barasa et al., 2017; Goedhuys, 2007; Robson, Haugh, & Obeng, 2009) found that a highly-skilled workforce contributes positively to firm-level innovation. The quality of the workforce is often measured by the level of formal education, on-the-job training, and experience. Thus, we expect skilled labor to be positively related to innovation and propose the following hypothesis:

H2. Skilled labor will be positively related to innovation

iv. Managerial Experience and Innovation

Research on dynamic capabilities, which emphasizes the importance of managerial capabilities, shows the positive impact of managerial actions on innovation (Babelytė-Labanauskė & Nedzinskas, 2017; Helfat & Martin, 2015). Managerial skills are usually acquired over time and are very critical for identifying innovation opportunities arising from changes in the environment (Barasa et al., 2017; H. Li & Atuahene-Gima, 2001). Moreover, since innovation is generally high-risk, managerial experience is considered important for understanding and mitigating these risks and enact strategies for successful innovation (Schilirò, 2010). Indeed, higher managerial experience may reflect higher levels of tacit knowledge and skills that are important for successfully identifying and managing innovation projects (Custódio, Ferreira, & Matos, 2019). Additionally, empirical evidence indicates that more experienced managers are better able to sense and respond to environmental signals (Barasa et al., 2017; McGee & Dowling, 1994; Nichter & Goldmark, 2009). Thus, we expect the managerial experience to be positively related to innovation and propose the following hypothesis:

H3. Managerial experience will be positively related to innovation

3.4 Regional-level Variables

Regional-level variables indicate regional endowments (Tojeiro-Rivero & Moreno, 2019) of the respective variable. Prior research on innovation, economic growth, and productivity show positive relationships between various institutional variables and innovation (Butkiewicz & Yanikkaya, 2006; D'Agostino & Scarlato, 2019; Kim & Loayza, 2019; Santarelli & Tran, 2018; Silve & Plekhanov, 2018; Vecchi et al., 2015). Specifically, positive relationships were observed between innovation and country- or regional-level infrastructure, human capital, R&D expenditure, and ICT exports. These are discussed below.

i.) Infrastructure

Infrastructure is important for innovation, economic growth, and productivity because it provides efficient and effective access to transportation, energy, water, information technology, and other technology infrastructure, all of which are promoting all economic activities (Kim & Loayza, 2019). According to Aschauer (1989), core infrastructure that consists of roads, airports, highways, water and sanitation and many infrastructure-related factors influence productivity in the US to a great extent. Similarly, Jorgenson, Ho, and Stiroh (2008) and Oliner, Sichel, and Stiroh (2007) found that Information and Communication Technology (ICT) played an important role in improving the productivity in the US during the mid-1990s and 2000s. Further, Straub (2008) analyzed 64 research papers covering 140 countries and found that infrastructure positively influences economic growth and enables firms to invest in more productive machinery, decreasing workers' commuting times, and promoting health and education (Kim & Loayza, 2019; Straub, 2008). However, in studies related to infrastructure in emerging economies, it is often found that innovation and infrastructure have a negative influence (Kim & Loayza, 2019) and hence it would be interesting to understand if it holds true in the case of India as well.

ii.) Human Capital

At the regional level, human capital can be considered the stock and flow of knowledge available to firms within the regions (Goldin, 2016; Jones et al., 2016). The level and quality of human capital in a region are influenced by the nature of the educational system in terms of the quantity and quality of higher educational institutions as well as access to them (Baro, 2001; Hanushek & Wößmann, 2007). Some authors contend that for education to contribute to productivity, it must consist of strong basic foundations and sufficient specialization, rich in both quantity and quality, and spread throughout the population (Baro, 2001; Hanushek & Wößmann, 2007). Human capital is also determined by the proportion of the population that has access to tertiary or postsecondary education. Several recent studies show that human capital positively influences innovation (Vecchi et al., 2015; Zelazny & Pietrucha, 2017). According to Kim and Loayza (2019), the knowledge and skills of the population are essential to generate new technologies and to disseminate, adapt, and implement them throughout the economy.

Further, for education to contribute to productivity, it must consist of strong basic foundations and sufficient specialization, rich in both quantity and quality, and spread throughout the population (Baro, 2001; Hanushek & Wößmann, 2007). In the case of developing countries, Kim and Loayza (2019) show that a sufficiently high level of education increases productivity growth by enabling them to adopt new technologies from frontier countries. For instance, Miller and Upadhyay (2000) show that education level can affect how developing countries adopt new technologies through trade. Generally, human capital is measured in a variety of ways including a country's average years of schooling (Baro, 2001; Benhabib, Spiegel, Aghion, & Durlauf, 2005), government expenditure on education, teacher-student ratio (Wei & Hao, 2011), the completion rate of secondary and tertiary education of the population (Benhabib et al., 2005; Bronzini & Piselli, 2009;

Erosa, Koreshkova, & Restuccia, 2010; Griffith, Redding, & Reenen, 2004), and literacy rate (Hippe, 2012).

In our study, human capital was considered in the form of labor. The labor indicator consists of several sub-indicators that include labor force participation rate (per 1000), percentage of the population with at least secondary level of education, percentage of individuals who received technical training out of the total population, seating capacity at Industrial Training Institutes (ITIs), the average wage of wage salaried persons aged 15 years and above, average wage of labor working in the manufacturing sector, the share of the workforce in manufacturing in percent, workers aged 15 years and above, man-days lost due to strike and lockouts. (NCAER State Investment Potential Index, 2017). These sub-indicators were aggregated using a weighted arithmetic mean to compute a single composite investment score.

iii.) ICT Exports

Today, technological capabilities are considered primary factors for competitiveness and growth due to the rising share of technological-intensive products globally (Fayaz & Bhatia, 2018). Past research has shown that firms that export products/services are often more innovative than other firms (Santarelli & Tran, 2018). The productivity of a firm is influenced by the firms' ability to export goods thus helping the firms reach global markets (Hausmann, Hwang, & Rodrik, 2007). Exports help firms in emerging countries better understand and learn from their customers, which could help improve (innovate) their products, and customers may even suggest new products to better meet their needs. Thus, exports can have a positive impact on product innovation (Jing Li et al., 2010; Xie & Li, 2017).

However, in recent times, China and India have emerged successful in the export of high-technology and service fields thus increasing their productivity that is almost similar to developed economies like the US and Japan (Fan, 2011). It was only in the 1990s that India implemented a new Economic Policy to remove restrictions in international trade and investments, thus resulting in access to foreign technologies, Foreign Direct Investments (FDI), and favoring the manufacturing and exporting firms. The development of Information and Communications Technology (ICT) exports and the evolution of high technology firms helped India become a knowledge powerhouse (Mani, 2008). The tremendous growth of the Indian economy is primarily due to the service sector (Fayaz & Bhatia, 2018). In our study, we consider ICT Exports as an indicator of knowledge diffusion since it measures the extent to which an economy of the state has scaled up from resource-driven to innovation-driven (India Innovation Index 2019).

iv.) Input of Innovative activities

Regional expenditure on R&D, which can be considered an indication of the knowledge endowment of the region (Tojeiro-Rivero & Moreno, 2019), is positively related to innovation and economic growth (Commission, 2014; Tödtling & Trippl, 2005). Similarly, Feldman and Florida (1994) argued that the concentration of R&D activities in a region provides knowledge, new scientific discoveries, and opens new opportunities for the firms located in the region.

Thus, the final regional variable considered for our study was R&D expenditure as a proportion of Gross State Domestic Product. Moreno, Paci, and Usai (2005) used R&D expenditure as a proportion of Gross State Domestic Product as an input of innovative activities, hence in our study as well, we used the same parameter.

Thus, we have the following hypotheses –

H4. Infrastructure will be positively related to innovation

H5. Human Capital will be positively related to innovation

H6. ICT Exports will be positively related to innovation

H7. Input of Innovative activities will be positively related to innovation

Based on the preceding analysis, we expect that the following regional-level variables - infrastructure, human capital, ICT exports, and input of innovative activities (R&D/GDSP) will positively influence innovation.

v.) Quality of Governance

As noted in the literature review, properly designed institutions can stimulate innovative behaviors (Laursen, Masciarelli, & Prencipe, 2012) while weak institutions can have the opposite effect (Greif, 2006) since institutions set the rules of the game (North, 1990). Prior studies involving the influence of institutions on innovation and economic growth have used many variables such as provincial competitiveness index (Santarelli & Tran, 2018); rule of law and democratic institutions (Butkiewicz & Yanikkaya, 2006); Herfindahl index (Silve & Plekhanov, 2015); tenure of provincial leaders and change in leadership (Tran, 2019) and regulatory quality, corruption and rule of law (Barasa et al., 2017). Many of these studies have reduced the laundry list of variables into composite indices (Barasa et al., 2017; Tran, 2019). The most widely used indicators of quality of institutions are regulatory quality, rule of law, and corruption (Barasa et al., 2017). Poor regulatory quality can increase transaction costs, affect the effective functioning of factor markets (e.g., labor and capital), and increase information asymmetries (Barasa et al., 2017; Meyer, Estrin, Bhaumik, & Peng, 2009). In the case of emerging economies, corruption at the firm-level of manufacturing industries and in regions having a more corrupt government has a negative association with innovation (C.-C. Lee, Wang, & Ho, 2020). It was also found that the country governance has a crucial role in the innovation of firms that engage in corruption (C.-C. Lee et al., 2020). In other studies, it was found that the rule of law has a positive influence on innovation and economic growth (Gimenez & Sanau, 2007; C.-C. Lee et al., 2020; Oluwatobi, Efobi, Olurinola, & Alege, 2015; Sena, Duygun, Lubrano, Marra, & Shaban, 2018). Furthermore, it was shown that high regulatory quality reduces information asymmetry, increases accountability, and curtails bank lending corruption (Gimenez & Sanau, 2007).

Kim and Loayza (2019) contend that there is significant evidence showing that good governance (reflected in the rule of law and the absence of corruption) positively affects productivity and economic growth. In the case of corruption, Mauro (1995) found that corruption has a negative effect on economic growth. This negative relationship was also reported by other studies (Knack & Keefer, 1995; C.-C. Lee et al., 2020). Further, several studies reported that the quality of institutions (measured by variables such as rule of law, corruption, and bureaucratic quality) is positively related to productivity (Chanda & Dalgaard, 2008; Rodrik, Subramanian, & Trebbi, 2004).

Based on the links of institutional quality, economic growth, productivity, and the links between these and innovation, we infer that institutional quality will positively affect innovation. Thus, we expect that high regulatory quality, low levels of corruption, and high rule of law will promote innovation. Barasa et al. (2017) examined the effect of regional institutional quality of regulatory quality, corruption, and rule of law factors on innovation through interactions with internal R&D. Following Barasa et al. (2017), we also tested these relationships in our study. Thus, we propose the following hypotheses:

H8a. High levels of Regulatory Quality Barrier will negatively moderate the effect of internal R&D on the firms' ability to innovate.

H8b. High levels of Corruption Barrier will negatively moderate the effect of internal R&D on the firms' ability to innovate.

H8c. High levels of Rule of Law Barrier will negatively moderate the effect of internal R&D on the firms' ability to innovate.

3.5 Control Variables

In line with previous innovation studies (e.g., Barasa et al., 2017; Tojeiro-Rivero & Moreno, 2019), we employed several firm-level control variables including firm age, firm size, legal status, industry, and access to external funding. Prior research (Ayyagari, Demirgüç-Kunt, & Maksimovic, 2011; Barasa et al., 2017; Jiménez-Jiménez & Sanz-Valle, 2011) has shown a positive relationship between firm size and innovation because larger firms have an advantage in economies of scale in terms of innovation as in production (Barasa et al., 2017). Similarly, many previous studies found that firm age is negatively related to innovation, which suggests that newer firms are more likely to introduce innovation relative to older firms (Ayyagari et al., 2011; Barasa et al., 2017). Prior research (Ayyagari et al., 2011; Barasa et al., 2017) also shows that ownership and legal status play an important role in innovations. These authors show that firms organized as corporations tend to be more innovative than firms that are incorporated e.g., sole proprietorships and partnerships. Similarly, external funding was reported to have a positive influence on innovation as reported by (Ayyagari et al., 2011; Barasa et al., 2017).

At the regional level, Gross State Domestic Product (GSDP) per capita is often regarded as a wealth index of a state/region (Moreno et al., 2005; Tojeiro-Rivero & Moreno, 2019). According to Tojeiro-Rivero and Moreno (2019), differences in the GDP per capita or wealth effects across different regions influence regional innovation differently. Thus, this effect should be controlled.

Chapter 4
Methodology

This chapter describes the methodology used in this research. The focus is on the data collection process, data and variables descriptions, and data analysis approach.

4.1 Data Collection

This study is based on two datasets corresponding to the two levels of analysis: firm-level variables and regional-level variables. Firm-level variables are taken from the World Bank Enterprise Survey and regional variables are obtained from various statistical sources from India. Both datasets are described in this section.

4.1.1 Enterprise Survey

The firm-level data is from the World Bank's Enterprise Survey, which is described based on information provided by the World Bank (Enterprise-Surveys, 2014). This survey includes a wide range of topics representing the business environment of the country, such as infrastructure, crime, corruption, competition, innovation, technology, labor force characteristics, managerial experience, access to finance, and a range of performance measures (Enterprise-Surveys, 2014). The Enterprise Survey contains a wide range of economic data with over 146,000 interviews from 143 countries around the world (Enterprise-Surveys, 2014). The Enterprise Survey gathers a variety of qualitative and quantitative information from firm managers and/or owners. The population of this survey is chosen to ensure adequate representation of small, medium, and large firms from all business sectors and industries. The public sector, administrative services, healthcare, and financial services are excluded from the population (Enterprise-Surveys, 2014). The questionnaire used in the Enterprise Survey is based on the Global Methodology in 2006 (Enterprise-Surveys, 2014). The data are grouped by countries and regional blocks. The regions included are Eastern Europe and Central Asia, Latin America and the Caribbean, East Asia and Pacific, South Asia, Africa, the Middle East, and North Africa (Enterprise-Surveys, 2014). All the data along with the raw datasets for countries of each year, panel datasets, and all survey-related questions and documents are accessible to the public (Enterprise-Surveys, 2014).

4.1.2 India and Enterprise Survey Dataset

The Enterprise Survey for India was conducted between June 2013 and December 2014 with the primary objective of getting feedback from firms on the status of the private sector. The survey included several topics including firm characteristics, gender participation, access to finance, annual sales, costs of inputs/labor, workforce composition, bribery, licensing, infrastructure, trade, crime, competition, capacity utilization, land and permits, taxation, informality, business-government relations, innovation and technology, and performance measures (India, 2014). Of all the questions in the survey, over 90% of them objectively ascertain (India, 2014) a country's business environment while the rest of the questions assess (India, 2014) the survey respondents' views on the growth and performance of the firm. A stratified random sampling technique was used to survey the firms via face-to-face interviews resulting in a total of 9281 firms. The key sampling unit of the firm-level survey is the location(s) of the firm where the actual business operations are carried out.

The strata for Enterprise Surveys are based on 3 criteria – industry, establishment size, and region (India, 2014). Stratification by industry consists of 11 manufacturing industries and 7 services industries[2] (India, 2014). The firm size strata for Enterprise Surveys divide firms into three groups based on the number of permanent full-time employees i.e. small, medium, and large. Small firms are the firms with 5 to 19 employees, medium firms are firms with 20 to 99 employees, and large firms have more than 99 employees (India, 2014).

The survey reclassifies the 29 states and 7 Union territories into 23 states as follows:– (1) Delhi being a Union Territory was considered a state; (2) The remaining 6 Union Territories – Chandigarh, Andaman and Nicobar, Pondicherry, Lakshadweep, Daman and Diu, and lastly Dadra and Nagar Haveli were not considered for the study due to their extremely small size and low contribution to the country's GDP; (3) Mizoram and Sikkim states were also not considered due to their low contribution to the country's GDP (less than 0.1%); (4) The survey data for the state

[2] Manufacturing: food, tobacco, textiles, garments, leather, wood, paper, publishing, printing and recorded media, refined petroleum product, chemicals, plastics & rubber, non-metallic mineral products, basic metals, fabricated metal products, machinery and equipment, electronics, precision instruments, transport machines, furniture, recycling, and retail.

Services: construction, services of motor vehicles, wholesale, hotels and restaurants, transportation, and IT of Andhra Pradesh included both Andhra Pradesh and Telangana; (5) The state of Arunachal Pradesh included the states – Arunachal Pradesh, Manipur, Meghalaya, Nagaland, and Tripura and hence were combined for stratification (India, 2014). The survey concentrated on major regions and the neighboring business regions. Table 2 shows the 23 states that are considered in this study.

Table 2: States of India

States	States
1. Andhra Pradesh (includes Telangana)	13. Karnataka
2. Arunachal Pradesh (includes Arunachal Pradesh, Manipur, Meghalaya, Nagaland & Tripura)	14. Kerala
3. Assam	15. Madhya Pradesh
4. Bihar	16. Maharashtra
5 Chhattisgarh	17. Orissa
6. Delhi	18. Punjab
7. Goa	19. Rajasthan
8. Gujarat	20. Tamil Nadu
9. Haryana	21. Uttar Pradesh
10.Himachal Pradesh	22. Uttaranchal
11. Jammu & Kashmir	23. West Bengal
12. Jharkhand	

The survey reveals two different kinds of questionnaires for the 3 categories of industries – manufacturing, retail, and others/non-retail. The questionnaire for Manufacturing consists of a common set of questions asked to all firms but added a few questions that pertain directly to manufacturing firms (India, 2014). Similarly, the service and other/non-retail questionnaires consist of a common set of questions asked to all firms and a few relevant questions to retail and other service-related firms (India, 2014). The variables in Tables 3 and 4 in Appendix 2 show the list of variables that were selected for this study from both the manufacturing and innovation questionnaires of the Enterprise Survey.

4.1.3 Regional Dataset

For the state-level data, we were able to access data for the variables from the following credible sources: India Brand Equity Foundation (IBEF), Indiastat.com, National Council of Applied Economic Research (NCAER), India Innovation Index, and R&D Expenditure Ecosystem. There was no single data source available for all the variables we were interested in our study. Each of these reputable data sources is described below.

i.)   IBEF

IBEF is a Government-owned agency under the Ministry of Commerce and Industry of the Government of India (IBEF, 2019). It was founded in 2003. The IBEF site provides a detailed analysis of all the states of India and is regarded as a useful resource center for information on the states and Union territories (IBEF, 2019). The website provides information on the economic status, physical, social and industrial infrastructure along with the important sectors and important policies and procedures initiated by the State and the Central Government (IBEF, 2019). For the purpose of the study, the following factors were extracted from this source – i.) Geographical area (sq. km); ii.) Total population (million) and iii.) Literacy rates.

ii.)   Indiastat.com

Indiastat.com provides statistical data about various states of India. It is owned by Datanet India, which is a private company (Indiastat, n.d.). This is a paid source, but they provided the information for two variables on a complimentary basis after having sent them an email explaining that the information will be used for the thesis research. They provided data on the Gross State Domestic Product (GSDP) in 2014 at constant prices and life expectancy at birth in 2017.

iii.)   Infrastructure Statistics (2014)

Data for infrastructure was obtained from a report produced by the Central Statistics Office that has a separate standing committee to collect data related to infrastructure and its sub-sectors (Infrastructure-Statistics, 2014). Two items on infrastructure were taken from this source, namely, state-level data on the road density per 1000 population and rail density per 1000 population.

iv.)   India Innovation Index 2019

This report provides extensive information on various innovation indicators for the 29 states and 7 Union territories along with individual state profiles. Examples of data provided include – knowledge diffusion; investment, and business environment indicators (NITI-Aayog, 2019). This report was created by the National Institution for Transforming India (NITI) Aayog that was established by the Government of India to achieve sustainable development goals and for innovation to prosper in the country (NITI-Aayog, 2019). For our study, we used data on ICT Exports for the year 2017 as one of the indicators of knowledge diffusion and the extent to which an economy of the state has scaled up from resource-driven to innovation-driven (NITI-Aayog, 2019).

v.) NCAER State Investment Potential Index

The National Council of Applied Economic Research (NCAER) is India's oldest and largest independent, non-profit, economic policy research institute (NCAER, 2017). NCAER's State Investment Potential Index report provides metrics of economic governance, competitiveness, and growth opportunities of 20 states and the Union Territory of Delhi (NCAER, 2017). For the purpose of our study, the labor indicator was considered that consists of several sub-indicators that include labor force participation rate (per 1000), percentage of the population with at least secondary level of education, percentage of individuals who received technical training out of the total population, seating capacity at Industrial Training Institutes (ITIs), the average wage of wage salaried persons aged 15 years and above, average wage of labor working in the manufacturing sector, the share of the workforce in manufacturing in percent, workers aged 15 years and above, man-days lost due to strike and lockouts (NCAER, 2017).

vi.) R&D Expenditure Ecosystem

This report was released by the Economic Advisory Council to the Prime Minister (EAC-PM) whose main objective is to collect up-to-date Research & Development (R&D) related data and make it available globally (EAC-PM, 2019). This report provides information on the R&D ecosystem of the country both at the national and state level. For our study, the R&D Expenditure as a proportion of Gross State Domestic Product (GSDP) (2016-17) values of different states were used.

