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How does innovation occur in India? Evidence from the JIRICO survey

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Abstract:

Based on the first innovation survey of 1139 firms in India, this paper provides innovation activities in India. Findings in this paper will provide insights to other emerging countries that pursue endogenous innovation.

Keywords: emerging country; India; innovation; invention; survey

JEL classification:

1. Introduction

This paper reports the results of the innovation survey conducted by the Jindal Initiative for Research in IP and Competition (JIRICO) to understand the industrial innovation ecosystem in India. This paper further compares with cases of other countries from prior studies. This study does not merely add one more case, but makes three distinct contributions to the field.

First, this study is the first academic exercise to measure innovation activities after major innovation-focused policy developments in India following questionnaires that prior studies modeled with developed countries. India is known as the next global growth pole. Understanding future potential, a handful of studies touched upon innovation activities in India (Reddy, 1998; Altenburg et al., 2008; DST, 2014; McMahon & Thorsteinsdóttir, 2013). Despite their commendable attempt, these studies are not detailed enough and do not disclose sufficient details about innovation activities and their inter-linkages with intellectual property system of India.

Second, in the past five years, three major policy developments – the National Science, Technology and Innovation Policy 2013, Atal Innovation Mission 2015, and the National Intellectual Property Rights Policy 2016 – took place in India. Ours is the first survey-based study after these policies were unveiled (See Dhar & Saha, 2014; Abhyankar, 2014; Herstatt et al., 2008 for pre-2014 assessment of India's innovation system).

Third, the case of India can provide insights for other emerging countries that pursue endogenous innovation. In recent years, we have observed a middle-income trap (Ohno, 2009) where fast growing developing countries experience slowdown in their economic growth after achieving a middle-income status and stay within that income range for a significant period of time. The underlying reasons for this are believed to be an inherent inability to transition from a growth model based on mass production and low-cost labor to a model based on higher-value-added products and services with skilled labor and extensive use of technology (World Bank, 2010). However, India is expected to be an exception that will likely avoid the middle-income trap (Felipe, 2012). India is one of the emerging countries that consider innovation as the key driver of economic development.

The structure of this paper is as follows. Section 2 reviews prior survey-based studies on which the current study is based, as well as a background of the innovation policy landscape in India. Section 3 describes the survey and the data collected. Section 4 presents an analysis of survey results. The final section concludes and summarizes the results.

2. Literature review

Innovation is central to the growth of output and productivity. In order to develop appropriate innovation policies, it is necessary to measure innovation activities. However, measuring innovation activities is not an easy task. While many factors are known to affect innovation, they are inter-related in a complex manner and evolve as circumstances change. One method is not enough to adequately understand the nature of innovation activities. Measurement of innovation activities has been supplemented by using various methods that include both qualitative method, e.g. interviews (Miozzo & Grimshaw, 2005; Belderbos et al., 2013), and quantitative method, e.g, corporate data, patent statistics (Griliches, 1990; Jaffe & Trajtenberg, 2002). Due to great strides in development of information technology and software tools recently, there is an attempt to use unstructured Big Data, e.g. data collected from sensors (Pentland, 2014) and those based on simulations (Schwarz & Ernst, 2009; Kwon & Motohashi, 2017). Each method has its own pros and cons, and hence, it must be selected carefully to match individual research settings.

One typical method to measure innovation activities is to use a firm-level survey. This method has been widely used by scholars and policy makers for the last three decades. Perhaps the most consolidated conceptual and methodological survey is one proposed by the Organisation for Economic Co-operation and Development (OECD), also known as the Oslo Manual (OECD, 2005). The manual provides a set of guidelines for the design and actual implementation of national surveys aimed at covering a wide range of dimensions of innovation activities. After its first publication in 1992, the Oslo Manual has been updated regularly to keep up with the evolving dynamics of industrial innovation. Community Innovation Surveys (CIS), conducted every four years, are used to monitor the progress of innovation in Europe. According to CIS 2008 that was carried out in 27 member countries of the European Union (excluding Greece), 51.6% enterprises across industrial and services sectors reported undertaking some form of innovation activity between 2006 and 2008. Out of these, almost 40% reported their innovation activity in terms of specific technological innovation, while 41% reported undertaking non-technological innovation.

We also use the CIS as the basic foundation of the questionnaire used in our survey, details of which are provided in later in this paper. A hurdle in the use of CIS (such as in Arundel, 2007) is a lack of indicators that are relevant for immediate policy needs. One of the main problems could be a poor link between the policy makers and statistical offices that use CIS data. Since data provided by CIS is routinely used for guiding individual European policies on knowledge diffusion and collaboration, the OECD and Eurostat are working on development of new CIS indicators. In another approach, Bergquist et al., 2017 measure the cluster size of inventive activity on the basis of international patent filings. Several scholars have used this approach to capture innovative activity at subnational level. However, the cluster identification strategy needs to be industry or technology specific, especially in the case of India, and should be able to capture performance and contribution of universities and other academic institutions for a more holistic understanding of innovation.