Table 5 in Appendix 2 lists the regional-level parameters that were considered for the analysis.

4.2 Data Analysis

In our study, we used STATA v.13 to analyze the data. Two STATA files were created – one containing the data of all firms for the manufacturing questionnaire and the other for the innovation questionnaire. We also created an Excel file containing data for all the regions. For the purpose of our study, we re-coded all those questions that had Yes or No answers to "1" as "Yes" and "0" as "No".

In the next section, the variables considered for our study are described.

4.3 Variables Description

4.3.1 Dependent Variable

In our study, product innovation was the dependent variable. Respondents were asked to answer the following question: "From fiscal year 2010/2011 thru 2012/2013, did this establishment introduce any innovative product or service?" Response categories were 1=yes, 0=no, and -9 = don't know.

Although a total of 9281 firms participated in the survey, around 3490 firms answered the question on product innovation as "Yes" while the remaining firms answered either "No" or "Don't Know". Hence, for the purpose of our study, we considered only those firms that answered the question either with a "Yes" or "No" and eliminated all the "Don't Know" answers by setting them as missing values.

4.3.2 Firm-Level Independent and Control Variables

The firm-level variables considered in our study comprised of independent variables and control variables. The independent variables were internal R&D, external R&D, managerial experience, and skilled labor. The control variables were firm age, firm size, legal status, industry, and external fund. Each of these variables is described below.

i.) Firm Age

In our study, the age of the firm was used as a control variable because previous research has shown that age of the firm is inversely related to innovation thus implying that newer firms are more likely to innovate products/services than older firms (Ayyagari et al., 2011; Barasa et al., 2017). However, the Enterprise Survey does not compute the age of the firm. Hence, we computed the difference between the year the survey was conducted, and the year the firm began its operations and then computed the log for each of the values. The table below shows the question associated with firm age. For our study, we considered only those firms that answered the question and eliminated all the "Don't Know" answers by setting them as missing values.

Variable	Description
Firm Age	Foundation Year - In what year did this establishment begin operations? Foundation_year - Year establishment began operations Don't Know = -9 Interview_year - Year the interview begins Firm_Age = Foundation_year - Interview_year

ii.) Firm Size

Previous research has shown that the size of the firm is positively associated with innovation (Ayyagari et al., 2011; Barasa et al., 2017; Jiménez-Jiménez & Sanz-Valle, 2011). The Enterprise Survey classifies firms as small firms if the firm has less than 20 employees; medium firms if the firm has employees between 20 and 99 employees and large firms if the number of employees is over 99 employees. However, for our study, the number of permanent, full-time workers in the firm was considered and then the log of each of these values was computed for the size of the firm and used as a control variable. The table below shows the questionnaire associated with firm size. For our study, we considered only those firms that answered the question and eliminated all the "Don't Know" answers by setting them as missing values.

Variable	Description
Firm Size	At the end of the fiscal year [Insert last complete fiscal year], how many permanent, full-time individuals worked in this establishment? Please include all workers and managers. Permanent, full-time workers are defined as all workers that work for a term of one or more fiscal years and/or have a guaranteed renewal of their employment and that work a full shift. No_of_employees - Permanent, full-time workers at the end of last fiscal year -9 - Don't Know (Spontaneous)

iii.) Industry

The industry variable was controlled as per previous studies (Goedhuys, 2007). Variations in the industry were controlled by a set of dummy variables for the industry with the reference category being the Construction industry. The industries in our study were Food, Tobacco, Textile, and Clothing; Wood, Paper, Chemicals, and Non-metallic Products, Machinery and Equipment, Wholesale, Retail, Transportation, Information Technology, Accommodation, and Other Services with reference category to the Construction industry.

iv.) Legal Status

According to previous studies (Ayyagari et al., 2011; Barasa et al., 2017), legal status plays an important role in innovation in which firms organized as corporations are more likely to innovate when compared to non-corporations like – sole proprietorship, partnership, and limited partnership. In our study, legal status was a dummy variable and used as a control variable with a value of "1" if the firm was organized as a corporation (A shareholding company with shares trade in the stock market and Shareholding company with non-traded shares or shares traded privately) and a value of "0" if otherwise (sole proprietorship, partnership, and limited partnership). The table below shows the questionnaire associated with legal status.

Variable	Description
Legal Status	What is this firm's current legal status? 1 – Shareholding company with shares trade in the stock market 2 – Shareholding company with non-traded shares or shares traded privately 3 – Solo proprietorship 4 – Partnership 5 – Limited partnership 6 – Other

v.) R&D

According to previous studies (Barasa et al., 2017; Crespi & Zuniga, 2012), R&D refers to tasks undertaken by firms to innovate products and/or services allowing them to remain competitive with other firms. For our study, we considered the questions related to internal R&D and external R&D. Internal R&D refers to tasks performed to improve knowledge on existing products and processes while external R&D refers to tasks contracted out to other firms or research organizations. In our study, we used a dummy variable for both internal R&D and external R&D separately whose value was "1" if the firm conducted internal R&D and external R&D and a value of "0" if otherwise. The table below shows the questionnaire associated with R&D. For our study, we considered only those firms that answered the question and eliminated all the "Don't Know" answers by setting them as missing values.

Variable	Description
Internal R&D	From fiscal year 2010/2011 thru 2012/2013 did this establishment conduct internal R&D? (Internal R&D is defined as creative work undertaken to increase knowledge for developing innovative products and processes.) 1 - Yes 0 - No -9 - Don't Know (Spontaneous)
External R&D	From fiscal year 2010/2011 thru 2012/2013 did this establishment conduct external R&D? (External R&D is defined as creative work, undertaken by other enterprises, public or private research organizations, which was paid for by this establishment.) 1 - Yes 0 - No -9 - Don't Know (Spontaneous)

vi.) Skilled Labor

The skilled labor variable is a dummy variable that was considered as per previous studies (Barasa et al., 2017) from the manufacturing questionnaire and asked respondents if the firm provided any formal training programs for its permanent, full-time workers taking a value of "1" if the answer was "Yes" and "0" if otherwise. The table below shows the questionnaire associated with skilled labor. For our study, we considered only those firms that answered the question and eliminated all the "Don't Know" answers by setting them as missing values.

Variable	Description
Skilled Labor	Over fiscal year [Insert last complete fiscal year], did this establishment have formal training programs for its permanent, full-time workers? 1 - Yes 0 - No -9 - Don't Know (Spontaneous)

vii.) Managerial Experience

The manufacturing questionnaire for the managerial experience asked respondents about the experience in terms of the number of years of the top manager and a value of 1 if less than one year. For our study, the managerial experience was also a dummy variable selected from the manufacturing questionnaire that took a value of "1" if the top manager's experience was greater than 10 years in the business sector and "0" if otherwise. This classification was used based on the similar cut-offs by Barasa et al. (2017). The table below shows the questionnaire associated with managerial experience. For our study, we considered only those firms that answered the question and eliminated all the "Don't Know" answers by setting them as missing values.

Variable	Description
Managerial Experience	How many years of experience working in this sector does the Top Manager have? b7 – Manager's experience in the sector 1 – Less Than One Year Don't Know = -9

4.3.3 Regional-level Variables

Like firm-level variables, the regional variables consisted of both independent and control variables. The independent variables were regional institutional barriers, R&D/Gross State Domestic Product also known as Input of Innovative activities, Human Capital, Infrastructure, and ICT Exports. The control variable was GDP per capita, which controls for differences in wealth effects among states. Each of these variables is described below.

viii.) Regional Institutional Barriers

For the purpose of our study, the regional institutional barriers were derived from the firm-level understanding of regulatory quality, corruption, and rule of law that were associated at the regional level (Barasa et al., 2017). Table 6 of Appendix 2 describes the actual questions, items, and response categories that reflect the governance and institutional quality barriers. The regulatory quality component consisted of questions asked to respondents related to the obstacle to the present operations of the firm on a five-point scale ranging from a value of "0" if the respondent answered as "No obstacle" to a value of "4" if the respondent answered as "Very Severe Obstacle". The respondent was asked to rate the obstacles of tax rates, tax administration, customs and trade, business licensing, and permits using the five-point scale. Similarly, the corruption component consisted of two questions asking the respondents if they think "The court system is fair, impartial and uncorrupted." On a four-point scale ranging from a value of "1" if the respondent answered as "Strongly disagree" to a value of "4" if the respondent answered as "Strongly agree"; and another question if corruption was an obstacle to the present operations of the firm on a five-point scale(0 = "No obstacle" to 4 = "Very Severe Obstacle"). Lastly, the rule of law component consisted of three questions asked to the respondent if (i.) courts; (ii.) political instability, and (iii.) Crime, theft, and disorder were an obstacle to the present operations of the firm on a five-point scale (0 = "No obstacle" to 4 = "Very Severe Obstacle").

The regional institutional quality barriers were standardized to accurately compare the influence of innovation on firm-level factors. For the purpose of standardization, we calculated the mean and standard deviation of each of the sub-components of the three regional institutional quality barriers (regulatory quality, corruption, and rule of law). The standardized components for each of the sub-components were derived by the difference of the individual values and the mean of the sub-components and the difference was then divided by the standard deviation of the respective sub-components. The standardized sub-components were then added together with their respective regional institutional quality barriers thus resulting in the final three barriers (regulatory quality, corruption, and rule of law).

ix.) Input of Innovative activities

For our study, the R&D Expenditure as a proportion of Gross State Domestic Product values of different states for the years 2016 and 2017 were considered thus implying the investment in R&D. The table below shows the description associated with the Input of Innovative Activities.

Variable	Description
Input of Innovative Activities	This was measured as the ratio of R&D expenditure divided by the Gross State Domestic Product.

x.) Human Capital

The table below shows the description associated with Human Capital and reflects the investment in Human Capital in the form of Labor.

Variable	Description
Human Capital	The indicator is normalized with 0 being the worst-case scenario and 100 being the best-case scenario. This indicator consists of several sub-indicators that include labor force participation rate (per 1000), Percentage of population with at least secondary level of education, percentage of individuals who received technical training out of the total population, seating capacity at Industrial Training Institutes (ITIs), Average wage of wage salaried persons aged 15 years and above, Average wage of labor working in the Manufacturing sector, Share of the workforce in Manufacturing in percent, workers aged 15 years and above, Man-days lost due to strike and lockouts.

xi.) Infrastructure

For the infrastructure variable that acts as an enabler of innovation, we considered the road density per 1000 population and rail density per 1000 population for all the regions. The values of the rail density and road density were added and then divided by 2 to compute the aggregate of the two factors for our study. The table below shows the description associated with Infrastructure.

Variable	Description
Infrastructure	Road density per 1000 population Rail density per 1000 population Aggregate = (Road density per 1000 population + Rail density per 1000 population) / 2

xii.) ICT Exports

For our study, we considered one of the sub-indicators of the Knowledge Diffusion indicator i.e., ICT Exports acting as an output of innovative activities that measured the extent to which an economy of the state has scaled up from resource-driven to innovation-driven. The table below shows the description associated with ICT Exports.

Variable	Description
ICT Exports	The values are transformed into a 0 to 100 scale with 0 being the worst-case scenario and 100 being the best-case scenario.

xiii.) GDP per capita

The variable GDP per capita measures the wealth of the state and has often been used in the influence of institutional factors on innovation (Moreno et al., 2005; Tojeiro-Rivero & Moreno, 2019). However, in our study, GDP per capita was computed as the ratio of Gross State Domestic Product divided by the total population in terms of per million people. The table below shows the description associated with GDP per capita.

Variable	Description
GDP per capita	Calculated as – GDP per capita = GSDP at Constant Prices (in 10 million) / Total population (million) (per million population) = GDP per capita / 1000000

4.3.4 Interaction Terms

xiv.) Internal R&D and Regional Institutional Barriers

In our study, we examined the effect of firm-level variables on the regional institutional barriers of regulatory quality, corruption, and rule of law. The interaction terms would help us understand that while firm-level factors are known to influence innovation, examining these interaction terms of firm-level and institutional variables would provide us an understanding of the variables that influence innovation in the presence of institutional variables under the current operations of the firm (Barasa et al., 2017).

Firms invest in R&D to expand their knowledge in scientific and technical aspects thus allowing them to innovate a new product/service (Barasa et al., 2017). However, the degree to which the firms derive value by conducting internal R&D and innovate a new product/service depends on the regional institutional quality (Barasa et al., 2017; Martín-de Castro et al., 2013). For firms that consider regional institutional quality as barriers for their innovation are less likely to benefit from R&D (Zhao, 2006).

Chapter 5
Results

5.1 Descriptive Analysis

Descriptive statistics provide a general description of the distribution of the sample and the measures used in the study. Table 7 shows that the sample size of this study was just under 3500 firms. Also, approximately 65 percent of responding firms indicated that they have an innovative output (product innovation), 46 percent conducted internal R&D, and just under 10 percent conducted external R&D. Further, just over 50 percent of the firms have managers who have more than 10 years of managerial experience, and just under half (46 percent) of the firms have a very skilled workforce i.e. provided additional new product training to their employees. Also, 63 percent of firms received some form of external funding from sources such as private or state-owned banks, government agencies or departments, NGOs, or international organizations.

Table 7: Descriptive Statistics of the variables

Variables	Obs.	Mean	Std. Dev.	Min	Max
Product Innovation	3490	0.6519	0.4765	0	1
Firm Age (log)	3492	2.7227	0.7966	0	7.6123
Firm Size (log)	3490	3.7720	1.2851	1.0986	8.9872
Legal Status	3492	0.1134	0.3171	0	1
External Fund	3492	0.6320	0.4823	0	1
GDP per capita	3492	0.0941	0.0541	0.0139	0.2600
Internal R&D	3478	0.4638	0.4988	0	1
External R&D	3479	0.0928	0.2903	0	1
Managerial Experience	3492	0.5052	0.5001	0	1
Skilled Labour	3492	0.4648	0.4988	0	1
Infrastructure (Rail & Road Density)	3492	1.9230	1.0122	0.44	4.635
ICT Exports	3492	13.8713	24.7076	0.01	100
Human Capital (Labor)	3492	53.0718	9.2433	32.3	73.8
R&D Expenditure/Gross State Domestic Product	3492	0.0659	0.0380	0.01	0.2
Regulatory Quality Barrier	3261	-0.0503	2.9835	-7.4760	12.998
Corruption Barrier	3391	0.0066	1.3756	-7.4117	3.7949
Rule of Law Barrier	3362	0.0079	2.1677	-4.2129	12.5755

Table 8 shows the distribution of firms that conducted internal and external R&D and produced product innovations. The data shows that around 34 percent of firms that conducted internal R&D produced product innovations while 13 percent of firms with internal R&D did not report any product innovations. Similarly, 7 percent of the firms that conducted external R&D introduced new products. Overall, it can be inferred that both internal and external R&D is very important for product innovations.

Table 8: Frequency Product Innovation and Internal R&D and External R&D

Internal R&D	**Product Innovation**		
	Yes (%; # firms)	No (%; # firms)	Total (# firms)
Yes (%; # firms)	33.77 (1174)	12.63 (439)	1613
No (%; # firms)	31.44 (1093)	22.15 (770)	1863
Total	2267	1209	3476
External R&D			
Yes (%; # firms)	7.07 (246)	2.21 (77)	323
No (%; # firms)	58.21 (2024)	32.50 (1130)	3154
Total	2270	1207	3477

Table 9 shows the frequency distributions of product innovation and managerial experience and skill levels of the workforce based on additional training provided by the company. As shown in Table 9, around 34 percent of firms whose managers have more than 10 years of experience in the sector have introduced product innovations. Similarly, 31 percent of firms that provide additional formal training to their employees introduced new product innovations. This implies that both managerial experience and formal training of employees seemed to have contributed positively to product innovation.

Table 9: Frequency of Product Innovation and Managerial Experience and Skilled Labor

Managerial Experience	**Product Innovation**		
	Yes (%; # firms)	No (%; # firms)	Total (# firms)
10 or more years	34.21 (1194)	16.30 (569)	1763
Less than 10 years	30.97 (1081)	18.51 (646)	1727
Total	2275	1215	3490
Skilled Labor/Training			
Formal training	31.00 (1082)	15.50 (541)	1623
No formal training	34.18 (1193)	19.31 (674)	1867
Total	2275	1215	3490

Table 10 shows the frequency of product innovation and the forms of ownership (shareholding corporation) and whether the firms received external funding. The data indicates that roughly 7 percent of shareholding corporations introduced new product innovation, but they represent only a small fraction of firms (7 percent = 257/3490) in the study. Also, roughly 42 percent of firms that received external funds from either the central government, state government, or other agencies produced product innovations. This suggests that access to external funds may improve the ability of firms to introduce innovations.

Table 10: Frequency of Product Innovation and Legal Status and External Fund

Legal Status	**Product Innovation**		
	Yes (%; # firms)	No (%; # firms)	Total (# firms)
Shareholding Corporation	7.36 (257)	3.98 (139)	396
Others	57.82 (2018)	30.83 (1076)	3094
Total	2275	1215	3490
External Fund			
External funds	41.83 (1460)	21.40 (747)	2207
No external Funds	23.35 (815)	13.41 (468)	1283
Total	2275	1215	3490

The frequency table for the regional institutional quality barriers is in Table 11, 12, and 13 of Appendix 3.

5.2 Correlations

Correlations refer to the association between two quantitative variables and whose values range from +1 to -1 (Sharma, 2005). When one variable increases as the other increases, it implies a positive correlation; on the contrary, if one variable decreases as the other increases, it implies a negative correlation. If there is no correlation between the variables, the value = 0 (Sharma, 2005). A correlation coefficient of 0.7 and above implies a strong positive correlation and a value of 0.3 and less implies a weak correlation (Sharma, 2005). In our study, the correlation coefficients are as shown in Table 14 and indicate that there are no serious correlation effects as all the values are substantially less than 0.7.

Table 14: Table of correlations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	1																
2	-0.007	1															
3	0.0807*	0.1271*	1														
4	-0.0022	0.032	0.2248*	1													
5	0.0659*	0.0659*	0.0749*	-0.0726*	1												
6	0.1478*	0.0440*	0.2776*	0.1069*	0.0304	1											
7	0.0731*	-0.0022	0.1050*	0.0263	0.0042	0.1449*	1										
8	0.0539*	0.3145*	0.0914*	0.1047*	-0.0812*	0.0447*	-0.0285	1									
9	0.029	0.0307	0.3046*	0.1737*	0.0223	0.1844*	0.0122	0.1047*	1								
10	0.0266	0.0335	0.1171*	0.0500*	-0.0700*	0.0450*	0.0512*	0.0797*	0.0908*	1							
11	0.0534*	-0.0521*	0.0062	0.0845*	-0.0905*	0.0063	0.0202	0.0601*	0.035	0.1161*	1						
12	0.1205*	-0.0694*	0.0617*	-0.0509*	0.1209*	-0.0595*	0.0606*	-0.1180*	-0.0897*	-0.0417	0.0476*	1					
13	0.1373*	-0.0321	-0.0544*	-0.0708*	0.2139*	-0.1766*	-0.0191	-0.0137	-0.1327*	0.0189	0.0158	0.4227*	1				
14	0.0009	-0.1205*	-0.0275	0.0933*	-0.2504*	-0.0308	0.0143	-0.0162	-0.0647*	0.0035	0.3989*	-0.1183*	-0.2087*	1			
15	-0.0558*	0.0294	0.0303	-0.0002	0.0207	0.0352	0.0137	0.0449	0.0298	-0.0249	-0.023	0.013	0.0136	-0.0073	1		
16	-0.0067	0.0005	0.032	0.0144	-0.0021	0.0529*	0.0101	0.0252	0.0288	-0.002	0.0023	-0.0005	-0.0001	-0.0002	0.3036*	1	
17	-0.0847*	0.044	0.0007	-0.0022	-0.0043	0.0143	0.0105	0.0198	0.0424	0.0015	0.01	0.0074	-0.0011	0.0053	0.5529*	0.2792*	1

1 – Product Innovation; 2 – Firm Age (log); 3 – Firm Size (log); 4 – Legal Status; 5 – GDP per capita; 6 – Internal R&D; 7 – External R&D; 8 – Managerial Experience; 9 – Skilled Labour; 10 – External Fund; 11 – Infrastructure (Rail & Road Density); 12 – ICT Exports (Knowledge Diffusion); 13 – Human Capital (Labor); 14 – Input of Innovative activities; 15 – Regulatory Quality Barrier; 16 – Corruption Barrier; and 17 – Rule of Law Barrier

In the next section, the results of the logistic regression and multi-level logistic regression are discussed.