A subset of prior work has paid special attention to invention activities based on focused survey of industrial inventors and R&D labs. Since the initial surveys (Mansfield, 1986; Levin et al., 1987) in the 1980s, inventor surveys have been conducted in several countries. For examples, surveys conducted for U.S. firms (Cohen et al., 2000; Cohen et al., 2000b; Graham et al., 2009; Arora et al.,

2014) and some of them further developed to compare with the case of Japanese firms (Cohen et al., 2002a; Nagaoka & Walsh, 2009). Walsh & Nagaoka, 2009 use results from the RIETI-Georgia Tech inventor survey on inventors of US and Japan holding triadic patents. They find that the quality of university researchers' patents is higher in U.S. than in Japan, while there is a shortage of women inventors in both countries. Inventions by small firms and PhDs are more common in the U.S. On average, American inventors are older and more mobile as compared to their Japanese counterparts, although mobility declines with age in the U.S. while it increases in Japan.

In Europe, Giuri et al., 2007 presented findings of a survey carried out in six European countries to understand nature of innovation activities, in addition to other surveys conducted independently in a handful of countries in Europe (Meyer, 2000; Scherer & Harhoff, 2000; Tijssen, 2002; Blind et al., 2006). Giuri et al., 2007 is based on a survey of inventors of 9017 European patents from six European countries - France, Germany, Italy, Netherlands, Spain and the UK. The underlying questionnaire - PatVal - provides information about motivation and composition of inventors. They found that one-third of all patents are assigned to individual inventors, while the rest are result of team effort; and one-fifth of all patents are developed in collaboration with other institutions. They also found that one-third of all patents were not in use for any specific economic or commercial purpose, while only 13.4% were licensed out. The cost of patenting emerged as a major concern for small organizations; and only a small percentage of patents yield large returns to overall investment made in innovation activity that culminated in those patents.

On the other side of the Atlantic, the 2008 Berkeley Survey is considered as the first comprehensive survey of patenting and entrepreneurship in the United States. Graham et al., 2009 analyze responses of 1332 early-stage technology companies founded since 1998, and find that technology startups hold greater number of patents than before. For many startup companies, patents are used to gain competitive advantage from their innovations, but this is more prevalent in biotechnology and computer hardware companies rather than software companies. They also find that startups use patents for entrepreneurial capital, for improving likelihood of successful exit from the market, as well as to improve bargaining positions in cross licensing and against infringement suits.

As seen from prior studies, surveys have been conducted in various countries. Accordingly, measuring innovation activities with a survey has a merit that enables cross-country comparison of innovation activities (their drivers and obstacles), and appropriation mechanism of innovating firms. While cross-country comparison from prior studies brings out several interesting features, it gives an impression that there are more differences than similarities between countries. One outstanding similarity seen from cross-country comparison is the significant role of lead-time advantage as an effective way of ensuing returns to investments made by innovating firms. Although all respondents from Germany, Japan, and the U.S. did not estimate effectiveness of patenting to prevent imitations, they considered lead-time advantage as the most effective strategy to protect their inventions (Cohen et al., 2002a; Blind et al., 2006; Nagaoka & Walsh, 2009). However, differences are numerous. For example, the other protection strategies after lead-time advantage rank differently between Germany, Japan, and the U.S. (Cohen et al., 2002a; Blind et al., 2006; Nagaoka & Walsh, 2009).

What we can learn from the previous studies is that innovation activities in each country must be understood in their context. Each country has different administrative, business and judicial practices that not only evolve over time, but also tend to affect the nature of business activity and intensity of innovation. Accordingly, simply observing similarities and differences is not enough to capture nature of innovation activities in a country, therefore measuring innovation activities after understanding the circumstances in which they occur is important. Obtaining insights from such a practice is also important for international business, FDI, knowledge flow and cross-border collaboration.

The shocks to an economy (whether they are short term due to an economic crisis, or long term in their impact on the environment and society) pose extraordinary challenges to all affected countries, developed, developing or emerging. STI Outlook, 2012 outlined an agenda for OECD countries where innovation policies played a vital role in restoring growth and competitiveness, by being "relevant" to address economic or social goals, "coherent" with each other and with other policies, and "inclusive" in their scope and the concerned actors (OECD, 2014, p.4). Innovation, in the context of developing country, is understood to include design and production of goods and services that are new to firms (irrespective of whether they are new to their competitors, customers or the world), purchase of new machinery and equipment as well as licensing (Mytelka, 2000; UNU-INTECH, 2004). In the Indian context, the National Knowledge Commission in 2007 defined innovation as a "process by which varying degrees of measurable value enhancement is planned and achieved, in any commercial activity. This process may be real or incremental, and it may occur systematically or sporadically in a company; it may be achieved by (i) introducing new or improved goods and services and/or, (ii) implementing new or improved operational processes and/or, (iii) implementing new or improved organizational/managerial processes".

Around the same time and recognizing the importance of innovation in enhancing competitiveness of Indian economy, the idea of National Innovation Survey for India was conceived. In 2010 the Department of Science and Technology of the Government of India carried out the first National Innovation Survey for the organized industrial sector to measure innovation and knowledge creation capabilities. The findings focused on Micro, Small and Medium Enterprises (MSMEs) and were published in a report in 2014 (DST, 2014).