5.3 Logistic Regression

The analysis was conducted using the following two-step approach where we begin with logistic regression and then used multi-level logistic regression. Logistic regression was used initially because the dependent variable, product innovation, is binary (Hosmer Jr, Lemeshow, & Sturdivant, 2013; Long & Freese, 2006). Second, although the dataset has two levels (firms are nested within states) and the errors terms are likely to be correlated rather than independent, Barasa et al. (2017) and others recommend starting with the basic logistic model before moving to multi-level, especially when the numbers of level two clusters are small (<50) (Long & Freese, 2006; Maas & Hox, 2004). This approach was used by Barasa et al. (2017) and since the number of level two clusters in this study was 23, we followed the approach used by Barasa et al. (2017).

After the basic logistic regression analysis, we performed multilevel mixed-effects logistic regression because the results of our logistic model indicated that there were some level two (state level) effects influencing firm-level innovation.

In the basic logistic regression analysis, we ran two models. The first model consisted of a set of control variables and independent variables, some of which were at the firm-level and some at the state level. In the second model, interaction terms were added. Figures 10 and 11 of Appendix 4 show the STATA output of the results of the logistic regression models. Figure 10 is for the baseline model, which included all variables except interaction terms. Figure 11 shows the results with interaction terms included (full model). Our analysis of the results was based on the following recommendations by various researchers on interpreting the results.

The log-likelihood, whose value ranges from $-\infty$ to $+\infty$, is a measure of goodness of fit for any model and is only used to compare multiple models (UCLA, n.d.-a). The LR Test is useful in comparing the two models and understand which model fits better. It is estimated by comparing the values of the log-likelihoods of the two models, if this difference has a statistically significant value, the model with more variables is considered a better fit than the model with fewer variables (Long & Freese, 2006; UCLA, n.d.-c). The test statistic that was displayed in the results, was the distributed chi-squared whose degrees of freedom were the number of parameters not included in the initial model (UCLA, n.d.-c).

In the case of logistic regression, the likelihood ratio chi-square test is used as an alternative to the F-test in OLS regression (Williams, 2013). It is computed by the difference in the value of log-likelihood for a null model to the value of the log-likelihood that has independent variables (Williams, 2013). Likelihood has a value of less than 1 and is the probability of the results given the coefficients of the independent variables (Williams, 2013). Hence, it is a convention to use -2 times the log of likelihood (Williams, 2013). -2LL depicts how the predicted model fits the likelihood. In our base model, it was computed as $-2 *(-1981.9329-(-1822.43)) = 319.0058 = 319.01$. For the full model, the LR chi2 value was 328.18. The value in the parentheses indicates the degrees of freedom (or) the number of independent variables in our study. Prob>chi2 is the probability of obtaining the chi-square statistic if the null hypothesis is true i.e., no independent variables in the model (UCLA, n.d.-a). This value is often compared to the significant value p-value of 0.05 or 0.01 to verify if the model is statistically significant (UCLA, n.d.-a). The Pseudo R^2 statistic[3], also known as McFadden R^2, is computed as the ratio of the log-likelihood of the final model (with the independent variables) to the base model (with no independent variables) i.e. Pseudo $R^2 = LL_{Model} / -2LL_0$ (Williams, 2013). However, this statistic is not the same as R^2 of the OLS regression (Williams, 2013) and therefore it should not be interpreted as such but can be reported (Hoetker, 2007). In our study, the LR test was statistically significant with a value of 0.0271 implying that the full model with the interaction terms is a better fit than the base model without the interaction terms (Figure 12 of Appendix 4 LR Test p-value less than 0.0000). The Akaike Information Criterion[4] (AIC), which is also used to compare models (Arabnia & Tran, 2015; Busemeyer & Diederich, 2014; Maas & Hox, 2004; Wagenmakers & Farrell, 2004) indicates that the full model with the interaction was better than the baseline model (Table 15 below).

Further, Hoetker (2007) and Long and Freese (2006) posit that the sign, magnitude, confidence intervals, and marginal effects are informative output for assessing hypotheses. Therefore, we focus on these aspects. Generally, in logistic regression, the coefficients are in terms of log odds indicating the amount of change in the log odds of the dependent variable for a one-unit change in the independent variable keeping all the other variables constant (Lottes, DeMaris, & Adler, 1996; C.-Y. J. Peng, Lee, & Ingersoll, 2002). However, because of the difficulties of interpreting log-odds, logistic regression coefficients are converted into odds ratio (OR), which aids interpretation (Hosmer Jr et al., 2013). An OR of 1 indicates an increased likelihood of an event occurring while an OR of 0 indicates a decreased likelihood of the event (Lottes et al., 1996). In this study, we considered variables with a significant level of 0.05 and smaller as statistically significant while those that are greater than 0.05 but ≤ 0.10 were considered marginally significant.

Tables 15 below shows the results of the baseline and full models in terms of log-odds.

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3 Pseudo $R^2 = LL_{Model} / -2LL_0$ where LL_{Model} – Log likelihood of the final model with the independent variables; $-2LL_0$ – Log likelihood of the base model with no independent variables.

4 AIC = -2 * log(L) + 2*k; where L – log likelihood; k – number of estimated variables; n – number of variables

5.4 Model 1 and Model 2 – Logistic Regression Results

Table 15: Results of the logistic regression in terms of log-odds

Variables	Model 1 - Baseline Model	Model 1 - Full Model
Firm & Regional Variables:		
Internal R&D	0.570*** (0.089)	0.577*** (0.089)
External R&D	0.363** (0.152)	0.378** (0.153)
Managerial Experience	0.229*** (0.087)	0.226*** (0.087)
Skilled Labour	0.096 (0.089)	0.100 (0.089)
Infrastructure (Rail & Road Density)	0.068 (0.049)	0.070 (0.049)
ICT Exports (Knowledge Diffusion)	0.009*** (0.002)	0.008*** (0.002)
Human Capital (Labor)	0.037*** (0.005)	0.038*** (0.005)
R&D Expenditure/Gross State Domestic Product	2.512** (1.220)	2.640** (1.222)
Regulatory Quality Barriers	-0.032* (0.016)	-0.056** (0.022)
Corruption Barriers	-0.021 (0.031)	-0.077* (0.041)
Rule of Law Barriers	-0.049** (0.022)	-0.012 (0.030)
Interaction Terms:		
Internal R&D * Regulatory Quality		0.054* (0.033)
Internal R&D * Corruption		0.134** (0.063)
Internal R&D * Rule of Law		-0.081* (0.045)
Control Variables:		
Firm Age (log)	-0.089 (0.054)	-0.088 (0.055)
Firm Size (log)	0.098*** (0.037)	0.096*** (0.037)
Legal Status - Shareholding Corporation	-0.203 (0.134)	-0.222 (0.135)
External Fund	0.053 (0.084)	0.058 (0.084)
Industry - Food, Tobacco, Textile, and Clothing	0.410* (0.230)	0.431* (0.231)
Industry - Wood, Paper, Chemicals and Non-metallic Products	0.671*** (0.227)	0.680*** (0.228)
Industry - Machinery and Equipment	0.642*** (0.222)	0.650*** (0.222)
Industry - Wholesale	-0.133 (0.314)	-0.151 (0.316)
Industry - Retail	0.553* (0.283)	0.558** (0.284)
Industry - Transportation	-0.079 (0.299)	-0.079 (0.301)
Industry - Information Technology	-0.130 (0.320)	-0.132 (0.320)
Industry - Accommodation	-0.279 (0.276)	-0.282 (0.277)
Industry - Other Services	-0.665** (0.300)	-0.657** (0.301)
GDP per capita	1.613** (0.792)	1.615** (0.795)
Constant	-2.884*** (0.429)	-2.932*** (0.431)
Log likelihood	-1822.43	-1817.8454
LR Chi2	319.01	328.18
Prob > chi2	0	0
Pseudo R2	0.0805	0.0828
Observations	3072	3072

Akaike Information Criterion (AIC)	3696.86	3693.691
Bayesian Information Criterion (BIC)	3853.642	3868.563
*** p<0.01, ** p<0.05, * p<0.1 & standard error form in parentheses		

The result of the full model shows that *firm age* and *GDP per capita* were statistically significant and positive as expected. Additionally, the results showed that firms' *internal R&D, external R&D* expenditures, and *managerial experience* were statistically significant and positively influenced innovation. These results are in line with our expectations and are consistent with Barasa et al. (2017) study that also uses the World Bank Enterprise Survey data. In terms of state-level variables, *ICT exports, human capital*, and *R&D expenditure as a proportion of gross state domestic product (R&D/GSDP)* were positively and significantly associated with innovation. These results are in line with our expectations and are in line with those reported by others (e.g., Fayaz & Bhatia, 2018; Jones et al., 2016; Kim & Loayza, 2019; McGee & Dowling, 1994; Tödtling & Trippl, 2005). Also, *regulatory quality barriers* and *corruption barriers* were significant but with negative signs, which indicate that they are minor obstalces that influence innovation since the variables are defined as barriers. The results of the full model also show that the three interaction terms were significant but internal *R&D*Corruption Barrier* was statistically significant at 0.01 level while *Internal R&D*Regulatory Quality Barrier* and *Internal R&D*Rule of Law Barrier* were significant at the 0.10 level. These results were generally consistent with similar country-level studies on the effects of governance quality (e.g., Moreno et al., 2005; Silve & Plekhanov, 2018; Tojeiro-Rivero & Moreno, 2019; Vecchi et al., 2015).

Table 16 below displays the odds ratio[5] of the variables in the models. The results showed that larger firms were more likely to innovate than smaller firms. Similarly, firms that invested in internal and/or external R&D had substantially greater odds of innovating. In terms of managerial experience, firms that have more managers with 10 or more years of relevant managerial experience were more likely to undertake innovations. In terms of state-level variables, it was observed that wealthier states (GDP per capita) and those that devoted a higher proportion of their GDP to R&D (R&D/GDSP) were substantially more likely to be innovative than those with lower levels. Additionally, states with better quality human capital and knowledge diffusion (ICT

[5] Odds Ratio = $\exp(b_i)$ where b_i – coefficient of each independent variable

exports) were more likely to have higher levels of innovating firms. It was noted that regulatory, corruption, and rule of law barriers decreased the odds of innovation.

Table 16: Odds ratio of the logistic regression

Variables	Model 1 - Baseline Model	Model 2 - Full Model
Firm & Regional variables:		
Internal R&D	1.769*** (0.157)	1.780*** (0.159)
External R&D	1.438** (0.219)	1.459** (0.223)
Managerial Experience	1.257*** (0.109)	1.254*** (0.109)
Skilled Labour	1.101 (0.098)	1.105 (0.098)
Infrastructure (Rail & Road Density)	1.070 (0.052)	1.072 (0.052)
ICT Exports (Knowledge Diffusion)	1.009*** (0.002)	1.009*** (0.002)
Human Capital (Labor)	1.038*** (0.005)	1.038*** (0.005)
R&D Expenditure/Gross State Domestic Product	12.335** (15.044)	14.019** (17.127)
Regulatory Quality Barriers	0.969* (0.016)	0.946** (0.021)
Corruption Barriers	0.979 (0.031)	0.926* (0.038)
Rule of Law Barriers	0.952** (0.021)	0.988 (0.029)
Interaction Terms:		
Internal R&D * Regulatory Quality Barriers		1.056* (0.035)
Internal R&D * Corruption Barriers		1.144** (0.072)
Internal R&D * Rule of Law Barriers		0.922* (0.041)
Control variables:		
Firm Age (log)	0.915 (0.050)	0.916 (0.050)
Firm Size (log)	1.103*** (0.041)	1.101*** (0.041)
Legal Status - Shareholding Corporation	0.817 (0.110)	0.801 (0.108)
External Fund	1.054 (0.089)	1.060 (0.089)
Industry - Food, Tobacco, Textile, and Clothing	1.507* (0.347)	1.539* (0.355)
Industry - Wood, Paper, Chemicals and Non-metallic Products	1.956*** (0.445)	1.974*** (0.450)
Industry - Machinery and Equipment	1.900*** (0.421)	1.916*** (0.426)
Industry - Wholesale	0.875 (0.275)	0.860 (0.272)
Industry - Retail	1.739* (0.493)	1.747** (0.496)
Industry - Transportation	0.924 (0.276)	0.924 (0.278)
Industry - Information Technology	0.878 (0.281)	0.877 (0.280)
Industry - Accommodation	0.757 (0.209)	0.755 (0.209)
Industry - Other Services	0.514** (0.155)	0.518** (0.156)
GDP per capita	5.016** (3.973)	5.030** (3.996)
Constant	0.056*** -(0.024)	0.053*** (0.023)
Observations	3072	3072
*** p<0.01, ** p<0.05, * p<0.1 & standard error form in parentheses		

Finally, the interaction terms indicated that *high corruption, poor regulatory quality,* and *rule of law barriers* will have some effect on internal R&D decisions. It seems that firms that conduct internal R&D and undertake innovation consider *regulatory barriers* in the form of the tax system, customs and trade regulations, and licensing and permits a moderate obstacle for innovation. However, *corruption barriers* seem to strongly impact internal R&D and innovation outcomes.

5.5 Interaction Plots

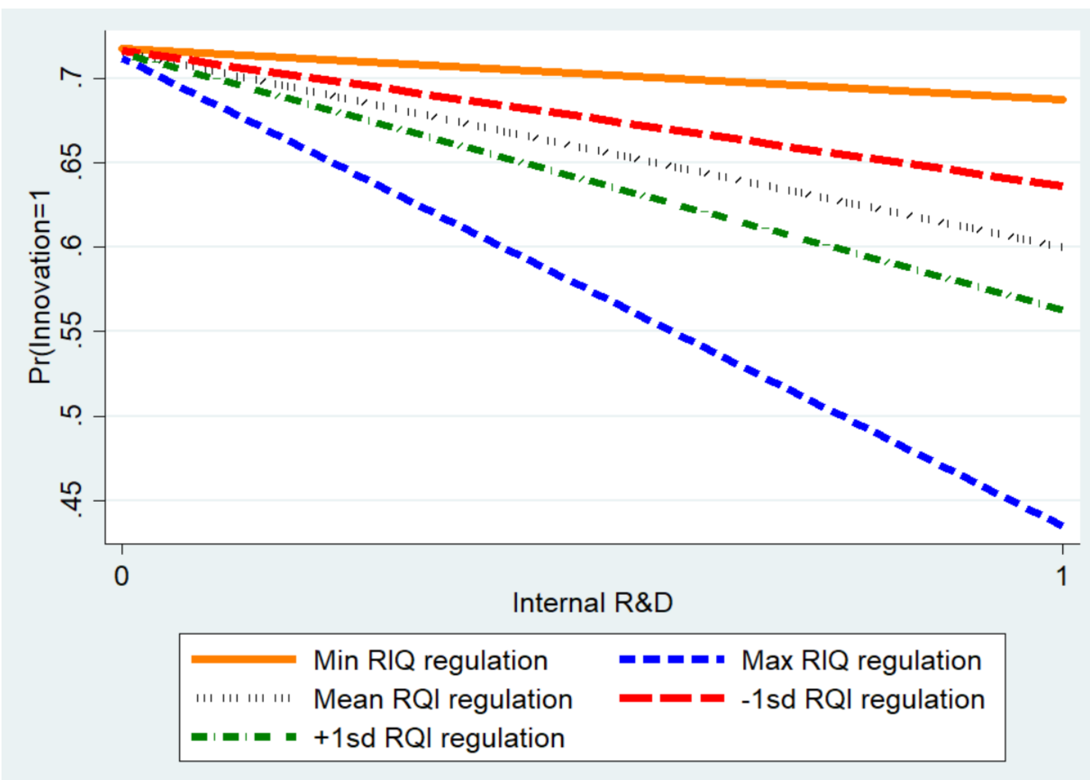
According to several researchers (e.g., Hoetker, 2007; Long & Freese, 2006; Maas & Hox, 2004), relying on the sign and magnitude of the interaction coefficients alone can lead to misleading interpretation. Hoetker (2007) showed mathematically that the sign of the interaction coefficient may not indicate the direction of the interaction effect and the significance of the interaction effect cannot be determined just by the significance of the interaction coefficient (p. 336). They also demonstrated that in the logit model, the sign and magnitude of the marginal effect can differ across observations. Thus, the argued graphic presentations can provide a richer understanding of the effects of the variables because doing so may indicate that the interaction effect is positive for some observations, null for others, and negative yet for others. Therefore, we present graphic representations for the interaction terms in our model at different levels as shown below. The plots show the predicted probability of innovation of internal R&D when regulatory quality, corruption, and rule of law barriers are at their means, minimum and maximum levels, and within one standard deviation above and below the mean. Each of these plots is examined in the order below.

5.5.1 Internal R&D and Regulatory Quality Barriers

Figure 13 shows the interaction plot of internal R&D and regulatory quality barriers indicating that the influence of a firm conducting internal R&D changes for different values of the regulatory quality barriers. For a minimum value of regulatory quality barriers, the effect of a firm conducting internal R&D on product innovation is higher than all other levels even though regulatory quality barriers seem to discourage innovation (highest probability is when internal R&D=0). On the same lines, the effect of maximum regulation and plus one standard deviation (higher regulatory quality) lead to an even lower probability of innovation (the lines are below the mean and the probability of innovation is smaller). The opposite effect is observed with respect to lower regulatory quality (minus one standard deviation).

This graph suggests that the effect on conducting internal R&D on innovation differs for different levels of regulatory quality barriers. It seems that lower regulatory quality barriers lead to a higher probability of innovation (around 0.7) than stronger regulatory quality barriers (around 0.4). Table 17 in Appendix 4 presents the marginal effects of these barriers on innovation through internal R&D at the various levels. However, even with this, the probability of conducting innovation is still strong at about 0.4. This interaction supports our expectation that a combination of internal R&D and a low degree of regulatory quality barriers enhance the influence of internal R&D on product innovation. This graph and the table of marginal effects provide a more nuanced understanding of the interaction term than the model, which shows a positive coefficient and small magnitude.