Among many important findings, it was found in the DST study that (1) most of the innovations are in the form of introducing new machines (70%), followed by improvement of the quality of the existing products, process and product innovations; (2) most of the innovative firms are privately owned; (3) access to knowledge/information was the most important barrier in addition to cost factor and availability of skilled manpower; (4) large size firms show more propensity to innovate, and in R&D activities, technology in-licensing, employing qualified manpower, organizational and marketing practices larger firms are more active than their smaller counterparts; (5) involvement in R&D activities increases with size and most of these activities are in-house, while ownership pattern does not have much significant effect on firms' technological innovation performance; (6) firms with formal R&D setup are ahead in product innovation and process innovation whereas firms that do not have formal R&D setup, (non-R&D firms) have more focus on new machines. Although it was the first survey-based study to formally understand industrial innovation in India, it did not explore vital aspects of India’s innovation ecosystem, namely the role of IPRs, of the intellectual property right system or even the mechanisms innovators rely on to seek returns to investments made in R&D within the process of innovation.

The National Science, Technology and Innovation Policy of 2013 (STIP 2013) lays down the way forward for Indian economic development by means of technological innovation and investment in science-led innovation in areas of high socio-economic importance. The other goals of the STI 2013 policy are to attain global competitiveness by forging impactful and synergistic collaborations, to attract private sector investment to boost R&D, and to nourish the grass-root level to fully leverage the potential of India’s human capital and skills. Science, Research and Innovation System for High Technology-led path for India (SRISHTI) was envisaged as the primary goal within the STI framework. Recognizing that the need of the hour is to increase R&D capabilities of India, the government has been increasing the number of higher education and technical education institutions that lay emphasis on basic science and fundamental research.

In 2015, the Indian Prime Minister gave approval for establishment of ‘Atal Innovation Mission’ (AIM) and Self Employment and Talent Utilization (SETU) in NITI Aayog with appropriate manpower. The focal point is to give substantial boost to the innovation ecosystem (by incentivizing innovation through innovation challenges, prizes and implementation of various incentive programmes), and to catalyze the entrepreneurial spirit in India. Under the guidance of NITI Aayog (National Institution for Transforming India), the Atal Innovation Mission has a budget of more than 200 Million USD for facilitating R&D and by providing an innovation promotion platform.

Finally, after several years of back and forth, the union cabinet approved India’s first National IPR policy in 2016. The policy, compliant with the TRIPS agreement and DOHA Development Agenda, has a mission to provide India with a dynamic, vibrant and a balanced IPR system. The objectives that have been laid down in the National IPR Policy provide a way forward on how to increase the outreach of the IP system to wider range of users in the public domain; on how to stimulate generation of IP rights; to strengthen the existing legal framework for IPRs; to make the administration and management of IPRs and the IP system more robust; to focus on commercialization of IPRs; and to strengthen up the enforcement and adjudication of IP infringements. In order to meet some of these objectives, especially creating awareness about the IP system, Cell for

IPR Promotion and Management (CIPAM) was constituted. Since the National IPR Policy will be reviewed every five years, the results of our study can be helpful for the policymakers to ascertain changes in the innovation ecosystem and uptake of IPRs in the aftermath of the policy coming into effect.

Kanwar & Hall (2016) find that financial markets in India, a fairly sophisticated developing economy, were valuing innovation investments highly, and there appeared to be under-investment in R&D in Indian manufacturing firms. It is imperative to understand the nature of R&D activity and innovation in light of strong positive changes in policies and global competitiveness of the Indian industry.

3. Data and method: JIRICO survey

The JIRICO survey was conducted in the period between 2016 and 2017. The survey is designed based on the seminal academic work conducted in the U.S. and Europe in the past 30 years, including (but not limited to) studies by Mansfield (1986), Levin et al. (1987), Cohen et al. (2002), Arundel et al. (2006), Graham et al. (2009), and Arora et al. (2014). The survey was sent to 11654 firms and 5710 R&D organizations registered in DST (Department of Science and Technology of India) database in the time period between 2016 and 2017, focusing only on organizations within the formal industrial sector of India that have R&D facility.[1] We adapted the 2014 Community Innovation Survey questionnaire that was based on the 2005 Oslo Manual. The sample consists of private companies, private research labs, contract research organizations, government-funded (centre and/or state) research organizations and academic institutions (both public and private funded) spread across all industrial clusters in India.

Excluding 110 responses due to substantial incompleteness of questionnaire, we used 1138 responses, yielding an adjusted response rate of 6.5 per cent. One may raise a concern to the low response rate, but we argue that this size is large enough for our study. Even though our sample rate is admittedly small, our response size is larger than other innovation surveys. For example, several hundreds of responses were used for cases of Japan (Cohen et al., 2002), Germany (Blind et al., 2006), Costa Rica, Panama, and Uruguay (Crespi & Zuniga, 2012).

As the first snapshot of the JIRICO survey, Tables 1 and 2 describe the sample by technology fields and by size of affiliations. Then, we classify the sample by the Indian industry classification.[2]

[1] We partnered with a survey administration firm, Market Insights, and with Advanced Intelligence Analytics to setup the sample on the basis of their proprietary Data Guru database and the DST Directory 2015 provided by the Department of Science and Technology. We use the Annual Survey of Industries of India 2014 as the sampling frame that we stratified by a 3-digit National Industrial Classification.