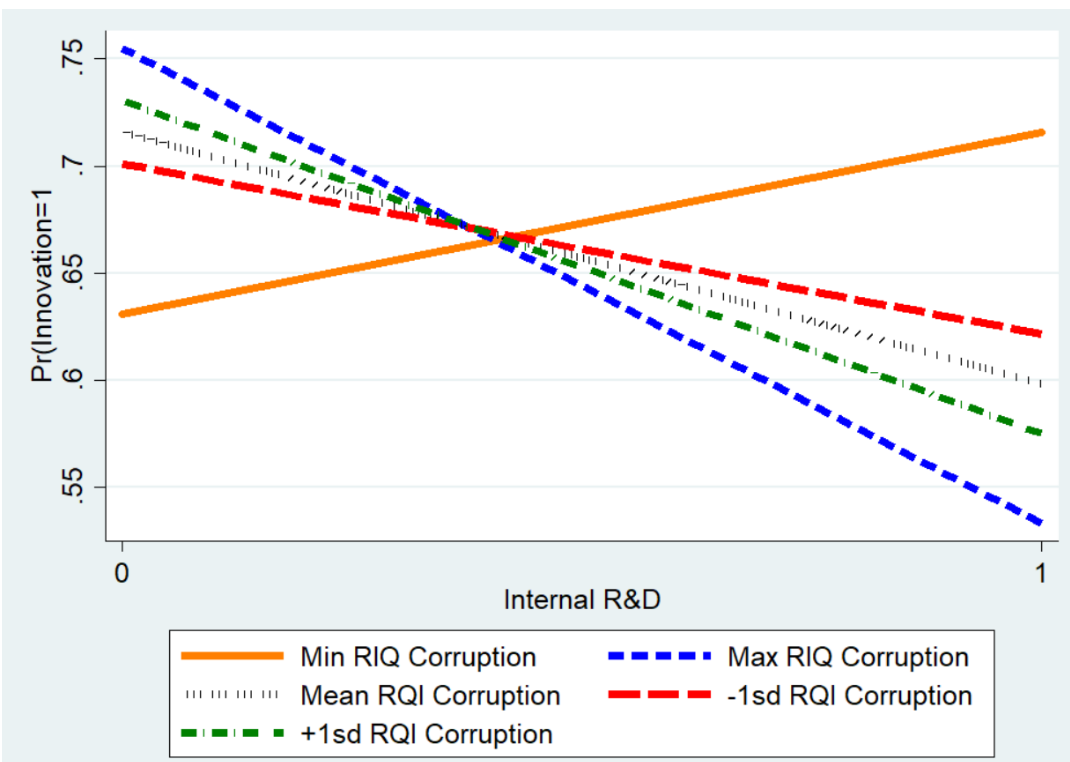
Figure 13: Predictive margins of Internal R&D with respect to Regulatory Quality barriers



5.5.2 Internal R&D and Corruption Barriers

Figure 14 shows the interaction plot of internal R&D and corruption barrier indicating that the influence on the innovation of a firm conducting internal R&D changes for different values of the corruption barrier. For a minimum value of corruption barrier, the effect of a firm conducting internal R&D on product innovation is substantially higher for minimum corruption levels (around 0.72) compared to maximum corruption levels (around 0.5). Similarly, for high degrees of corruption (1 standard deviation above the mean) the effect of a firm conducting internal R&D on product innovation is substantially reduced compared to lower degrees of corruption (1 standard deviation below the mean). Thus, we observe a significant effect in this interaction term indicating that the institutional corruption influences internal R&D and innovation within firms. This interaction strongly supports our expectation that a high degree of corruption weakens the influence of internal R&D on product innovation.

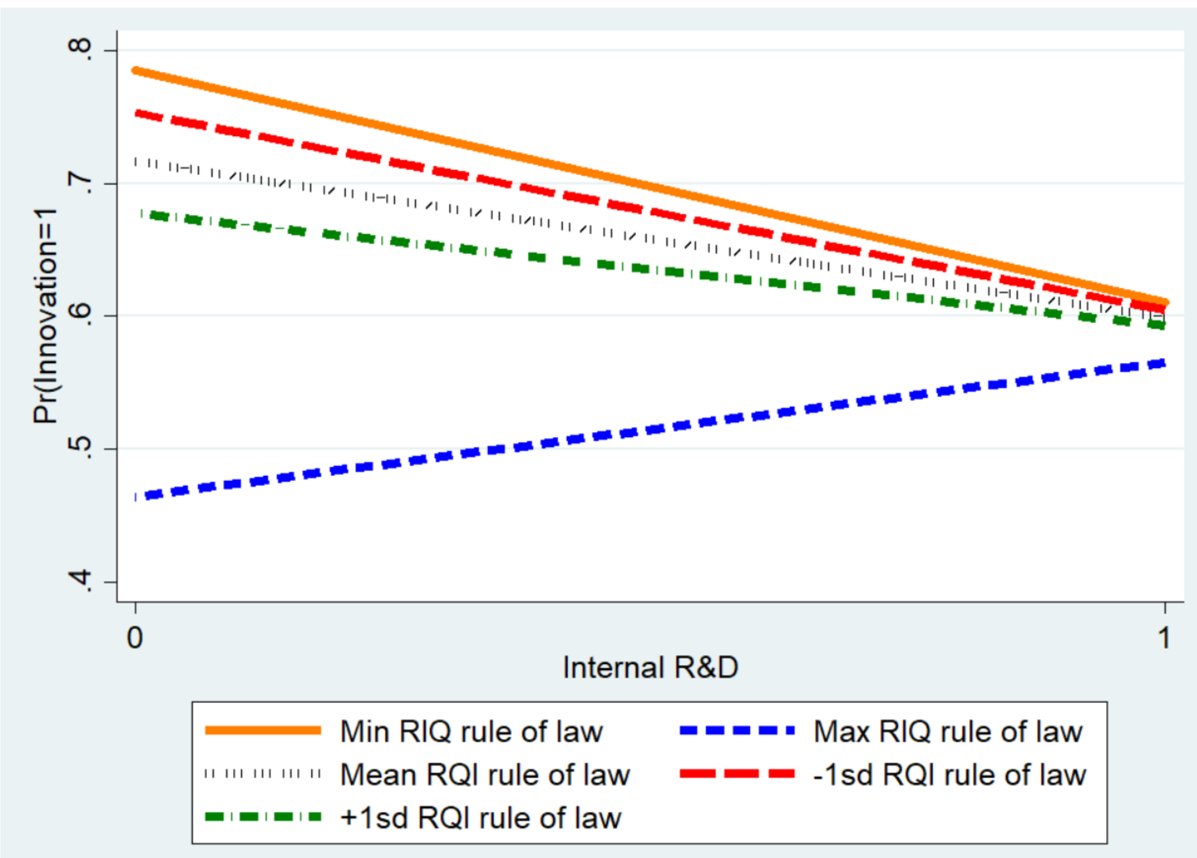
Figure 14: Predictive margins of Internal R&D with respect to Corruption barriers



5.5.3 Internal R&D and Rule of Law Barriers

Figure 15 shows the interaction plot of internal R&D and rule of law barrier indicating that the influence on the innovation of a firm conducting internal R&D changes for different values of rule of law barrier. The graph shows that the minimum rule of law barriers leads to a higher level of innovation. This same pattern is observed in contexts with lower levels (minus one standard deviation) of rule barriers. The graph also shows that higher rule of law barriers (maximum values and plus one standard deviation) substantially reduces the innovation in firms. Thus, we observe that lower values of rule of law barriers gradually increases the effect of internal R&D on product innovation. This interaction supports our expectations that high degrees of rule of law barriers weaken the impact of internal R&D on innovation.

Figure 15: Predictive margins of Internal R&D with respect to Rule of Law barriers



In summary, we observe that several of the variables show relationships that were similar to other studies. For example, *internal R&D* variable was similar to that found in (e.g., Arundel et al., 2008;

Barasa et al., 2017; Crespi & Zuniga, 2012; Goedhuys, 2007; Kamau & Munandi, 2009; K. Lee & Kang, 2007; Tojeiro-Rivero & Moreno, 2019; C. C. Wang & Lin, 2013). On the other hand, some of the variables were not significant like *skilled labor* although previous studies (Al-Laham et al., 2011; Barasa et al., 2017; Cohen & Levinthal, 1990; Goedhuys, 2007; Liu & Buck, 2007; McGuirk et al., 2015; Robson et al., 2009; Roper & Love, 2006) have shown that it positively influences innovation. Another variable that we expected to be significant was *infrastructure* since past research (Aschauer, 1989; Kim & Loayza, 2019; Straub, 2008) has also shown that it has a positive association with innovation.

5.6 Multi-level Model: Mixed-Effects Logistic Regression

As discussed previously, following the logistic regression analysis, we conducted a multi-level analysis given the nested nature of our dataset – firms nested in states. Multi-level analysis enables a parallel analysis of the results of both the group level and individual level variables while considering the dependence of observations within groups (Luke, 2019). It allows us to examine how the individual level and group level variables are associated with the variation at both the levels (Luke, 2019). According to Austin and Merlo (2017), the typical multilevel logistic regression integrates cluster-specific random effects to account for the within-cluster correlation of subject outcomes. It assumes that the random effects are independent in the model. Also, mixed-effects logistic regression is useful when the dependent variable is dichotomous in which the log odds of the outcomes are modeled as a linear combination of the predictor variables when data are clustered or there are both fixed and random effects (UCLA, n.d.-b). Further, we observe that several recent studies on entrepreneurship have used multi-level analysis to analyze how individual-level and country-level factors influence entrepreneurship (De Clercq, Lim, & Oh, 2013; Elam & Terjesen, 2010).

Thus, multi-level analysis was used in this study to enable the systematic analysis of the effects of the regional and firm-level factors and their cross-level interactions. Our analysis also examined variations in the parameters across groups (i.e., regional and firm-level) in comparison to the fixed and random intercepts (Sommet & Morselli, 2017). In our model, we have two levels (1 = firm-level and 2 = regional level). Level 1 variables are the firm-level variables that included – *internal*

R&D, external R&D, managerial experience, skilled labor. Level 2 variables are the regional-level variables that included – *infrastructure, ICT exports, human capital,* the *input of innovative activities, regulatory quality barriers, corruption barriers,* and the *rule of law barriers*. We also included a set of firm-level and regional-level control variables in the model. In STATA, the command MELOGIT is used to estimate a mixed-effects logistic regression.

The general form of the equation for the multi-level model is given below –

Prob (Product Innovation) = f (Internal R&D, External R&D, Managerial Experience, Skilled Labor, GDP per capita, Infrastructure, ICT Exports, Human Capital, Input of Innovative activities, Regulatory Quality Barrier, Corruption Barriers, Rule of Law Barriers, Firm Age, Firm Size, Legal Status, Industry, External Fund)

Log (odds ratio) = $\beta_0 + \beta_1$ *Internal R&D* + β_2 *External R&D* + β_3 *Managerial Experience* + β_4 *Skilled Labor* + β_5 *Infrastructure* + β_6 *ICT Exports* + β_7 *Human Capital* + β_8 *Input of Innovative activities* + β_9 *Regulatory Quality Barriers* + β_{10} *Corruption Barriers* + β_{11} *Rule of Law Barriers* + β_{12} *(Internal R&D X Regulatory Quality Barriers)* + β_{13} *(Internal R&D X Corruption Barriers)* + β_{14} *(Internal R&D X Rule of Law Barriers)* + *Firm-level control variables* + *Regional-level control variable* + e_{ij}

where *i* refers to firm *i* and *j* refers to state *j*.

The STATA output is shown in Appendix 4, Figures 16, and 17. The output displays statistics regarding the log-likelihood, number of observations at each level (firms and states), and degrees of freedom. The Prob > chi2 is the probability of getting the chi-square statistic if the model has zero independent variables and is usually compared to the p-value (0.05 or 0.1) to verify if the model is statistically significant. In our case, it was less than 0.00 implying a statistically significant model. The Wald test is defined as the ratio of the variance estimate divided by its standard error estimate (Newsom, 2019). The Wald chi-square test is used to verify if any of the independent variables are significant in the model. The results of the Wald test are shown in Figure 18 of Appendix 4. Multi-level models are identified to have fixed effects and random effects estimates where fixed-effects estimates are the standard regression coefficients on the logit scale and the random effects estimates represent the estimated variance in the intercept on the logit scale and refer to the variation across regions (UCLA, n.d.-b; Williams, 2013).

The results of the mixed-effects logistic regression of the baseline model and the full model are as shown in Table 18 below. Table 19 in Appendix 4 shows the odds ratio of the mixed-effects logistic regression of the baseline model and the full model.

From Table 18, we find that the variables – *firm size, internal R&D, external R&D, human capital, regulatory quality barriers* along with the interaction term (*internal R&D * corruption*) were statistically significant at 0.05 level whereas the variables - *corruption barriers* and the interaction term (*internal R&D * regulatory quality*) were significant at 0.1 level. However, we observed that the variables – *regulatory quality barriers, corruption barriers,* and the interaction term (*internal R&D * regulatory quality*) have a negative coefficient implying that these factors are considered a minor obstacle in the ability of the firm to innovate a product/service. The random effects examine the variation across regions above and beyond the differences in firm level variables. Since the random effects estimates for our multilevel full model was 0.221 which is non-zero and not close to zero, it implied that the effect benefits the model and the difference between the regions is not accounted for by independent variables only. Tables 24 and 25 of Appendix 4 shows the results of logistic and mixed-effects logistic regression with reference to Small-sized firms and manufacturing sector.

Table 18: Results of the mixed-effects logistic regression of the baseline model and full model

Variables	**Model 3 – Mixed-effects Logistic Regression (Baseline Model)**	**Model 4 – Mixed-effects Logistic Regression (Full Model)**
Firm & Regional Variables:		
Internal R&D	0.573*** (0.093)	0.576*** (0.093)
External R&D	0.374** (0.155)	0.388** (0.155)
Managerial Experience	0.100 (0.093)	0.096 (0.094)
Skilled Labour	0.024 (0.095)	0.025 (0.095)
Infrastructure (Rail & Road Density)	0.054 (0.106)	0.055 (0.106)

ICT Exports (Knowledge Diffusion)	0.008 (0.006)	0.008 (0.006)
Human Capital (Labor)	0.043*** (0.014)	0.044*** (0.014)
R&D Expenditure/Gross State Domestic Product	1.638 (2.837)	1.794 (2.835)
Regulatory Quality Barrier	-0.031* (0.017)	-0.057** (0.022)
Corruption Barrier	-0.020 (0.032)	-0.075* (0.042)
Rule of Law Barrier	-0.052** (0.023)	-0.018 (0.031)
Interaction Terms:		
Internal R&D * Regulatory Quality Barriers		0.056* (0.034)
Internal R&D * Corruption Barriers		0.131** (0.064)
Internal R&D * Rule of Law Barriers		-0.074 (0.046)
Control Variables:		
Firm Age (log)	-0.091 (0.057)	-0.090 (0.057)
Firm Size (log)	0.092** (0.038)	0.090** (0.038)
Legal Status - Shareholding Corporation	-0.113 (0.138)	-0.132 (0.139)
External Fund	-0.092 (0.090)	-0.088 (0.090)
Industry - Food, Tobacco, Textile, and Clothing	0.330 (0.240)	0.350 (0.241)
Industry - Wood, Paper, Chemicals and Non-metallic Products	0.662*** (0.237)	0.671*** (0.238)
Industry - Machinery and Equipment	0.571** (0.231)	0.579** (0.231)
Industry - Wholesale	-0.092 (0.327)	-0.112 (0.328)
Industry - Retail	0.495* (0.295)	0.495* (0.295)
Industry - Transportation	-0.013 (0.308)	-0.014 (0.309)
Industry - Information Technology	-0.028 (0.335)	-0.030 (0.334)
Industry - Accommodation	-0.348 (0.286)	-0.351 (0.287)
Industry - Other Services	-0.717** (0.310)	-0.712** (0.311)
GDP per capita	1.119 (2.045)	1.141 (2.044)
Constant	-2.744*** (0.840)	-2.791*** (0.839)
var(_cons[a2])	0.221*** (0.082)	0.221*** (0.081)
Log likelihood	-1781.9062	-1777.6273
Prob > chi2	0	0
Wald chi2	180.14	187.02
Obs per group: min	37	37
Obs per group: avg	133.6	133.6
Obs per group: max	220	220
chibar2(01)	81.05	80.44
Prob>=chibar2	0	0
Observations	3072	3072
Number of groups	23	23
Intraclass Correlation (ICC)	0.0631	0.0629
*** p<0.01, ** p<0.05, * p<0.1 & standard error form in parentheses		

In assessing the model, we first examined the variance inflation factor (VIF) to check for multicollinearity of the independent variables in the analysis (Stephanie, 2015). Multicollinearity implies a correlation between independent variables. High multicollinearity indicates the variables are strongly correlated. VIF is the ratio of the variance of all the variables in the model divided by the variance of the model with a single variable alone (Stephanie, 2015). A VIF value of 1 implies that there is no correlation between the variables. A value between 1 and 5 implies a moderate correlation and a value of greater than 5 indicates a strong correlation. The higher the value of VIF, the less reliable are the regression results (Stephanie, 2015). Generally, VIF values of above 10 signify a high correlation (Stephanie, 2015). In our model, the VIF values are all below 5 suggesting that multicollinearity is not an issue with the model. The VIF values for all the independent variables are as shown in Table 20.

Table 20: VIF values of all the independent variables

Independent Variables	**VIF**	**1/VIF**
Firm Age (log)	1.15	0.8694
Firm Size (log)	1.26	0.7908
Legal Status	1.10	0.9053
GDP per capita	1.12	0.8891
Internal R&D	1.16	0.8626
External R&D	1.04	0.9623
Managerial Experience	1.16	0.8618
Skilled Labour	1.18	0.8498
External Fund	1.05	0.9538
Infrastructure (Rail & Road Density)	1.29	0.7748
ICT Exports (Knowledge Diffusion)	1.27	0.7894
Human Capital (Labor)	1.36	0.7332
R&D Expenditure/Gross State Domestic Product	1.38	0.7266
Regulatory Quality Barrier	1.50	0.6681
Corruption Barrier	1.12	0.8896
Rule of Law Barrier	1.47	0.6796
Mean VIF	1.23	

We also examined the Intraclass Correlation Coefficient[6] (ICC). The ICC is computed as the ratio of the between-cluster variance to the total variance (Liljequist, Elfving, & Roaldsen, 2019). The primary objective of ICC is to determine if a multilevel model is required or not. It usually has values between 0 and 1 (Liljequist et al., 2019). If the value of ICC is equal to 0, it implies that the model need not have multiple levels, and a simple regression/logistic regression analysis be performed (Sommet & Morselli, 2017). In our study, we find that the value of ICC for the base model and full model as 0.0631 and 0.0629 respectively. This means that about 6% of the chances of a firm innovating a product/service is explained by variations between regions and the remaining 94% is explained by variations within regions. Therefore, multi-level logistic regression seems suitable for this study.

OLS Regression Results

We also performed an Ordinary Least Squares (OLS) regression using the number of innovative products a firm introduced from the fiscal year 2011/2012 through 2012/2013 as the dependent variable and the same independent variables of the logistic regression model. Unlike our binary dependent variable (0/1 no innovation/innovation), this variable, which measures the level of innovation effort was tested to determine if it provides any new or different insights. OLS is used since it is not a binary variable. However, the results showed very little statistical significance and performed less than the logistic model.

[6] ICC = $\frac{\sigma^2_{u_0}}{\sigma^2_{u_0}+\sigma^2_e}$ where $\sigma^2_{u_0}$ – between-cluster variance; σ^2_e – error variance

Chapter 6
Discussion

This study investigated whether differences in regional-level factors or the contextual situations across the many states of India combined with firm-level factors influenced firm-level innovation. At the firm level, we examined several factors pertaining to firm resources including internal and external R&D expenditures, managerial experience, and skill-levels of workers. At the regional level, we examined several factors including governance quality (regulatory quality, rule of law and corruption), human capital, infrastructure, state-level investment in R&D, and innovation output (knowledge diffusion). Firm-level data was obtained from the World Bank's Enterprise Survey for India, which is a free dataset available to researchers upon registration for an account. Regional-level data was obtained from various statistical and data collection agencies in India, most of which are affiliated with various government ministries. We used logistic regression and multi-level mixed-effects logistic regression since our dependent variables, product innovation, was binary, and because firms were nested in regions. The analysis was based on over 3,000 firms from 23 states, defined to match the classification used by the World Bank Enterprise Survey in collecting data for India.

The findings of our study confirmed several of our expectations and our main hypothesis – that governance quality at the regional level (measured in terms of regulatory quality barriers, corruption barriers, and rule of law barriers) affects how firms use its internal R&D resources to foster innovation. The coefficient of the *regulatory quality barrier* was statistically significant with a negative influence on innovation indicating that firms considered tax rates, tax administration, customs and trade regulations, and business licensing and permits a minor obstacle in their ability to innovate. Specifically, we found that a high level of these barriers, particularly high levels of corruption, had a serious dampening effect on firm-level innovation. This finding suggests that while a firms' internal R&D investment is a key input to generate innovation, the extent to which they can harness their innovation potential is conditioned by the quality of regional institutions in which they operate. For instance, the results indicated that the marginal effects on innovation of low versus high levels of corruption were substantial (about 20 percent) for firms investing in internal R&D for innovation. Similar levels of marginal effects were observed with respect to the regulatory and rule of law barriers.