[2] Our technological classification is based on the National Industrial Classification of India (NIC), which is published by the Central Statistical Organization, the Ministry of Statistics and Programme Implementation, Government of India. We reorganized the industrial classification into the technological classification. For example, the NIC assigns Division 72 as

The survey also provides information about the size of affiliations: less than 50, 51-50, 51-100, 101-500, 500-1000, and more than 1000.[3] The total counts of the technological fields in the tables below (the right most columns) show that chemical engineering and pharmaceuticals are the most represented technologies in the JIRICO survey, spanning 13 divisions of the official industrial classification. We found the private sector to be the primary driver of all kinds of innovation activities. Meanwhile, in terms of size, organizations of all types and sizes are evenly distributed in the sample. Often, significant role of micro enterprises in India are mentioned in addition to small and medium-sized enterprises in steering growth of the overall industry, and the JIRICO survey reflects those enterprises.

Table 1. Description of the sample by technological field and by size of affiliations

Technology Field	**1 - 50**	**51 - 100**	**101 - 500**	**501 - 1000**	**> 1000**	**Total** % share
Chemical Engineering & Pharmaceuticals	94	85	106	151	106	542 (47.6%)
Mechanical Engineering	19	26	27	71	68	211 (18.6%)
Electrical Engineering	18	21	23	29	24	115 (10.1%)
ICT	44	16	15	17	40	132 (10.6%)
Other Engineering	9	10	9	11	10	49 (4.3%)
Others	17	11	17	19	25	89 (7.8%)
Total % share	201 (17.7%)	169 (14.9%)	197 (17.3%)	298 (26.2%)	273 (24.0%)	1138 (100.0%)

Table 2. Description of the sample by National Industrial Classification (NIC) of India

Technology Field	**Industry Fields**	**NIC Divisions**	**Sample Size**
Chemical Engineering & Pharmaceuticals	F&B, Petroleum, Textiles, Apparels, Leather, Wood,	*13 Divisions:* 10, 11, 13-23	542

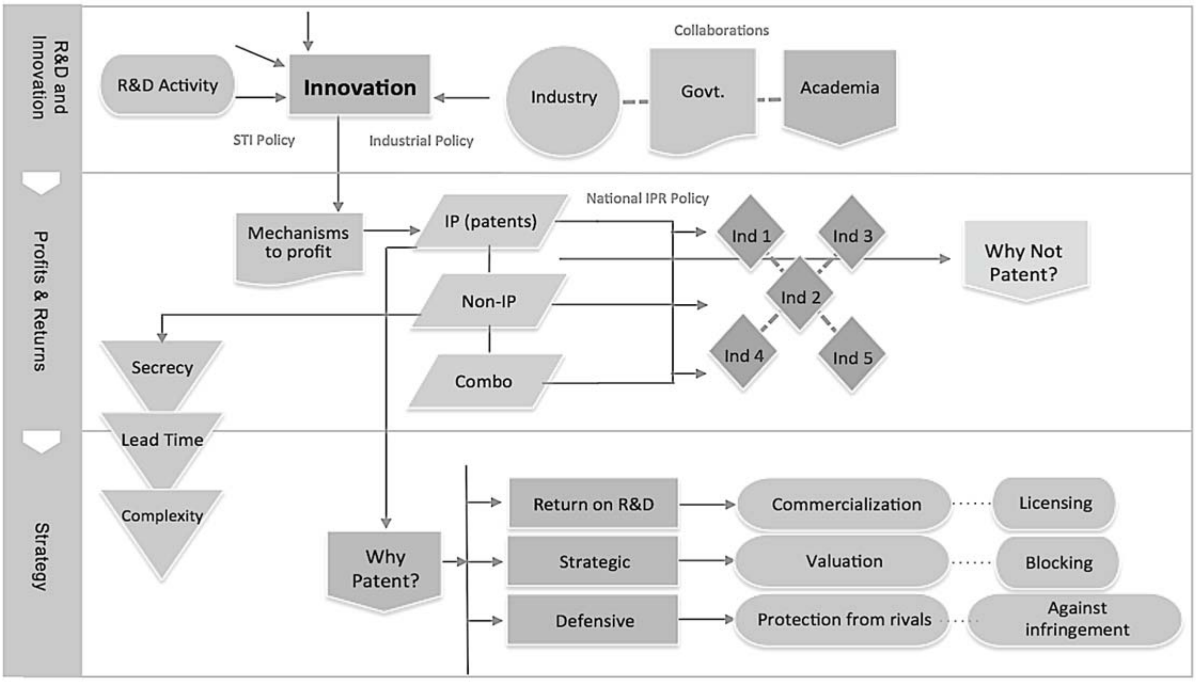
'Scientific research and development' regardless of specific R&D field. We reviewed each profile of such respondents and assigned a technological classification that best fits to the main technological field of them.

[3] The sample is roughly classified into private and non-private sectors. Institutions such as contract research organizations, universities, and public research institutes are classified as non-private sector. Details are presented in the appendix.