Thus, these results highlight the importance of quality of governance for firm-level innovation. According to a report published by the National Crime Records Bureau on corruption in India for the year 2017, the states of Maharashtra followed by Orissa and Karnataka reported the most number of corruption cases while the states of Uttaranchal and Goa reported the least number of corruption cases (NCRB, 2017). In our study, we found that the state of Orissa had high corruption barriers followed by Karnataka and Maharashtra while Uttaranchal reported low corruption barriers. Even though studies show that corruption barriers are high in the state of Maharashtra, the innovation capability of the state remains high, which suggests that maybe the "grease the wheels theory" (Huntington, 2006) might be at play. However, the analysis of this effect is considered outside the scope of this analysis and could be the subject of further analysis.

Basically, better institutional environments can amplify firm-level resources for innovation, while a weak institutional environment could have the opposite effect. This finding is in line with Zhao (2006) study regarding environments with weak intellectual property rights. Similarly, Barasa et al. (2017) also reported similar findings and contend that even though firm-level resources are known to drive innovation, institutional quality moderates the ability of firms to extract and appropriate value form its resources. It is observed in our study that even minimum levels of quality of governance barriers moderate the ability of firms to leverage their resources for innovation. This finding implies that state governments can amplify the ability of firms by introducing policy changes designed to reduce governance barriers or to enhance governance quality. It seems that without such governance changes, firms are limited in their ability to maximize the benefit from their resources for innovation. Also, poor governance quality may discourage firms that are at the margin in terms of committing resources for innovation may be discouraged.

Two other contextual variables that seem to enhance the ability of firms to amplify their resources for innovation are the quality of *human capital* of the state and the level of R&D investments a state (*R&D/GDSP*) makes into its economy. Both showed strong positive contributions to firm-level innovation indicating that just like the quality of firm-level human resources and innovation input (R&D), they are crucially needed.

The coefficient of *input of innovative activities* implied that greater investment in R&D exclusively in the field of Science and Technology increased the ability of the firm to innovate a new product/service. The states of Maharashtra, Delhi, Karnataka, Tamil Nadu, Gujarat, West Bengal, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, and Kerala have a large proportion of highly skilled labor force thus responsible for the development of ICT sector in these regions. The proportion of job opportunities in Maharashtra, Delhi, Karnataka, and Tamil Nadu together constitute about 65% of the total jobs because of the presence of major IT hubs in these states that requires a large number of skilled workforce thus the R&D expenditure has been increasing over the years (Aspiringminds, 2017). The IT sector constitutes about 76 percent of the R&D outsourcing market. The states of Gujarat, Maharashtra, Madhya Pradesh, Kerala, and Karnataka have the highest R&D expenditures in the field of Science & Technology. It can be argued that these investments can be considered innovation inputs that provide states and firms within states a competitive advantage over those with less of these resources.

Additionally, we observe that ICT exports also contributed positively to enabling firms to leverage their resources for innovation and even to enhance their overall innovation potential. Exporting ICT technology is considered an important component of global knowledge diffusion in India because it allows Indian firms to build closer ties with suppliers, customers, and other stakeholders. It can also improve their knowledge acquisition through learning, which can also improve their ability to adopt foreign technology. This way they can better understand product and technology markets, which in turn can make them more innovative. Recently, Facebook invested $5.7 billion for a 9.99% stake in Reliance Jio Platforms. This partnership would create a bundle of opportunities for businesses and essentially serve other important stakeholders of the Indian market such as agricultural workers, small and medium enterprises, educational institutions, and healthcare providers (Pham, 2020). States with high ICT exports and high human capital produce good companies that interact globally.

It seems that investments in these areas have the potential for huge payoffs for innovation as they improve the knowledge/innovation infrastructure of states. We observe that the physical infrastructure variable was not significant, which was somewhat surprising but deeper analysis of the literature seems to support the proposition that physical infrastructure is key to economic growth and productivity and through these indirectly impact innovation (Butkiewicz & Yanikkaya, 2006; Silve & Plekhanov, 2015, 2018; Tojeiro-Rivero & Moreno, 2019; Tran, 2019).

We find that the coefficients of *internal R&D* and *external R&D* are statistically significant thus supporting our first hypotheses – H1a and H1b. This implies that for every firm that conducts either *internal R&D* or *external R&D*, their ability to innovate a product/service is higher.

The value of the coefficient for *skilled labor* is not statistically significant thus rejecting our third hypothesis (H2) implying that formal training provided by firms for its workers does not influence the ability of the firm to innovate a new product/service.

The coefficient of *managerial experience* is statistically significant thus supporting our second hypothesis – H3 and suggesting that the firms having manager(s) whose experience is greater than 10 years in the business sector have more ability to innovate a new product/service.

The coefficient of *human capital* is statistically significant thus supporting our fifth hypothesis – H5. In our case, the *human capital* factor consists of several sub-indicators of Labor and suggests that employee education, wage component, workforce participation, and the number of working days together influence the ability of the firm to innovate a new product/service. This further implies that a firm having a higher number of employees who have completed secondary level of education and received technical training; provide a good salary and offer incentives and benefits to employees and have employees in the age group of 16-64 is positively related to product innovation.

The coefficient of *ICT exports* is statistically significant in the case of logistic regression thus supporting our sixth hypothesis – H6. The component of the *ICT exports* is one of the sub-indicators of Knowledge Diffusion and implies that with the use of ICT for exporting services, firms associate themselves with many customers at a timely and less-expensive rate. Firms also have an opportunity to establish virtual branches globally without the need for investment of tangible assets. These factors together increase the ability of the firm to innovate a new product/service.

Our seventh hypothesis (H7) is also supported by the statistically significant value of the coefficient of *input of innovative activities* implying that greater investment in R&D exclusively in the field of Science and Technology increases the ability of the firm to innovate a new product/service.

The influence of firm-level factor (*internal R&D*) with regional-level factor (*corruption*) has predicted a positive association with the firms' ability to innovate a new product/service. This suggests that firms conduct internal R&D and engage in product innovation even though they face corruption as a major obstacle for their innovation. Hence, this supports our eighth and final hypothesis (H8b).

However, we find that the coefficients of the remaining variables imply that they don't have any effect on the firms' ability to innovate a new product/service thus rejecting our hypotheses – H3, H4, H8a, H8c.

Summary

The results of the logistic regression suggest that the odds of a firm innovating a product/service (controlling for *firm age, firm size, legal status, GDP per capita, external funding*) are predicted to –

i. increase 1.780 times and 1.459 times for each firm conducting Internal R&D and External R&D respectively;
ii. increase 1.254 times for each firm that has a manager whose experience in the field is greater than 10 years;
iii. increase 1.009 times, 1.038 times for firms located in regions with a high proportion of each ICT Exports, and Human Capital respectively;

iv. increase 14.019 times for each increase in the expenditure of R&D as a proportion of Gross State Domestic Product;

v. increase 0.946 times for each firm facing a minor obstacle of Regulatory Quality barriers;

vi. lastly, increase 1.144 times for each firm conducting internal R&D and facing a major obstacle of Corruption.

Hence, a firms' ability to innovate is more common among the young firms conducting Internal R&D, External R&D, having managers whose experience is greater than 10 years in the business sector and for the regions with greater ICT Exports, Labor productivity, expenditure of R&D, a minor obstacle of Regulatory Quality barriers and for those firms conducting Internal R&D even with a major obstacle of corruption in their current operation.

Similarly, the results of the mixed-effects logistic regression suggest that the odds of a firm innovating a product/service (controlling for firm age, firm size, industry, legal status and GDP per capita) are predicted to–

i. increase 1.778 times and 1.474 times for each firm conducting Internal R&D and External R&D respectively;

ii. increase 1.045 times for regions with a high proportion of Human Capital respectively. For instance, regions with higher labour force participation rate, higher percentage of population with at least secondary education and other indicators of Human Capital respectively;

iii. increase 0.945 times for each firm facing a minor obstacle of Regulatory Quality that further consists of obstacles – tax rates, tax administration, customs and trade regulations and business licensing and permits respectively;

iv. lastly, increase 1.140 times for each firm conducting internal R&D and facing a major obstacle of Corruption in their current operations.

Hence, a firms' ability to innovate is more common among the firms conducting Internal R&D, External R&D, and for the regions with greater Labor productivity facing a minor obstacle of Regulatory Quality barriers and for those firms conducting Internal R&D even with a major obstacle of corruption in their current operations.

Cronbach's Alpha Test

Cronbach's Alpha Test[7] is a measure of internal consistency of a test or scale whose value ranges between 0 and 1. It measures how closely a set of items is related as a group. It is also considered a measure of reliability (Tavakol & Dennick, 2011). It is usually written as a function of the number of items in the test and the average inter-correlation among the items (UCLA, n.d.-d). Many studies have reported different acceptable values of alpha ranging from 0.65 to 0.95. Low values of alpha can be due to a low number of questions, poor inter-relatedness between items, or heterogeneous constructs (Tavakol & Dennick, 2011). On the contrary, high values of alpha (>0.90) may imply few items in the test are redundant as they are testing the same question but in a different way (Tavakol & Dennick, 2011). The alpha values for the regional institutional quality barriers are as shown in Figures 19, 20, and 21.

Figure 19: Cronbach's alpha test for Regulatory Quality Barriers

Item	Obs	Sign	item-test correlation	item-rest correlation	average interitem correlation	alpha
obstacle_tax	3486	+	0.7800	0.5937	0.5357	0.7758
obstacle_t~n	3486	+	0.8662	0.7387	0.4403	0.7024
obstacle_b~e	3487	+	0.8139	0.6475	0.4981	0.7486
obstacle_t~s	3272	+	0.7343	0.5238	0.5803	0.8058
Test scale					0.5143	0.8090

Figure 20: Cronbach's alpha test for Corruption Barriers

Average interitem correlation:	0.0540
Number of items in the scale:	2
Scale reliability coefficient:	0.1025

[7] $\alpha = \frac{N\bar{c}}{\bar{v}+(N-1)\bar{c}}$ where N – number of items in the test; $\bar{c}$ – average inter-item covariance among the items; $\bar{v}$ – average variance

Figure 21: Cronbach's alpha test for Rule of Law Barriers

Item	Obs	Sign	item-test correlation	item-rest correlation	average interitem correlation	alpha
obstacle_c~s	3388	+	0.7874	0.4922	0.3062	0.4689
obstacle_c~t	3470	+	0.6948	0.3296	0.5247	0.6882
obstacle_p~y	3486	+	0.8038	0.5169	0.2670	0.4215
Test scale					0.3657	0.6336

From the results of the Cronbach's alpha test for the regional institutional quality barriers, we find that the alpha test for Regulatory Quality and Rule of Law barriers suggest the sub-obstacles of these barriers perfectly capture the barriers, however, the low value of corruption barriers is due to the poor correlation between the items.

From a policy perspective, policymakers are encouraged to look for ways to improve the quality of education to grow the stock and flow of high-quality human capital, particularly in science, technology, and business. A similar observation is made with respect to R&D investments to establish knowledge infrastructure for the development, acquisition, use, and exchange of knowledge and to build social networks for knowledge collaboration. The results indicate that even small investments in these areas have the potential to drive substantial improvements in innovation in the states. The presence of a highly skilled workforce in the states of Maharashtra, Delhi, Karnataka, Tamil Nadu, Gujarat, West Bengal, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, and Kerala has led to the growth of ICT sector in India and hence show that human capital has a large influence on innovation. Microsoft alliance with Reliance Jio Infocomm Limited (JIO) would promote digital innovation in India thus helping businesses with the latest technologies (Maheshwari, 2019).

There is a need for better rules that govern the taxation procedure, R&D funding as well as the implications for the legal and institutional structures of firms (Dutz, 2007). There is a need for the government to introduce a policy and regulatory framework that promote firms to take up initiatives that they usually consider risky by providing appropriate funding for their R&D (Dutz, 2007). According to "grease the wheel" theory, corruption may be a link between firm operations and government-related formalities that can lead to Pareto improving outcomes (Huntington, 2006). In another study by Murphy, Shleifer, and Vishny (1991), it was found that corruption hinders innovation by lengthy and tiresome procedures for business licensing and permits related to R&D investment thus hampering the innovation capability of firms. Jain (2018) in one of her studies about R&D spending and corruption in Indian firms found that corruption impedes firms in investing in R&D thus negatively affecting their ability to innovate a product/service. Jain (2018) used data on crimes related to corruption like bribes in the region where the firm is located to understand the scenario of corruption in that region.

Accounting for the variations within regions, from the results of both the models, we find that not all the factors that were significant in the logistic regression were significant in the multilevel model. We did robustness checks with the infrastructure variable using electricity generation (in Gigawatt hour GW) and it showed up to be partially significant at 0.1 level. We also did robustness checks with the ICT exports variable using patent intensity, but the results were not significant. However, the parameters remained the same in the analysis for the two variables. Table 21 of Appendix 5 describes the variables that were considered for robustness checks. Table 22 and 23 of Appendix 6 show the results of logistic and mixed-effects logistic regression with the interaction terms of managerial experience and internal R&D; skilled labor and internal R&D.

Some of the factors that we expected to be significant were – ICT Exports, and Input of Innovative activities variables. This is because, there is a need for the Indian government to introduce reforms and investments in these factors (National Research Council, 2007). The strength of India lies in its large regional market, growing population, a large number of highly educated people, scientists, engineers, strong R&D infrastructure. Thus, with proper economic reforms and investments in R&D by the government, the infrastructure of the country can be improved to a greater extent (National Research Council, 2007). There is also a need for the expansion of infrastructure for higher-level education and training more younger students at the workplace in India. To improve the knowledge infrastructure of India, a global collaboration of India with developed nations like the USA would also increase its innovation potential (National Research Council, 2007).

From a managerial perspective, managers can also get a better understanding of strategies and investment they should take to enhance innovation within their firms by collaborating with universities and other educational institutions for R&D. Firms should be aware of the external environments and their competitors and customer requirements that help them to identify potential business opportunities (Tian et al., 2019). Firms should also consider digitizing their businesses with the help of Information and Communication Technology (ICT) that improves their efficiency (Tian et al., 2019). Lastly, firms should engage in entrepreneurship; improve their innovation capability, and expand their organizational culture valuing learning and innovation (Tian et al., 2019).

The results of our study investigated the effect of firm-level and regional-level factors on product innovation in emerging economies – India. Policymakers in India can get a better understanding of the relevant factors that influence firm-level innovation so that they can direct policy and resources to promote innovation in their respective states. Our results can also help governments and policymakers to design policies to improve the Information and Communication Technology (ICT) exports, infrastructure, R&D expenditure in the field of Science and Technology.

Overall, our analysis shows that regional-level contexts are crucially important for promoting innovation and for explaining disparities in firm-level innovation across states in India. Moreover, these regional-level quantities certainly amplify firm-level resources for innovation. Thus, from a theoretical perspective, it seems that firm-level RBT of the firm only provides a partial explanation of firm-level innovation. Similarly, it can be observed that institutional theory provides only a partial explanation of firm-level innovation. Therefore, it seems integrating these two theories can provide a deeper and more nuanced understanding of innovation.

Chapter 7

Limitations and Future Research

Our study analyzed the firm-level and regional-level factors influencing innovation in firms in India. Although our study provided a deeper understanding of the impact of regional factors on firm-level innovation, there are a couple of limitations, which require caution in applying the results. In terms of regional-level variables, due to lack of data, our study did not include financial sophistication and the role of venture capital, two important economic dimensions of India innovation system. These are important dimensions given the large amount of small and medium-sized enterprises in India. Also, due to lack of data, we did not include social capital, another important cultural institution dimension with considerable varieties in India. Further, because we used regional-level data from various sources, they covered different years when compared to the firm-level data from the World Bank Enterprise Survey, which was in 2014. For example, the data for the variables ICT Exports and Human Capital belonged to the year 2017. This limitation is found in many studies like ours (Volkwein & Sweitzer, 2006) and it has been argued that institutional-level data do not change drastically from year to year especially not in relative terms. Thus, we do not believe that this limitation invalidates the findings, but most are kept in mind when considering the results.

Second, there was no single dataset that followed a particular year and had information for all the regional variables. We had to use multiple data sources that referred to different years but the same period although very little change in these variables was observed except for population which had a slight increase in their values for the majority of the regions.

Thirdly, there have been studies taken in context with regions in developed economies like European Union (EU), Spanish, however, there were no prior studies related to India to compare our results for a better understanding. Hence a lack of base model from a comparison point of view limits our understanding of the context. Finally, our dataset consisted of a small sample size of around 3492 firms that introduced innovative products/services out of 9281 firms and cross-sectional data which may not well represent a heterogenous firm population in India.

In terms of the future, we believe that our study provides insights that can be used to initiate other research studies. For instance, we found that the stock of human capital at the state level had a strong positive impact on innovation. Our study used a composite measure that comprises of various aspects of human skills and knowledge, but future studies can investigate human capital using more fine-grained indicators or a larger set of human capital dimensions to get a more nuanced understanding of the specific and relevant aspects. This understanding can be very useful to policymakers and add to the literature on human capital in innovation. Similarly, we found that state-level R&D (R&D/GDSP) had a strong positive impact on innovation but this expenditure is spread across many activities and agencies and some are direct funding, and some are indirect support. Future research can explore how various aspects of state R&D expenditures impact innovation by regions. This will show the most impactful for each region and can be used to inform R&D expenditure to most impactful areas. Further, we found that the three pillars of governance quality – regulatory quality, corruption, and rule of law – are major disincentives to innovation and the impact was different across regions. Future studies could compare what specific aspects of governance quality produce positive results in states where it is working and examine how this might be implemented in states with weaker governance quality. Also, future studies can examine more fine-tuned dimensions (e.g., tax regulations or import rules) to determine their specific contribution as disincentives to innovation. Such knowledge can guide changes to alleviate the constraints.

Additionally, at a broader level, research examining the innovation performance of male-owned firms versus female-owned firms could be a fruitful area of research. Also, research on other dimensions of innovation, namely, process, organizational, and marketing innovation, could lead to insights that are currently lacking. Another topic for future research can be how open innovation and collaboration practices among firms, government agencies, universities, and other stakeholders in the innovation process influence innovation across different regions. Finally, comparative analysis of the business practices and ecosystems of states with strong institutions and innovation performance can help to identify areas where weaker states can take action to improve their innovation performance.

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Appendix 1

Table 1: Firm-level factors considered from a few of the past studies

Year	Author(s)	Journal	Title	Firm-level variables used in the study
2008	Anthony Arundel, Bordoy, & Kanerva	INNO-Metrics Thematic Paper	Neglected innovators: How do innovative firms that do not perform R&D innovate	Product and process innovation, firm age, firm size, sector, country, internal R&D, external R&D, skilled labor, total innovation expenditures, market, innovative capabilities, change in the firm's turnover, and source of ideas for innovation from within the firm.
2019	Tojeiro-Rivero, Damián Moreno, Rosina	Research Policy	Technological cooperation, R&D outsourcing, and innovation performance at the firm level: The role of the regional context	Product innovation, firm age, firm size, internal R&D external R&D, R&D funding, and cooperation.
2017	Barasa, Laura Knoben, Joris Vermeulen, Patrick Kimuyu, Peter Kinyanjui, Bethuel	Research Policy	Institutions, resources, and innovation in East Africa: A firm-level approach	Product innovation, firm age, firm size, internal R&D, employee education, skilled labor, managerial experience, legal status, foreign technology external funding, and sector and country variables.
2007	Goedhuys, Micheline	Industrial and Corporate Change	Learning, product innovation, and firm heterogeneity in developing countries; Evidence from Tanzania	Product innovation, firm age, firm size, skilled labor, R&D intensity, connectivity in the firm (website, internet, email), investment in machinery and equipment, skills level of workers, the intensity of collaboration, foreign ownership, and sector.
2015	McGuirk, Helen Lenihan, Helena Hart, Mark	Research Policy	Measuring the impact of innovative human capital on small firms' propensity to innovate	Product, process, service innovation, firm size, sector, employee education, managerial experience, skilled labor, job satisfaction, and willingness to changes.
2013	Bala Subrahmanya, MH	International Journal of Innovation Management	External support, innovation, and economic performance: what firm-level factors matter for high-tech SMEs? How?	Product and process innovation, firm age, firm size, firm objective, legal status, employee education, skilled labor, presence of design office, frequency of innovations, industry, sales turnover, total sales, and external support for innovation.

2014	Ceccagnoli, Marco Higgins, Matthew J Palermo, Vincenzo	Journal of Economics & Management Strategy	Behind the scenes: sources of complementarity in R&D	Product innovation, firm size, internal R&D, external R&D, country, firm resources for innovation, number of competitors, market size, number of scientific publications by the firm, and number of patents granted to the firms.

Appendix 2

Table 3: Variables considered from the manufacturing questionnaire

Variable	New Variable Name	Question	Question Type
b5	Foundation_year	In what year did this establishment begin operations? b1 - Year establishment began operations Don't Know = -9	Enter the year
ha14y	Interview_year	Year the interview begins	Enter the year
l1	no_of_employees	At the end of fiscal year [Insert last complete fiscal year], how many permanent, full-time individuals worked in this establishment? Please include all workers and managers. Permanent, full-time workers are defined as all workers that work for a term of one or more fiscal years and/or have a guaranteed renewal of their employment and that work a full shift. l1 - Permanent, full-time workers at the end of last fiscal year -9 - Don't Know (Spontaneous)	Enter value
b1	Legal_Status	What is this firm’s current legal status? 1 – Shareholding company with shares trade in the stock market 2 – Shareholding company with non-traded shares or shares traded privately 3 – Solo proprietorship 4 – Partnership 5 – Limited partnership 6 – Other	Select one of the options
b7	Managerial_Experience	How many years of experience working in this sector does the Top Manager have? b7 – Manager’s experience in sector 1 – Less Than One Year Don't Know = -9	Enter value

l10	Skilled_Labour	Over fiscal year [Insert last complete fiscal year], did this establishment have formal training programs for its permanent, full-time workers? 1 - Yes 2 - No -9 - Don't Know (Spontaneous)	Yes/No
h7a	Obstacle_court_system	Please tell me if you Strongly disagree, Tend to disagree, Tend to agree, or Strongly agree with the statement: "The court system is fair, impartial and uncorrupted". 1 (Strongly disagree) 2 (Tend to disagree) 3 (Tend to agree) 4 (Strongly agree)	Select one of the options
j30f	Obstacle_corruption	Using the response options on the card; To what degree Corruption is an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)	Select one of the options
h30	Obstacle_courts	Using the response options on the card; To what degree Courts is an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)	Select one of the options
j30e	Obstacle_political_instablty	Using the response options on the card; To what degree Political instability is an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)	Select one of the options

i30	Obstacle_crime_theft	Using the response options on the card; To what degree is Crime, Theft, and Disorder an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)	Select one of the options
j30a	Obstacle_tax	Using the response options on the card; To what degree Tax rates is an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)	Select one of the options
j30b	Obstacle_tax_adminstration	Using the response options on the card; To what degree Tax administration is an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)	Select one of the options
d30b	Obstacle_trade_customs	Using the response options on the card; To what degree Customs and trade regulations is an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)	Select one of the options
j30c	Obstacle_buslicense	Using the response options on the card; To what degree Business licensing and permits is an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)	Select one of the options

Table 4: Variables considered from the innovation questionnaire

Variable	New Variable Name	Question	Question Type
hb1	Product_Innovation	From fiscal year 2010/2011 thru 2012/2013, did this establishment introduce any innovative product or service? 1 - Yes 2 - No -9 - Don't Know (Spontaneous)	Yes/No
hf1a	Internal_RandD	From fiscal year 2010/2011 thru 2012/2013 did this establishment conduct internal R&D? (Internal R&D is defined as creative work undertaken to increase knowledge for developing innovative products and processes.) 1 - Yes 2 - No -9 - Don't Know (Spontaneous)	Yes/No
hf2a	External_RandD	From fiscal year 2010/2011 thru 2012/2013 did this establishment conduct external R&D? (External R&D is defined as creative work, undertaken by other enterprises, public or private research organizations, which was paid for by this establishment.) 1 - Yes 2 - No -9 - Don't Know (Spontaneous)	Yes/No
hf7a	Internal_funds	From fiscal year 2010/2011 thru 2012/2013, did this establishment fund its innovation activities from any of the following sources: Own funds? 1 - Yes 2 - No -9 - Don't Know (Spontaneous) -7 - Doesn't apply (Spontaneous)	Yes/No
hf7b	External_Funds	From fiscal year 2010/2011 thru 2012/2013, did this establishment fund its innovation activities from any of the following sources: Private or state-owned banks? 1 - Yes 2 - No -9 - Don't Know (Spontaneous) -7 - Doesn't apply (Spontaneous)	Yes/No

hf7c	External_Funds	From fiscal year 2010/2011 thru 2012/2013, did this establishment fund its innovation activities from any of the following sources: Government agencies or departments? 1 - Yes 2 - No -9 - Don't Know (Spontaneous) -7 - Doesn't apply (Spontaneous)	Yes/No
hf7d	External_Funds	From fiscal year 2010/2011 thru 2012/2013, did this establishment fund its innovation activities from any of the following sources: NGOs or international organizations? 1 - Yes 2 - No -9 - Don't Know (Spontaneous) -7 - Doesn't apply (Spontaneous)	Yes/No
hf7e	External_Funds	From fiscal year 2010/2011 thru 2012/2013, did this establishment fund its innovation activities from any of the following sources: Other, moneylenders, friends, relatives, etc.? 1 - Yes 2 - No -9 - Don't Know (Spontaneous) -7 - Doesn't apply (Spontaneous)	Yes/No

Table 5: Regional-level variables

New Variable Name	Parameters	Source
GDP per capita	Calculated as – GDP Per Capita(million) = GSDP at Constant Prices(in 10 million) / Total population (million) GDP Per Capita (per million population) = GDP Per Capita / 1000000	The Gross State Domestic Product was collected from Indiastat.com with the help of which we calculated the GDP per capita by taking the ratio of the Gross State Domestic Product at constant prices of the year 2014 by the total population.
Infrastructure	Road density per 1000 population Rail density per 1000 population Aggregate = (Road density per 1000 population + Rail density per 1000 population) / 2	Infrastructure Statistics, 2014
ICT Exports	ICT Exports is one of the sub-indicators of Knowledge Diffusion indicator and measures the extent to which an economy of the state has scaled up from resource-driven to innovation-driven. The values are transformed into a 0 to 100 scale with 0 being the worst-case scenario and 100 being the best-case scenario.	India Innovation Index Report
Human Capital	The indicator is normalized with 0 being the worst-case scenario and 100 being the best-case scenario. This indicator consists of several sub-indicators that include labor force participation rate (per 1000), Percentage of population with at least secondary level of education, percentage of individuals who received technical training out of the total population, seating capacity at Industrial Training Institutes (ITIs), Average wage of wage salaried persons aged 15 years and above, Average wage of labor working in the Manufacturing sector, Share of the workforce in Manufacturing in percent, workers aged 15 years and above, Man-days lost due to strike and lockouts.	National Council of Applied Economic Research (NCAER) State Investment Potential Index
Input of innovative activities	This is measured as the ratio of R&D expenditure divided by the Gross State Domestic Product.	Economic Advisory Council to the Prime Minister (EAC-PM)

Table 6: Regional Institutional Quality Barriers

Regional Institutional Quality Barrier	Variable	Description
Regulatory Quality Barriers	Obstacle_tax	Using the response options on the card; To what degree Tax rates is an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)
	Obstacle_tax_ adminstration	Using the response options on the card; To what degree Tax administration is an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)
	Obstacle_trade_customs	Using the response options on the card; To what degree Customs and trade regulations is an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)
	Obstacle_buslicense	Using the response options on the card; To what degree Business licensing and permits is an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)

Corruption Barriers	Obstacle_court_system	Please tell me if you Strongly disagree, Tend to disagree, Tend to agree, or Strongly agree with the statement: "The court system is fair, impartial and uncorrupted". 1 (Strongly disagree) 2 (Tend to disagree) 3 (Tend to agree) 4 (Strongly agree)
	Obstacle_corruption	Using the response options on the card; To what degree Corruption is an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)
Rule of Law Barriers	Obstacle_courts	Using the response options on the card; To what degree Courts is an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)
	Obstacle_political_instablty	Using the response options on the card; To what degree Political instability is an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)
	Obstacle_crime_theft	Using the response options on the card; To what degree is Crime, Theft and Disorder an obstacle to the current operations of this establishment? 0 (No obstacle) 1 (Minor obstacle) 2 (Moderate obstacle) 3 (Major obstacle) 4 (Very Severe Obstacle)

Appendix 3

Table 11: Frequency distribution of Regulatory Quality Barriers

Regulatory Quality	0 - No obstacle (%, # firms)	1 - Minor Obstacle (%, # firms)	2 - Moderate Obstacle (%, # firms)	3 - Major Obstacle (%, # firms)	4 - Very Severe Obstacle (%, # firms)	Total
Tax rates	18.27 (637)	25.87 (902)	27.42 (956)	21.57 (752)	6.86 (239)	3486
Tax administration	25.76 (898)	29.17 (1017)	28.71 (1001)	11.62 (405)	4.73 (165)	3486
Customs and trade regulations	50.73 (1660)	28.18 (922)	11.67 (382)	5.1 (167)	4.31 (141)	3272
Business licensing and permits	36.19 (1262)	31.14 (1086)	21.39 (746)	8.72 (304)	2.55 (89)	3487

Table 12: Frequency distribution of Corruption Barriers

Corruption	0 - No obstacle (%, # firms)	1 - Minor Obstacle (%, # firms)	2 - Moderate Obstacle (%, # firms)	3 - Major Obstacle (%, # firms)	4 - Very Severe Obstacle (%, # firms)	Total
Corruption	13.45 (469)	18.3 (638)	26.24 (915)	22.89 (798)	19.13 (667)	3487
		1 - Strongly disagree (%, # firms)	**2 - Tend to disagree (%, # firms)**	**3 - Tend to agree (%, # firms)**	**4 - Strongly agree (%, # firms)**	**Total**
Court System - The court system is fair, impartial, and uncorrupted.		14.79 (502)	13.73 (466)	50.81 (1725)	20.68 (702)	3395

Table 13: Frequency distribution of Rule of Law Barriers

Rule of Law	0 - No obstacle (%, # firms)	1 - Minor Obstacle (%, # firms)	2 - Moderate Obstacle (%, # firms)	3 - Major Obstacle (%, # firms)	4 - Very Severe Obstacle (%, # firms)	Total
Courts	52.39 (1775)	28.07 (951)	12.22 (414)	5.4 (183)	1.92 (65)	3388
Political instability	41.91 (1461)	26.45 (922)	17.01 (593)	10.21 (356)	4.42 (154)	3486
Crime, theft, and disorder	59.39 (2061)	25.68 (891)	11.24 (390)	2.68 (93)	1.01 (35)	3470

Appendix 4

Figure 10: Results of logistic regression of the baseline model

```
Iteration 0:   log likelihood = -1981.9329
Iteration 1:   log likelihood = -1824.7863
Iteration 2:   log likelihood = -1822.4312
Iteration 3:   log likelihood =   -1822.43
Iteration 4:   log likelihood =   -1822.43

Logistic regression                             Number of obs     =      3072
                                                LR chi2(25)       =    319.01
                                                Prob > chi2       =    0.0000
Log likelihood =   -1822.43                     Pseudo R2         =    0.0805
```

Product_Innovation	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Firm_Age	-.0891262	.0544324	-1.64	0.102	-.1958118	.0175593
Firm_Size	.0981273	.0367842	2.67	0.008	.0260315	.170223
Legal_Status						
Shareholding Corporation	-.2026109	.1344861	-1.51	0.132	-.4661989	.0609771
Industry						
Food, Tobacco, Textile, and Clothing	.4099667	.230199	1.78	0.075	-.0412151	.8611485
Wood, Paper, Chemicals and Non-metalic Products	.6706894	.2274786	2.95	0.003	.2248395	1.116539
Machinery and Equipment	.6419615	.2217579	2.89	0.004	.207324	1.076599
Wholesale	-.1332865	.3144731	-0.42	0.672	-.7496424	.4830694
Retail	.5531294	.2833182	1.95	0.051	-.002164	1.108423
Transportation	-.0792306	.2991177	-0.26	0.791	-.6654906	.5070294
IT	-.1303233	.3197912	-0.41	0.684	-.7571026	.4964559
Accomodation	-.2788784	.2756654	-1.01	0.312	-.8191726	.2614158
Other Services	-.6646061	.3003272	-2.21	0.027	-1.253237	-.0759756
GDP_percapita	1.612593	.7921605	2.04	0.042	.0599867	3.165199
Internal_RandD						
Establishment conduct Internal R&D.	.570353	.0889267	6.41	0.000	.3960598	.7446462
External_RandD						
Establishment conduct External R&D.	.3633107	.1522113	2.39	0.017	.064982	.6616395
Managerial_Experience						
Manager's experience is greater than 10 years.	.2288178	.0869282	2.63	0.008	.0584416	.3991941
Skilled_Labour						
Establishment provide formal training to any of its empl..	.0961977	.0888421	1.08	0.279	-.0779296	.2703251
External_Fund						
Private or state-owned banks; Government agencies or dep..	.0529013	.0841457	0.63	0.530	-.1120212	.2178239
RIB_Regulatory_Quality	-.031539	.0162986	-1.94	0.053	-.0634837	.0004058
RIB_Corruption	-.0211146	.0312695	-0.68	0.500	-.0824016	.0401725
RIB_Rule_of_Law	-.0488314	.0221635	-2.20	0.028	-.0922711	-.0053916
Rail_Road_Density	.0679675	.0485418	1.40	0.161	-.0271726	.1631077
Knowledge_Diffusion	.0086759	.0021155	4.10	0.000	.0045296	.0128222
Labor	.0371969	.0051945	7.16	0.000	.0270158	.0473779
RDExpenditure_Proportion_GSDP	2.512439	1.219596	2.06	0.039	.122076	4.902803
_cons	-2.884253	.4294784	-6.72	0.000	-3.726016	-2.042491

Figure 11: Results of logistic regression of the full model (interactions)

```
Iteration 0:   log likelihood = -1981.9329
Iteration 1:   log likelihood =  -1820.355
Iteration 2:   log likelihood =  -1817.847
Iteration 3:   log likelihood = -1817.8454
Iteration 4:   log likelihood = -1817.8454

Logistic regression                             Number of obs   =       3072
                                                LR chi2(28)     =     328.18
                                                Prob > chi2     =     0.0000
Log likelihood = -1817.8454                     Pseudo R2       =     0.0828
```

Product_Innovation	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Firm_Age	-.0879073	.0545572	-1.61	0.107	-.1948375	.0190229
Firm_Size	.0958977	.0368461	2.60	0.009	.0236806	.1681147
Legal_Status						
Shareholding Corporation	-.2217014	.1348766	-1.64	0.100	-.4860548	.042652
Industry						
Food, Tobacco, Textile, and Clothing	.4313203	.2308113	1.87	0.062	-.0210616	.8837023
Wood, Paper, Chemicals and Non-metalic Products	.6801315	.228053	2.98	0.003	.2331559	1.127107
Machinery and Equipment	.650017	.2223107	2.92	0.003	.2142959	1.085738
Wholesale	-.1505015	.3156505	-0.48	0.634	-.7691651	.468162
Retail	.5580329	.2836915	1.97	0.049	.0020077	1.114058
Transportation	-.0787277	.3007836	-0.26	0.794	-.6682528	.5107974
IT	-.1316852	.3195605	-0.41	0.680	-.7580123	.4946419
Accomodation	-.2816543	.2767151	-1.02	0.309	-.824006	.2606973
Other Services	-.6574987	.3010385	-2.18	0.029	-1.247523	-.0674741
GDP_percapita	1.615399	.7945479	2.03	0.042	.0581139	3.172684
Internal_RandD						
Establishment conduct Internal R&D.	.5765685	.0891569	6.47	0.000	.4018243	.7513128
External_RandD						
Establishment conduct External R&D.	.3775213	.1528282	2.47	0.014	.0779835	.6770591
Managerial_Experience						
Manager's experience is greater than 10 years.	.226311	.0870427	2.60	0.009	.0557104	.3969116
Skilled_Labour						
Establishment provide formal training to any of its employees.	.0996166	.0889887	1.12	0.263	-.074798	.2740312
External_Fund						
Private or state-owned banks; Government agencies or departme..	.0578973	.0843401	0.69	0.492	-.1074063	.2232009
RIB_Regulatory_Quality	-.0558439	.0218047	-2.56	0.010	-.0985804	-.0131074
RIB_Corruption	-.077172	.0407783	-1.89	0.058	-.157096	.002752
RIB_Rule_of_Law	-.0121255	.0297597	-0.41	0.684	-.0704535	.0462024
Rail_Road_Density	.0698996	.0486324	1.44	0.151	-.0254181	.1652173
Knowledge_Diffusion	.0084775	.0021233	3.99	0.000	.004316	.012639
Labor	.0376665	.0052171	7.22	0.000	.0274411	.0478919
RDExpenditure_Proportion_GSDP	2.640421	1.221707	2.16	0.031	.2459193	5.034922
Internal_RandD#c.RIB_Regulatory_Quality						
Establishment conduct Internal R&D.	.0543728	.0328596	1.65	0.098	-.0100307	.1187764
Internal_RandD#c.RIB_Corruption						
Establishment conduct Internal R&D.	.1343808	.0626227	2.15	0.032	.0116426	.2571189
Internal_RandD#c.RIB_Rule_of_Law						
Establishment conduct Internal R&D.	-.080873	.0446675	-1.81	0.070	-.1684197	.0066736
_cons	-2.931766	.4308612	-6.80	0.000	-3.776238	-2.087294

Figure 12: LR Test

Model 1 – Firm-level and regional-level variables without the interaction terms

Model 2 – Full model including the interaction terms

```
. lrtest model1 model2

Likelihood-ratio test                                 LR chi2(3)  =      9.17
(Assumption: model1 nested in model2)                 Prob > chi2 =    0.0271
```

Figure 16: Results of mixed-effects logistic regression of the baseline model

```
Fitting fixed-effects model:

Iteration 0:   log likelihood = -1823.5688
Iteration 1:   log likelihood = -1822.4302
Iteration 2:   log likelihood =   -1822.43
Iteration 3:   log likelihood =   -1822.43

Refining starting values:

Grid node 0:   log likelihood = -1793.7191

Fitting full model:

Iteration 0:   log likelihood = -1793.7191  (not concave)
Iteration 1:   log likelihood = -1783.6051
Iteration 2:   log likelihood = -1782.0296
Iteration 3:   log likelihood = -1781.9093
Iteration 4:   log likelihood = -1781.9062
Iteration 5:   log likelihood = -1781.9062

Mixed-effects logistic regression               Number of obs      =      3072
Group variable:              a2                 Number of groups   =        23

                                                Obs per group: min =        37
                                                               avg =     133.6
                                                               max =       220

Integration method:     laplace
```

	Wald chi2(25) = 180.14					
Log likelihood = -1781.9062	Prob > chi2 = 0.0000					

Product_Innovation	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Firm_Age	-.0909484	.0572628	-1.59	0.112	-.2031815	.0212847
Firm_Size	.0921046	.0382375	2.41	0.016	.0171605	.1670487
Legal_Status						
Shareholding Corporation	-.1131102	.1384262	-0.82	0.414	-.3844206	.1582003
Industry						
Food, Tobacco, Textile, and Clothing	.3299814	.2403599	1.37	0.170	-.1411154	.8010783
Wood, Paper, Chemicals and Non-metalic Products	.6619671	.2370011	2.79	0.005	.1974534	1.126481
Machinery and Equipment	.5710001	.2308916	2.47	0.013	.118461	1.023539
Wholesale	-.0917757	.326725	-0.28	0.779	-.7321448	.5485935
Retail	.4954942	.2945038	1.68	0.092	-.0817227	1.072711
Transportation	-.0125334	.3077505	-0.04	0.968	-.6157133	.5906465
IT	-.0280114	.3346312	-0.08	0.933	-.6838765	.6278538
Accomodation	-.3479633	.2863152	-1.22	0.224	-.9091308	.2132041
Other Services	-.7168465	.3104822	-2.31	0.021	-1.32538	-.1083124
GDP_percapita	1.118548	2.045174	0.55	0.584	-2.889918	5.127015
Internal_RandD						
Establishment conduct Internal R&D.	.5725538	.0926015	6.18	0.000	.3910582	.7540494
External_RandD						
Establishment conduct External R&D.	.3737071	.1546702	2.42	0.016	.070559	.6768552
Managerial_Experience						
Manager's experience is greater than 10 years.	.0997028	.0934365	1.07	0.286	-.0834294	.282835
Skilled_Labour						
Establishment provide formal training to any of its employees.	.0238968	.0950146	0.25	0.801	-.1623285	.2101221
External_Fund						
Private or state-owned banks; Government agencies or departme..	-.0918023	.0900053	-1.02	0.308	-.2682096	.0846049
RIB_Regulatory_Quality	-.0314158	.0166655	-1.89	0.059	-.0640796	.0012481
RIB_Corruption	-.0199544	.0319103	-0.63	0.532	-.0824974	.0425886
RIB_Rule_of_Law	-.0524604	.0227196	-2.31	0.021	-.09699	-.0079308
Rail_Road_Density	.0544324	.1059501	0.51	0.607	-.153226	.2620908
Knowledge_Diffusion	.0083717	.0055561	1.51	0.132	-.002518	.0192615
Labor	.0431003	.014282	3.02	0.003	.0151081	.0710926
RDExpenditure_Proportion_GSDP	1.637606	2.837118	0.58	0.564	-3.923043	7.198255
_cons	-2.744413	.839559	-3.27	0.001	-4.389919	-1.098908
a2						
var(_cons)	.2214381	.0816167			.1075277	.4560205