	Printing, Chemicals, Rubber, Plastics		
Mechanical Engineering	Metals, Machinery, Vehicles, Waste, Automotive	*7 Divisions:* 24, 25, 28-30, 33, 38	211
Electrical Engineering	Computers, Energy, Electronics, Optics	*3 Divisions:* 26, 27, 35	115
Information & Communication Technologies	Software, Testing, Hardware, Telecom, Programming, Sound, Audio, Video	*5 Divisions:* 58, 59, 61-63	132
Other Engineering	Other manufacturing	*3 Divisions:* 31, 32, 38	49
Others	Other non-manufacturing	All other divisions	89
		Total	**1138**

Figure 1 illustrates the overview of the survey undertaken by JIRICO. Within the first phase encompassing R&D activity, several policy levers are used to ensure that investments by various organizations engaged in R&D activities are induced in the right areas and with the support of right incentives. Both the STI policy of 2013 and the ever-evolving industrial policy highlight the mechanisms used by the government to accomplish this. The survey, firstly and building on the first National Innovation Survey of India, tries to get a better picture of the type of innovation activities that R&D focused firms doing business in India are engaged in (more details of the type of activities are in the next section). Secondly, the survey tries to find the reasons why firms undertake innovation and the challenges they face that hinder innovation activity. The survey also sought to understand the role of collaborations between firms across industrial sectors, government organizations (public or state government firms, and government-funded R&D) and academic institutions (public or private funded) during the lengthy process of R&D and industrial innovation. The subsequent aspects of the survey were adapted from Cohen (2002) wherein we try to understand the appropriateness of mechanisms that firms engaged in innovation activities rely on to ensure returns on R&D investment. If the firms opt for IP-based mechanisms, then we try to understand why firms do so laying emphasis on why they choose to use patents. Additionally, if they don’t rely on the IP system then we try to understand their motives to not patent.

Figure 1. An overview of the JIRICO survey



4. Analysis

In this section, we review our results on 1) innovation activity, 2) motivation and challenges in patenting innovations, and 3) appropriability mechanisms to seek returns on investments made on innovation activities.

4.1 Innovation activities

First, we review innovation activities in India in detail. We asked respondents to report the types of innovation activities (list adapted from the definition proposed in the Oslo Manual) their organization is engaged in from the seven categories: 1) In-house R&D, 2) External R&D, 3) Acquisition of machinery, equipment, software and buildings, 4) Acquisition of existing knowledge from other enterprises or organizations, 5) Design and packaging, 6) Business practices, and 7) Others. Details presented in Table 3 below.

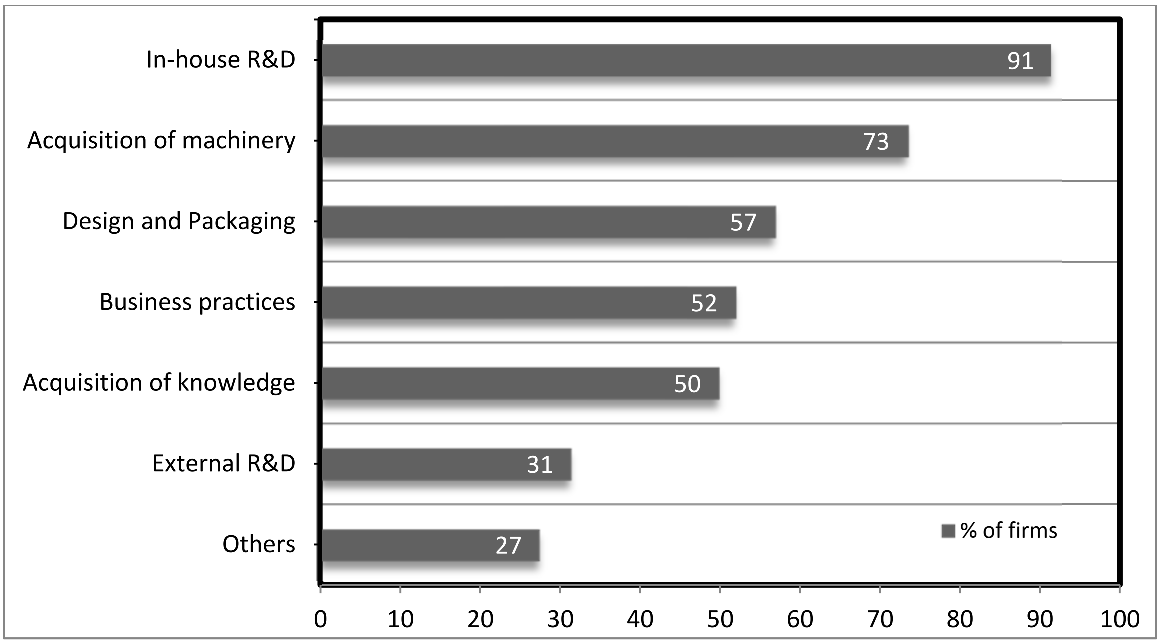
Table 3. Description of innovation activities of firms

Innovation activity	Description
In-house R&D	R&D activities undertaken by respondent's enterprise to create new knowledge or to solve scientific/ technical problems (incl. software development in-house that meets this requirement)
External R&D	R&D that the respondent's enterprise has contracted out to other enterprises (including other enterprises in the respondent's group) or to

	public or private research organizations
Acquisition of machinery, equipment, software, & buildings	Acquisition of advanced machinery, equipment, software, and buildings to be used for new/ significantly improved products
Acquisition of existing knowledge from other enterprises or organizations	Acquisition of existing know-how, copyrighted works, patented and non-patented inventions, etc. from other enterprises or organizations for the development of new or significantly improved products and processes
Design and packaging	In-house or contracted out activities to design or alter the shape or appearance of goods or services
Business practices	In-house organization business practices such as supply chain management business re-engineering, knowledge management, lean production, quality management, etc.
Others	Such as methods of product placement, sales channels & pricing

Our aggregate result for type of innovation activity is shown in Figure 2. In-house R&D is ranked overall as the primary innovation activity. This is rather expected because the sample consists of firms that have some kind of research facility. It is nevertheless impressive because the priority of our case is a bit different from typical approaches observed from industrialization of East Asian countries. During industrialization of China and Korea, knowledge transfer from advanced countries played a key role in rapid growth of Chinese and Korean firms, respectively (Kim, 1997; Mu & Lee, 2005). Knowledge transfer occurred by encouragement of foreign direct investment and recruiting highly skilled workers from advanced countries, among other factors. To a certain extent, local firms also conducted in-house R&D for rapid growth and development of capabilities of Chinese and Korean firms, but such in-house R&D was limited to activities including localization of advanced knowledge from abroad and reverse-engineering advanced products.

Figure 2. Mean % of firms' engagement in innovation activities



Note: Respondents were asked: "Does your enterprise engage in the following innovation activities? For the purpose of this survey, innovation refers to introduction of a new or significantly improved product[4], process[5], organizational method[6], or marketing[7] method by your organization/enterprise/university (OECD 2012).

However, India's case seems different from cases of China and Korea. As seen in Figures 3 and 4, enterprises in India are interested in innovation more than mere imitation and localization of advanced products and processes. Although it will take some time, this way of innovation activity increases their technological capability by cumulating experience from try and error. Capital investment by acquiring advanced machinery, equipment, software, & buildings (to develop new or significantly improved products and processes) follows. Accordingly, there will be synergy between intensive in-house R&D and advanced capital investment and economic growth in India is likely to be achieved by leap-frogging II (Lim & Lee, 2001).

[4] A product innovation is the market introduction of a new or significantly improved good or service with respect to its capabilities, user friendliness, components or sub-systems. Product innovations (new or improved) must be new to your enterprise, but they do not need to be new to your market. Product innovations could have been originally developed by your enterprise or by other enterprises or institutions.

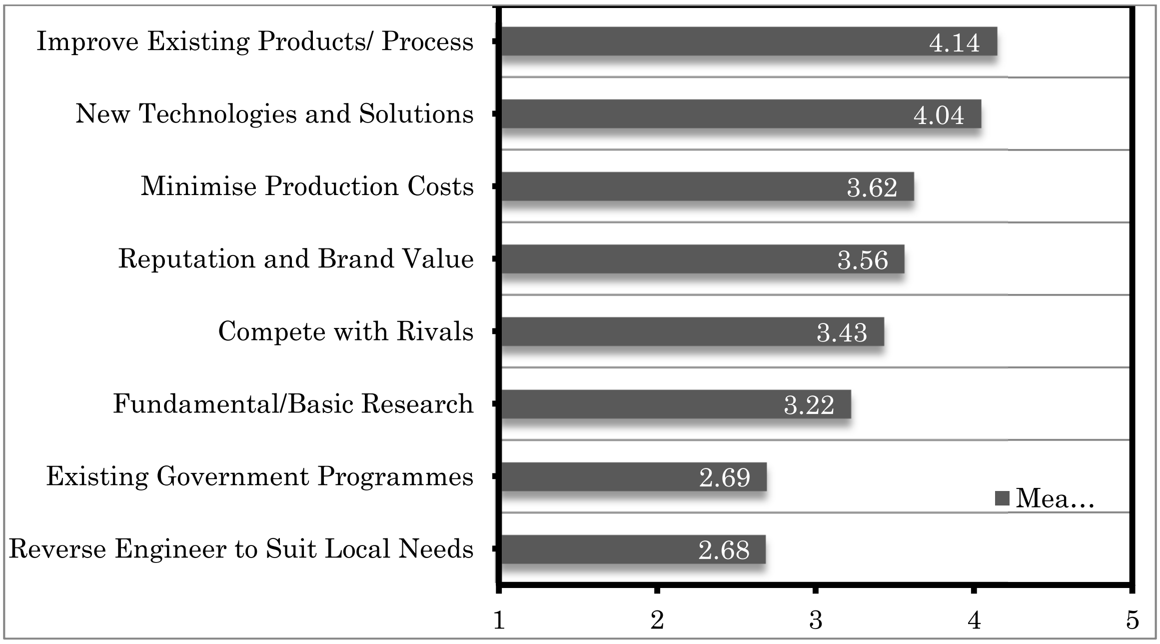
[5] A process innovation is the implementation of a new or significantly improved production process, distribution method, or supporting activity. Process innovations must be new to your enterprise, but they do not need to be new to your market. The innovation could have been originally developed by your enterprise or by other enterprises or institutions.