LR test vs. logistic regression: chibar2(01) = 81.05 Prob>=chibar2 = 0.0000

Figure 17: Results of mixed-effects logistic regression of the full model (interactions)

```
Fitting fixed-effects model:

Iteration 0:   log likelihood = -1819.0778
Iteration 1:   log likelihood = -1817.8457
Iteration 2:   log likelihood = -1817.8454
Iteration 3:   log likelihood = -1817.8454

Refining starting values:

Grid node 0:   log likelihood = -1789.5384

Fitting full model:

Iteration 0:   log likelihood = -1789.5384  (not concave)
Iteration 1:   log likelihood = -1779.3513
Iteration 2:   log likelihood = -1777.7269
Iteration 3:   log likelihood = -1777.6283
Iteration 4:   log likelihood = -1777.6273
Iteration 5:   log likelihood = -1777.6273

Mixed-effects logistic regression               Number of obs      =      3072
Group variable:              a2                 Number of groups   =        23

                                                Obs per group: min =        37
                                                               avg =     133.6
                                                               max =       220

Integration method:     laplace
                                                Wald chi2(28)      =    187.02
Log likelihood = -1777.6273                     Prob > chi2        =    0.0000
```

Product_Innovation	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Firm_Age	.913921	.0524222	-1.57	0.117	.8167403	1.022665
Firm_Size	1.094482	.0419435	2.36	0.018	1.015286	1.179856
Legal_Status						
Shareholding Corporation	.8764458	.1216502	-0.95	0.342	.667696	1.15046
Industry						
Food, Tobacco, Textile, and Clothing	1.419395	.3417788	1.45	0.146	.8854023	2.275441
Wood, Paper, Chemicals and Non-metalic Products	1.955922	.464609	2.82	0.005	1.227884	3.115628
Machinery and Equipment	1.784542	.4127588	2.50	0.012	1.134087	2.808063
Wholesale	.8939894	.2930442	-0.34	0.732	.4702337	1.699616
Retail	1.640774	.4837888	1.68	0.093	.9205947	2.924347
Transportation	.9859364	.3048123	-0.05	0.963	.5378873	1.807201
IT	.9707319	.3240253	-0.09	0.929	.5046295	1.867351
Accomodation	.7038531	.2022853	-1.22	0.222	.4007275	1.236274
Other Services	.490897	.1527102	-2.29	0.022	.2668057	.9032035
GDP_percapita	3.131186	6.399097	0.56	0.576	.0570345	171.9017
Internal_RandD						
Establishment conduct Internal R&D.	1.77822	.1650163	6.20	0.000	1.482502	2.132926

External_RandD						
Establishment conduct External R&D.	1.473566	.2288488	2.50	0.013	1.086866	1.997853
Managerial_Experience						
Manager's experience is greater than 10 years.	1.100905	.1030739	1.03	0.305	.9163364	1.32265
Skilled_Labour						
Establishment provide formal training to any of its employees.	1.025353	.0975896	0.26	0.793	.8508616	1.235628
External_Fund						
Private or state-owned banks; Government agencies or departme..	.9153814	.0826104	-0.98	0.327	.7669795	1.092497
RIB_Regulatory_Quality	.9449542	.0212429	-2.52	0.012	.9042229	.9875203
RIB_Corruption	.9277557	.0388643	-1.79	0.073	.8546262	1.007143
RIB_Rule_of_Law	.9817047	.0301245	-0.60	0.547	.9244021	1.042559
Rail_Road_Density	1.056585	.111869	0.52	0.603	.8585805	1.300253
Knowledge_Diffusion	1.008192	.005597	1.47	0.142	.9972816	1.019222
Labor	1.044543	.0149092	3.05	0.002	1.015727	1.074178
RDExpenditure_Proportion_GSDP	6.015175	17.05585	0.63	0.527	.0232109	1558.854
Internal_RandD#c.RIB_Regulatory_Quality						
Establishment conduct Internal R&D.	1.057942	.0356498	1.67	0.095	.9903273	1.130174
Internal_RandD#c.RIB_Corruption						
Establishment conduct Internal R&D.	1.139828	.0728292	2.05	0.041	1.005661	1.291894
Internal_RandD#c.RIB_Rule_of_Law						
Establishment conduct Internal R&D.	.9282316	.042587	-1.62	0.105	.8484054	1.015569
_cons	.0613752	.0515152	-3.32	0.001	.0118451	.3180149
a2						
var(_cons)	.2208082	.0814286			.1071798	.4549014

LR test vs. logistic regression: chibar2(01) = 80.44 Prob>=chibar2 = 0.0000

Table 17: Marginal effects of regional institutional quality barriers on innovation through Internal R&D

Regional Institutional Quality Barriers	Levels	Internal R&D	Margin	S.E.	z	Pr (z)	CI
Regulatory Quality Barriers	Minimum	1	0.6873	0.0341	20.15	0.000	.6204 - .7541
		0	0.7175	0.0369	19.42	0.000	.6451 - .7899
	Maximum	1	0.4348	0.0655	6.64	0.000	.3065 - .5631
		0	0.7119	0.0609	11.68	0.000	.5925 - .8313
	Mean	1	0.5994	0.0122	49.22	0.000	.5756 - .6233
		0	0.7155	0.0122	58.6	0.000	.6916 - .7394
	+1 Std. Dev	1	0.5563	0.0213	26.1	0.000	.5145 - .5981
		0	0.7145	0.0196	36.44	0.000	.6761 - .7530
	-1 Std. Dev	1	0.6411	0.0197	32.58	0.000	.6026 - .6797
		0	0.7164	0.0205	34.97	0.000	.6763 - .7566
Corruption Barriers	Minimum	1	0.7159	0.0574	12.48	0.000	.6035 - .8284
		0	0.631	0.0765	8.25	0.000	.4811 - .7808
	Maximum	1	0.5332	0.0376	14.18	0.000	.4595 - .6070
		0	0.7548	0.033	22.85	0.000	.6901 - .8196
	Mean	1	0.5988	0.0121	49.39	0.000	.5751 - .6226
		0	0.7159	0.0122	58.81	0.000	.6920 - .7397
	+1 Std. Dev	1	0.5787	0.0165	35.1	0.000	.5464 - .6110
		0	0.7284	0.0157	46.43	0.000	.6976 - .7591
	-1 Std. Dev	1	0.6187	0.0156	39.57	0.000	.5880 - .6493
		0	0.7031	0.0165	42.53	0.000	.6707 - .7355
Rule of Law Barriers	Minimum	1	0.6102	0.0302	20.21	0.000	.5510 - .6694
		0	0.7849	0.025	31.35	0.000	.7358 - .8340
	Maximum	1	0.5653	0.0843	6.71	0.000	.4002 - .7305
		0	0.4642	0.0953	4.87	0.000	.2774 - .6509
	Mean	1	0.5991	0.0121	49.42	0.000	.5753 - .6229
		0	0.7171	0.0123	58.28	0.000	.6930 - .7412
	+1 Std. Dev	1	0.5923	0.0203	29.16	0.000	.5525 - .6321
		0	0.6706	0.0211	31.78	0.000	.6292 - .7119
	-1 Std. Dev	1	0.6059	0.0209	29.03	0.000	.5650 - .6468
		0	0.7596	0.0188	40.37	0.000	.7227 - .7965

Table 19: Results of the odds ratio of the mixed-effects logistic regression of the baseline model and full model

Variables	Model 3 - Mixed-effects Logistic Regression (Baseline Model)	Model 4 - Mixed-effects Logistic Regression (Full Model)
Firm & Regional variables:		
Internal R&D	1.773*** (0.164)	1.778*** (0.165)
External R&D	1.453** (0.225)	1.474** (0.229)
Managerial Experience	1.105 (0.103)	1.101 (0.103)
Skilled Labour	1.024 (0.097)	1.025 (0.098)
Infrastructure (Rail & Road Density)	1.056 (0.112)	1.057 (0.112)
ICT Exports(Knowledge Diffusion)	1.008 (0.006)	1.008 (0.006)
Human Capital (Labor)	1.044*** (0.015)	1.045*** (0.015)
R&D Expenditure/Gross State Domestic Product	5.143 (14.591)	6.015 (17.056)
Regulatory Quality Barrier	0.969* (0.016)	0.945** (0.021)
Corruption Barrier	0.980 (0.031)	0.928* (0.039)
Rule of Law Barrier	0.949** (0.022)	0.982 (0.030)
Interaction Terms:		
Internal R&D * Regulatory Quality		1.058* (0.036)
Internal R&D * Corruption		1.140** (0.073)
Internal R&D * Rule of Law		0.928 (0.043)
Control variables:		
Firm Age (log)	0.913 (0.052)	0.914 (0.052)
Firm Size (log)	1.096** (0.042)	1.094** (0.042)
Legal Status - Shareholding Corporation	0.893 (0.124)	0.876 (0.122)
External Fund	0.912 (0.082)	0.915 (0.083)
Industry - Food, Tobacco, Textile, and Clothing	1.391 (0.334)	1.419 (0.342)
Industry - Wood, Paper, Chemicals and Non-metallic Products	1.939*** (0.459)	1.956*** (0.465)
Industry - Machinery and Equipment	1.770** (0.409)	1.785** (0.413)
Industry - Wholesale	0.912 (0.298)	0.894 (0.293)
Industry - Retail	1.641* (0.483)	1.641* (0.484)
Industry - Transportation	0.988 (0.304)	0.986 (0.305)
Industry - Information Technology	0.972 (0.325)	0.971 (0.324)
Industry - Accommodation	0.706 (0.202)	0.704 (0.202)
Industry - Other Services	0.488** (0.152)	0.491** (0.153)
GDP per capita	3.060 (6.259)	3.131 (6.399)
Constant	0.064*** (0.054)	0.061*** (0.052)
	1.248*** (0.102)	1.247*** (0.102)
Observations	3072	3072
Number of groups	23	23
*** p<0.01, ** p<0.05, * p<0.1 & standard error form in parentheses		

Figure 18: Wald Test

```
. test Rail_Road_Density Knowledge_Diffusion Labor RDExpenditure_Proportion_GSDP RIB_Regulatory_Quality RIB_Corruption RIB_Rule_of_Law

 ( 1)  [Product_Innovation]Rail_Road_Density = 0
 ( 2)  [Product_Innovation]Knowledge_Diffusion = 0
 ( 3)  [Product_Innovation]Labor = 0
 ( 4)  [Product_Innovation]RDExpenditure_Proportion_GSDP = 0
 ( 5)  [Product_Innovation]RIB_Regulatory_Quality = 0
 ( 6)  [Product_Innovation]RIB_Corruption = 0
 ( 7)  [Product_Innovation]RIB_Rule_of_Law = 0

           chi2(  7) =  134.50
         Prob > chi2 =    0.0000

.
```

Appendix 5

Table 21: Robustness checks for the mixed-effects logistic regression

Variable	Robustness check variable	Source
Infrastructure	Power generation in Gigawatt hour (GWh)	Infrastructure Statistics Volume 1 (2014) has information on the infrastructure of the regions of India. Some of them rail density, road density, telecommunication, and power generation. The Power generation variable in our study consisted of hydro, thermal, nuclear, and renewable sources of energy.
ICT Exports	Patent Intensity	Indian Patent Office (IPO) that has information about all patent-related data. For our study, we used the 2016-2017 data.

Appendix 6

Table 22: Results of logistic regression with interaction terms of Managerial Experience and Skilled Labor

Variables	Logistic Regression with Managerial Experience	Logistic Regression with Skilled Labor
Firm & Regional Variables:		
Internal R&D	0.569*** (0.089)	0.570*** (0.089)
External R&D	0.368** (0.152)	0.369** (0.152)
Managerial Experience	0.225*** (0.087)	0.227*** (0.087)
Skilled Labour	0.088 (0.089)	0.100 (0.089)
Infrastructure (Rail & Road Density)	0.069 (0.049)	0.068 (0.049)
ICT Exports (Knowledge Diffusion)	0.009*** (0.002)	0.009*** (0.002)
Human Capital (Labor)	0.037*** (0.005)	0.037*** (0.005)
R&D Expenditure/Gross State Domestic Product	2.487** (1.220)	2.510** (1.222)
Regulatory Quality Barriers	-0.034 (0.023)	-0.047** (0.022)
Corruption Barriers	-0.041 (0.044)	-0.022 (0.043)
Rule of Law Barriers	-0.069** (0.032)	-0.029 (0.032)
Interaction Terms:		
Internal R&D * Regulatory Quality	0.002 (0.033)	0.035 (0.033)
Internal R&D * Corruption	0.046 (0.062)	0.002 (0.063)
Internal R&D * Rule of Law	0.040 (0.045)	-0.041 (0.045)
Control Variables:		
Firm Age (log)	-0.090* (0.054)	-0.088 (0.055)
Firm Size (log)	0.104*** (0.037)	0.096*** (0.037)
Legal Status - Shareholding Corporation	-0.210 (0.135)	-0.205 (0.135)
External Fund	0.050 (0.084)	0.050 (0.084)
Industry - Food, Tobacco, Textile, and Clothing	0.422* (0.231)	0.410* (0.230)
Industry - Wood, Paper, Chemicals, and Non-metallic Products	0.684*** (0.228)	0.675*** (0.228)
Industry - Machinery and Equipment	0.654*** (0.222)	0.645*** (0.222)
Industry - Wholesale	-0.129 (0.316)	-0.140 (0.316)
Industry - Retail	0.559** (0.284)	0.552* (0.284)
Industry - Transportation	-0.060 (0.300)	-0.078 (0.300)
Industry - Information Technology	-0.135 (0.320)	-0.133 (0.320)
Industry - Accommodation	-0.263 (0.276)	-0.273 (0.276)
Industry - Other Services	-0.656** (0.301)	-0.665** (0.301)
GDP per capita	1.603**(0.792)	1.622** (0.794)
Constant	-2.906*** (0.430)	-2.888*** (0.430)
Log likelihood	-1821.2774	-1821.7616
LR Chi2	321.31	320.34
Prob > chi2	0.0000	0.0000

Pseudo R2	0.0811	0.0808
Observations	3072	3072
Akaike Information Criterion (AIC)	3700.555	3701.523
Bayesian Information Criterion (BIC)	3875.427	3876.396
*** p<0.01, ** p<0.05, * p<0.1 & standard error form in parentheses		

Table 23: Results of mixed-effects logistic regression with interaction terms of Managerial Experience and Skilled Labor

Variables	Mixed-effects Logistic Regression with Managerial Experience	Mixed-effects Logistic Regression with Skilled Labor
Firm & Regional Variables:		
Internal R&D	0.571*** (0.093)	0.573*** (0.093)
External R&D	0.375** (0.155)	0.378** (0.155)
Managerial Experience	0.096 (0.094)	0.098 (0.094)
Skilled Labour	0.018 (0.095)	0.026 (0.095)
Infrastructure (Rail & Road Density)	0.056 (0.106)	0.054 (0.106)
ICT Exports (Knowledge Diffusion)	0.008 (0.006)	0.009 (0.006)
Human Capital (Labor)	0.043*** (0.014)	0.043*** (0.014)
R&D Expenditure/Gross State Domestic Product	1.621 (2.836)	1.662 (2.847)
Regulatory Quality Barriers	-0.034 (0.023)	-0.046** (0.023)
Corruption Barriers	-0.048 (0.045)	-0.039 (0.044)
Rule of Law Barriers	-0.065** (0.032)	-0.037 (0.033)
Interaction Terms:		
Internal R&D * Regulatory Quality	0.003 (0.034)	0.033 (0.034)
Internal R&D * Corruption	0.062 (0.064)	0.043 (0.065)
Internal R&D * Rule of Law	0.025 (0.046)	-0.033 (0.046)
Control Variables:		
Firm Age (log)	-0.090 (0.057)	-0.091 (0.057)
Firm Size (log)	0.097** (0.038)	0.092** (0.038)
Legal Status - Shareholding Corporation	-0.120 (0.139)	-0.118 (0.138)
External Fund	-0.093 (0.090)	-0.097 (0.090)
Industry - Food, Tobacco, Textile, and Clothing	0.344 (0.241)	0.324 (0.240)
Industry - Wood, Paper, Chemicals, and Non-metallic Products	0.675*** (0.237)	0.659*** (0.237)
Industry - Machinery and Equipment	0.583** (0.231)	0.568** (0.231)
Industry - Wholesale	-0.095 (0.328)	-0.111 (0.328)
Industry - Retail	0.496* (0.295)	0.482 (0.295)
Industry - Transportation	0.001 (0.309)	-0.016 (0.308)
Industry - Information Technology	-0.034 (0.335)	-0.035 (0.334)
Industry - Accommodation	-0.333 (0.287)	-0.342 (0.286)

Industry - Other Services	-0.711** (0.311)	-0.722** (0.311)
GDP per capita	1.127 (2.044)	1.083 (2.052)
Constant	-2.766*** (0.839)	-2.744*** (0.842)
var(_cons[a2])	0.221*** (0.082)	0.223*** (0.082)
Log likelihood	-1780.9251	-1781.0609
Prob > chi2	0.0000	0
Wald chi2 (28)	181.66	181.42
Obs per group: min	37	37
Obs per group: avg	133.6	133.6
Obs per group: max	220	220
chibar2(01)	80.70	81.40
Prob>=chibar2	0.0000	0.0000
Observations	3072	3072
Number of groups	23	23
Intraclass Correlation (ICC)	0.0630	0.0635
*** p<0.01, ** p<0.05, * p<0.1 & standard error form in parentheses		

Table 24: Results of logistic regression with reference variable of Small-sized firms and Manufacturing sector

Variables	Model
Firm & Regional Variables:	
Internal R&D	1.824*** (0.160)
External R&D	1.490*** (0.227)
Managerial Experience	1.227** (0.106)
Skilled Labour	1.094 (0.095)
Infrastructure (Rail & Road Density)	1.081 (0.051)
ICT Exports (Knowledge Diffusion)	1.008*** (0.002)
Human Capital (Labor)	1.039*** (0.005)
R&D Expenditure/Gross State Domestic Product	11.632* (14.587)
Regulatory Quality Barriers	0.945*** (0.021)
Corruption Barriers	0.921** (0.037)
Rule of Law Barriers	0.986 (0.029)
Interaction Terms:	
Internal R&D * Regulatory Quality	1.055 (0.035)
Internal R&D * Corruption	1.147** (0.072)
Internal R&D * Rule of Law	0.924* (0.041)
Control Variables:	
Firm Age (log)	0.930 (0.050)
Firm Size (log) (Medium)	1.014 (0.100)
Firm Size (log) (Large)	1.291** (0.153)
Legal Status - Shareholding Corporation	0.822 (0.110)
Manufacturing Sector	2.288*** (0.234)

External Fund	1.055 (0.088)
GDP per capita	4.347* (3.356)
Constant	0.054*** (0.020)
Observations	3074
Log likelihood	-1825.5819
LR Chi2	314.40
Prob > chi2	0.0000
Pseudo R2	0.0793
Akaike Information Criterion (AIC)	3695.164
Bayesian Information Criterion (BIC)	3827.84
*** p<0.01, ** p<0.05, * p<0.1 & standard error form in parentheses	

Table 25: Results of mixed-effects logistic regression with reference variable of Small-sized firms and Manufacturing sector