[6] An organizational innovation is a new organizational method in your enterprise's business practices (including knowledge management), workplace organisation or external relations that has not been previously used by your enterprise. It must be the result of strategic decisions taken by management, & excludes mergers/acquisitions, even if for the first time.

[7] A marketing innovation is the implementation of a new marketing concept or strategy that differs significantly from your enterprise' existing marketing methods and which has not been used before. It requires significant changes in product design or packaging, product placement, product promotion or pricing. Exclude seasonal, regular and other routine changes in marketing methods.

Existing government programmes (some of which were mentioned in the previous section) do not seem to be an important reason, on average, for firms to undertake innovation activity. This could perhaps be a point to reconsider the target and assess the real impact of some of the ongoing policies of central and state governments that seek to incentivize technological innovation on an industrial scale. The high rate of R&D (both internal and external) for contract research organizations is not unexpected, however, firms are not undertaking in-house or contracted out activities to design or alter the shape or appearance of their goods or services. This is in contrast to previous findings outside India where firms tend to lay emphasis on even the non-technological design aspects of their offerings.

Figure 3. Reasons to undertake an innovation activity



Note: Respondents were asked: "What are the reasons for your organization to undertake an innovation activity?" 0 (not in the figure) implied that the reason is either not relevant or not applicable to your organization, 1 implies very low importance, 2 implies low importance, 3 implies moderate importance, 4 implies high importance and 5 implies very high importance. 'Improvement' refers to improving an existing product or process; 'Exploration' refers to exploring new technologies or new solutions; 'Production cost' refers to minimizing production costs; 'Reputation' refers to firm reputation and brand value; 'Business Rivalry' refers to competing with rivals within the same industry; 'Fundamental research' refers to conducting fundamental or basic research; 'Existing govt. support' refers to taking advantage of existing government support programmes; 'Reverse engineering' refers to reverse engineering technologies to suit local needs.

Figure 4. Reasons to undertake an innovation activity, by organization type

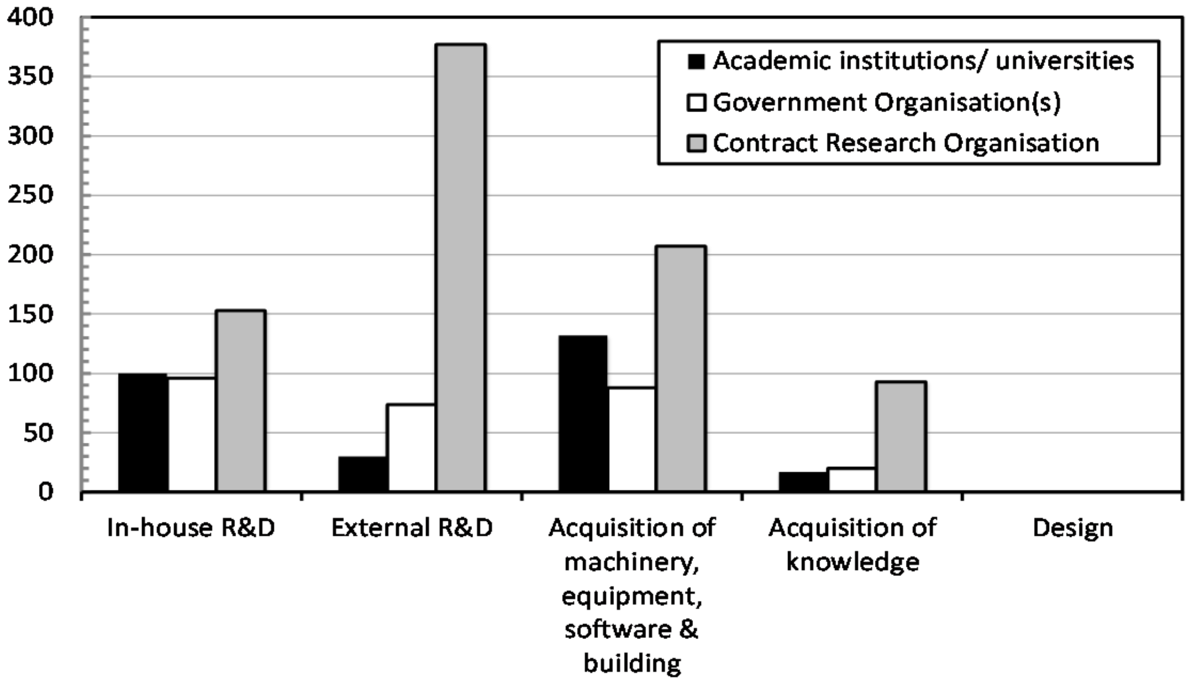
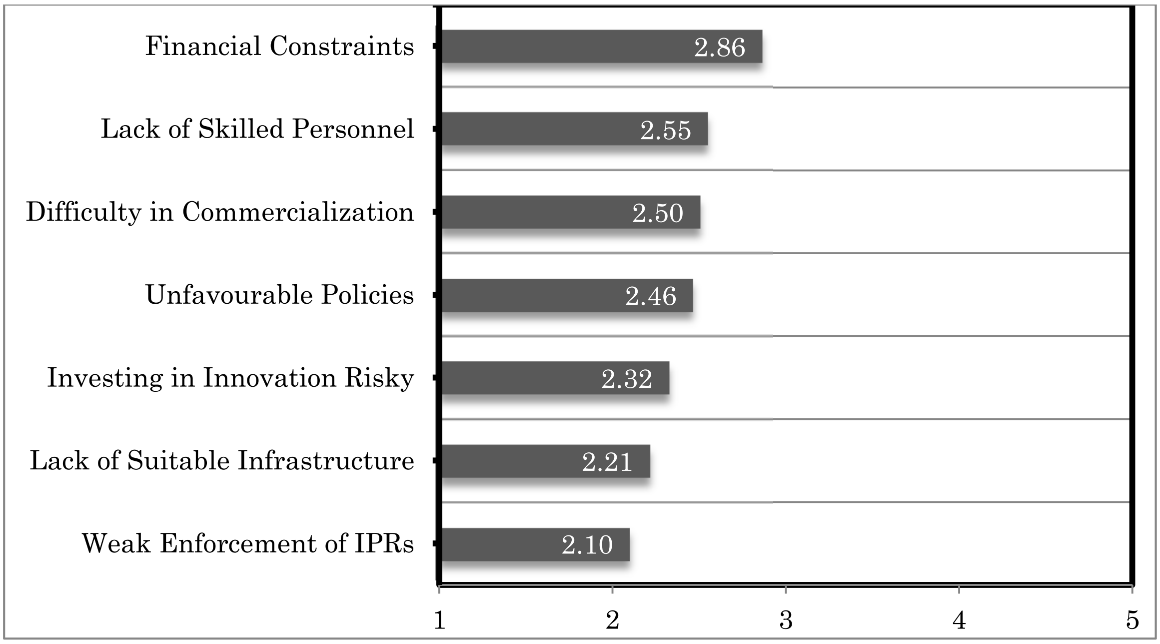