Variables	Model
Firm & Regional Variables:	
Internal R&D	1.823*** (0.166)
External R&D	1.503*** (0.233)
Managerial Experience	1.084 (0.101)
Skilled Labour	1.010 (0.094)
Infrastructure (Rail & Road Density)	1.059 (0.110)
ICT Exports (Knowledge Diffusion)	1.008 (0.006)
Human Capital (Labor)	1.044*** (0.015)
R&D Expenditure/Gross State Domestic Product	5.320 (15.380)
Regulatory Quality Barriers	0.945** (0.021)
Corruption Barriers	0.921** (0.038)
Rule of Law Barriers	0.981 (0.030)
Interaction Terms:	
Internal R&D * Regulatory Quality	1.056 (0.036)
Internal R&D * Corruption	1.146** (0.073)
Internal R&D * Rule of Law	0.930 (0.042)
Control Variables:	
Firm Age (log)	0.925 (0.052)
Firm Size (log) (Medium)	0.995 (0.102)
Firm Size (log) (Large)	1.281** (0.158)
Legal Status - Shareholding Corporation	0.905 (0.124)
Manufacturing Sector	2.172*** (0.232)
External Fund	0.907 (0.081)
GDP per capita	3.260 (6.506)
Constant	0.063*** (0.051)
	1.246*** (0.101)
Observations	3074

Obs per group: min	37
Obs per group: avg	133.7
Obs per group: max	220
chibar2(01)	80.57
Prob>=chibar2	0.0000
Number of groups	23
Log likelihood	-1785.2976
Wald chi2(21)	175.67
Prob > chi2	0.0000
Intraclass Correlation (ICC)	.0628
*** p<0.01, ** p<0.05, * p<0.1 & standard error form in parentheses	

Appendix 7

Figure 1: R&D Expenditure in the field of Science, Technology and Agriculture

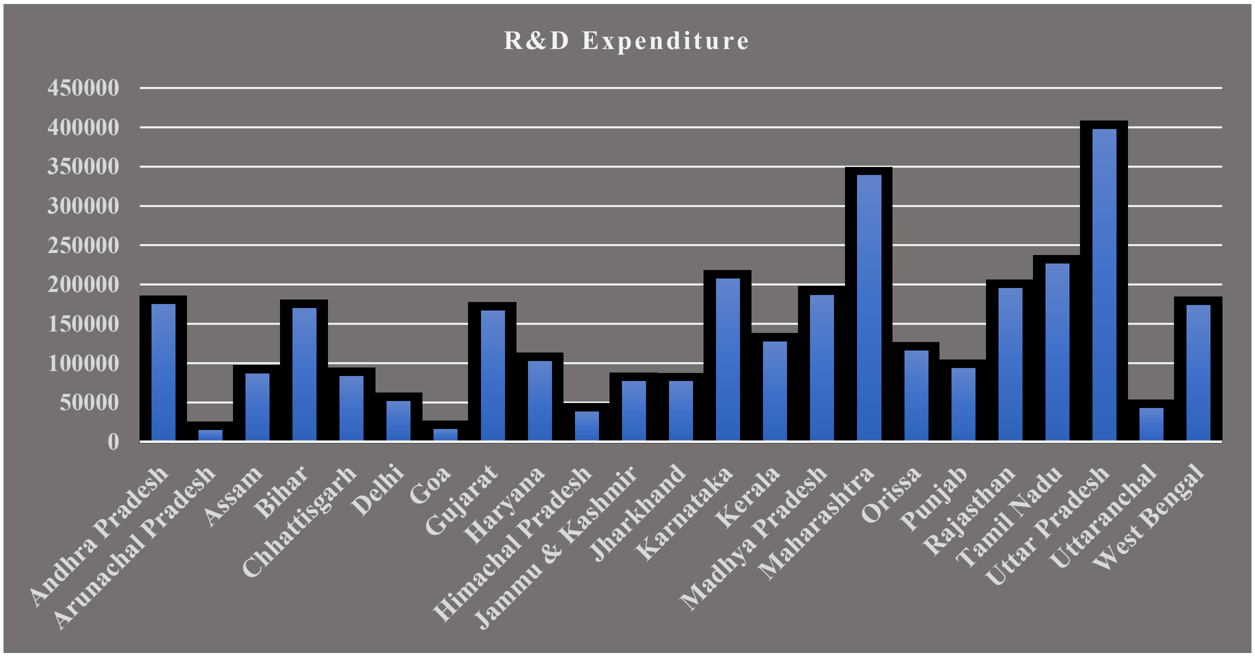

Figure 2: Number of R&D institutions funded by state

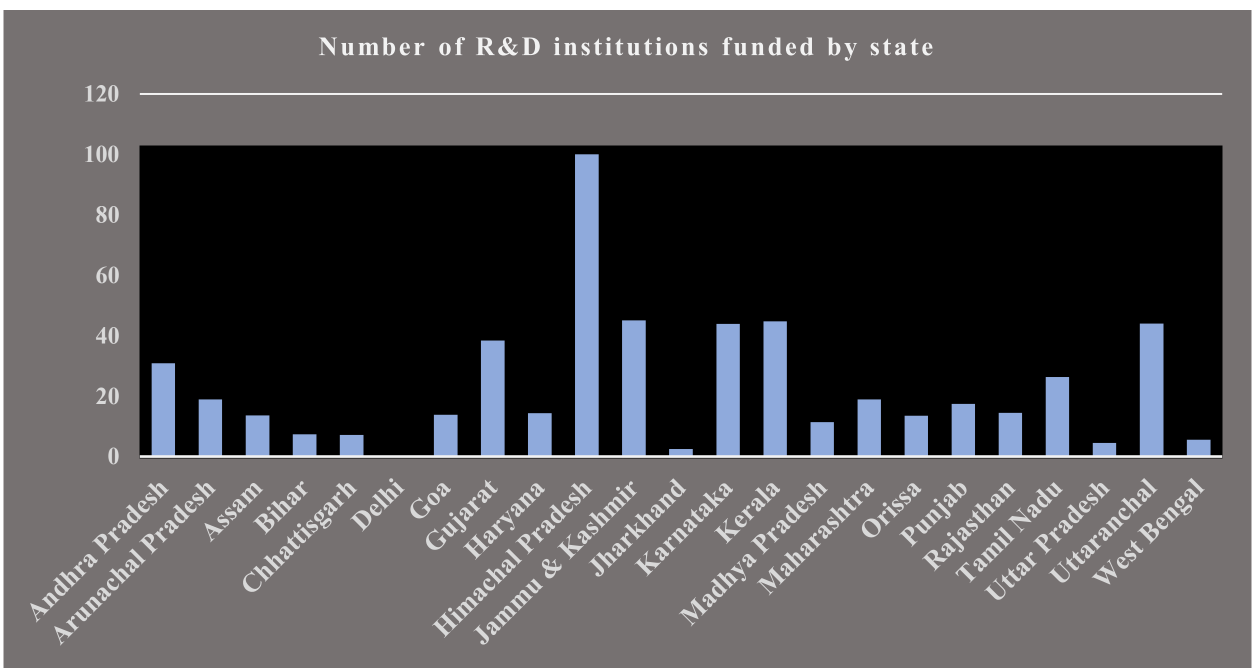

Figure 3: Enrolment in Ph.D.

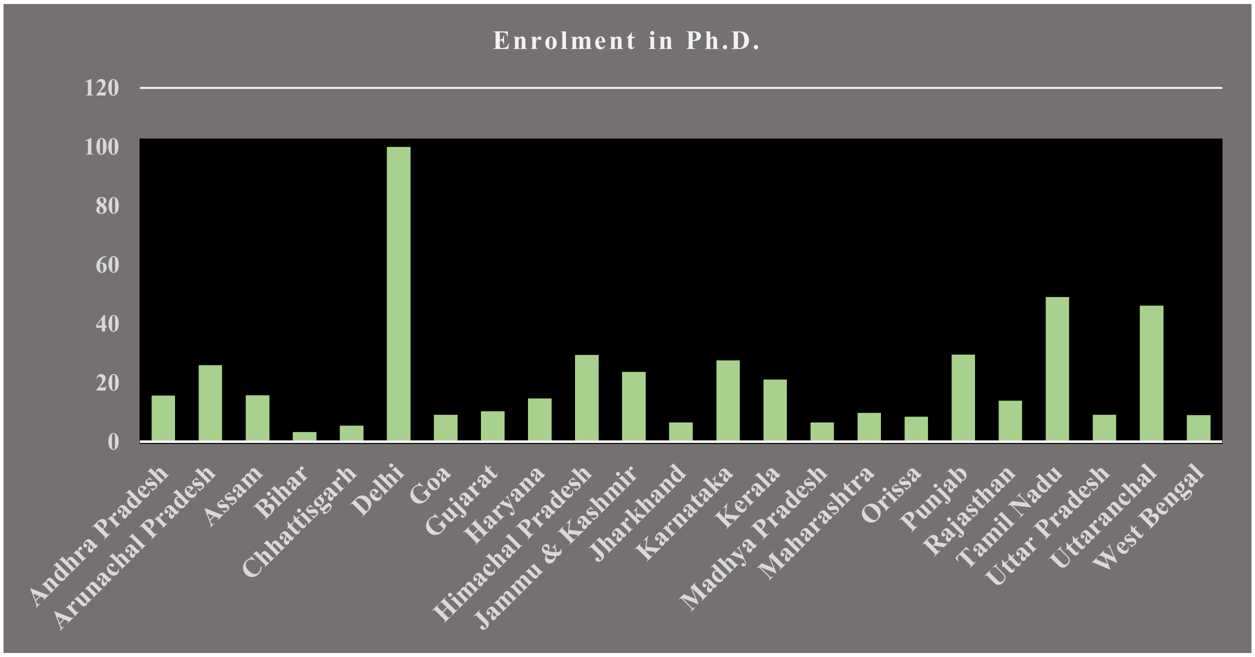

Figure 4: State government expenditure on higher & technical education

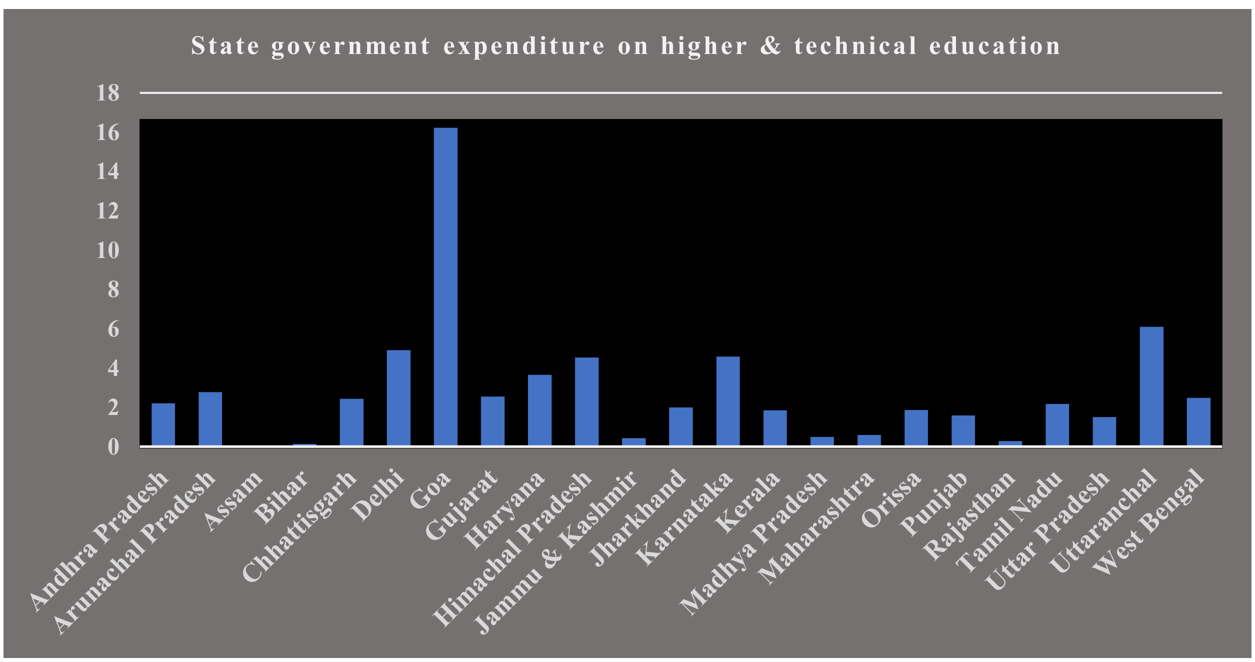

Figure 5: Venture capital deals

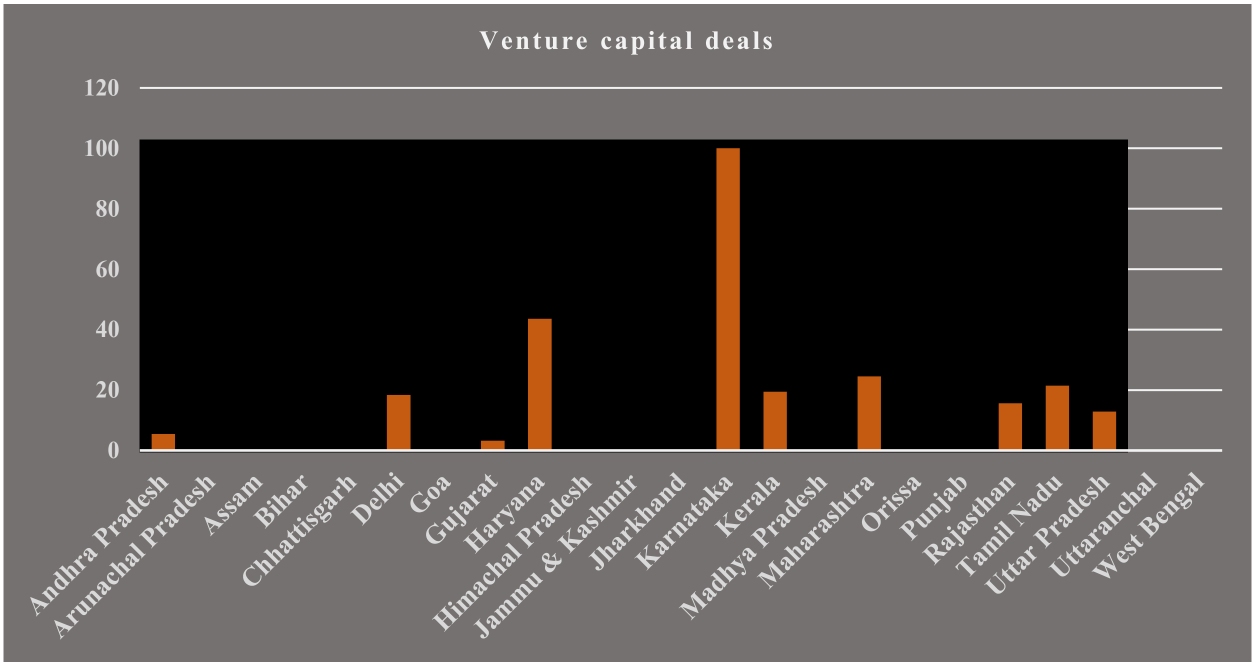

Figure 6: Patents filed from the states

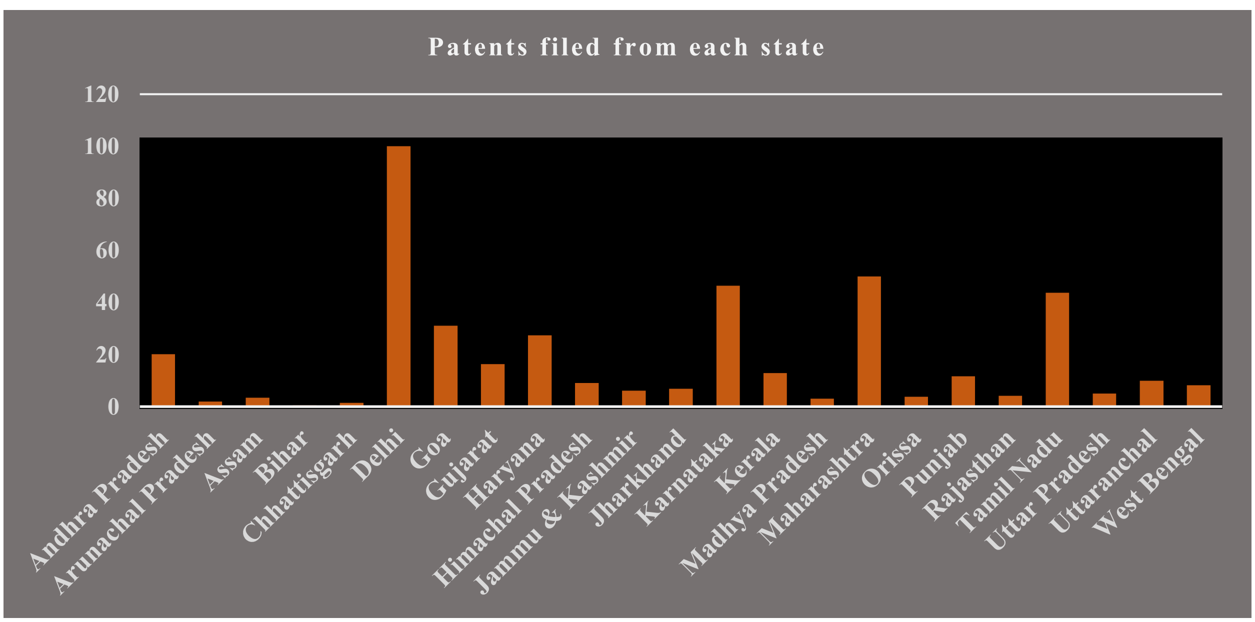

Figure 7: Number of startups in the state

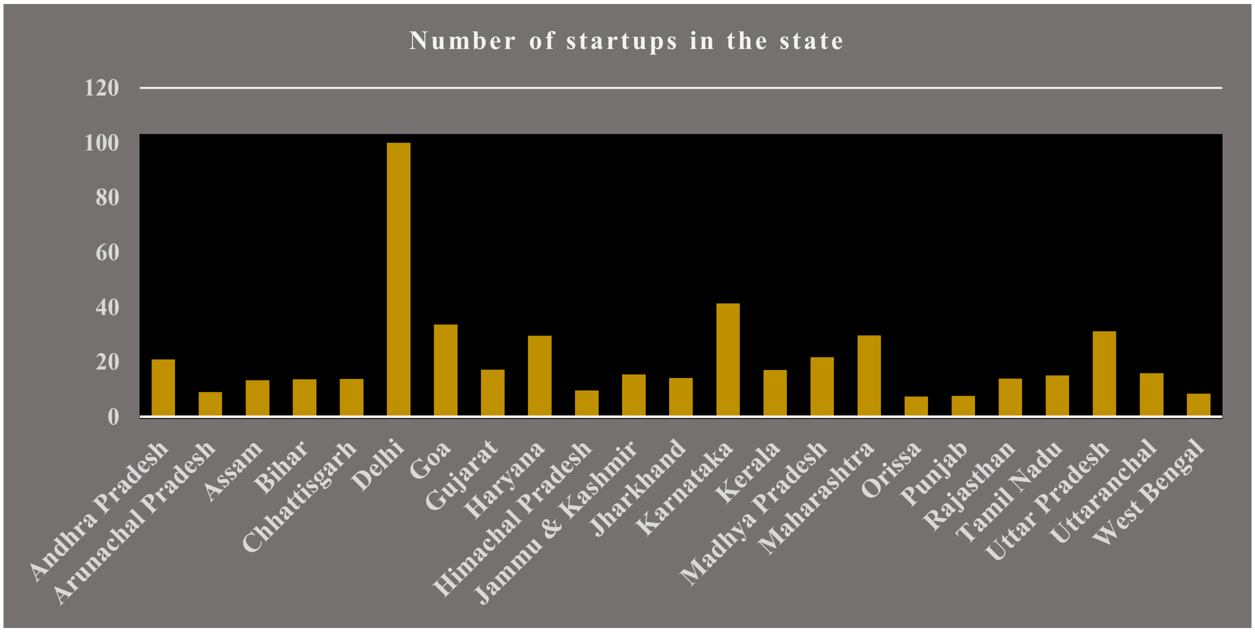

Figure 8: Number of registered GI

Figure 9: Number of publications by state universities