Figure 5. Challenges hindering innovation



Note: Respondents were asked: "What are the challenges you face in carrying out innovation activities in your organisation?" 0 (not in the figure) implied that the reason is either not relevant or not applicable to your organization, 1 implies very low importance, 2 implies low importance, 3 implies moderate importance, 4 implies high importance and 5 implies very high importance.

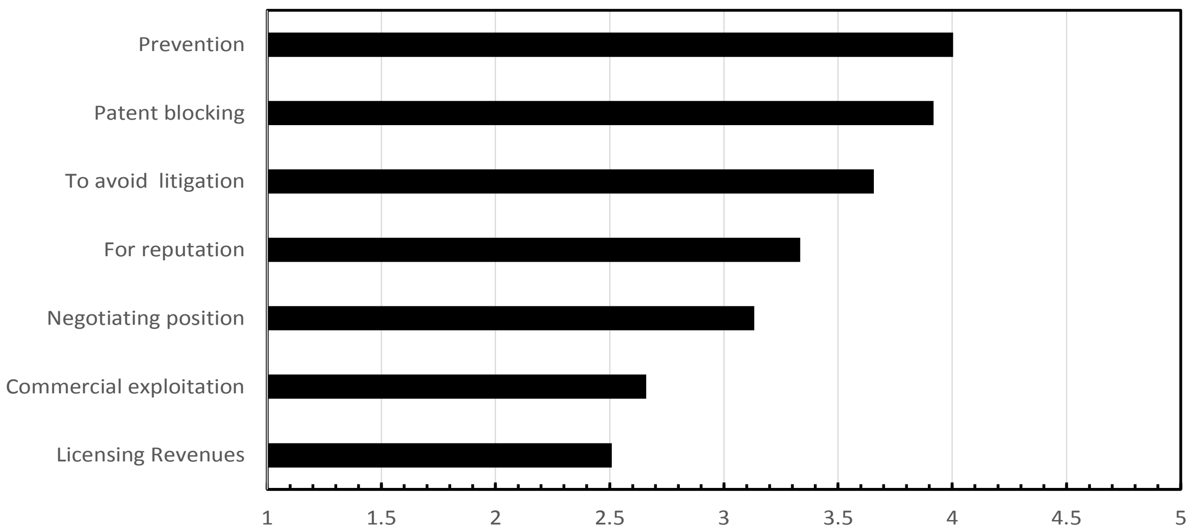
Figure 5 illustrates challenges that are hindering innovation, across all sampled firms in India, and brings out both expected and unexpected results. About 15 years ago, the Council for Scientific and Industrial Research – a government of India agency - initiated what was for long considered as the largest public-private partnership for R&D in India. It was initiated primarily to help firms deal with financial constraints, in the form of grant-in-aid and soft loans – in a better manner. For smaller organizations, financial instruments involved substantial support in the form of loans and capital subsidy scheme for technology upgradation. However, our results suggest that financial constraints, across firms of all sizes, are still the biggest challenge hindering innovation. In terms of comparison across firm size, it was found that micro and small firms consider financial constraint to innovation as almost "highly important", while it was lower than "moderately important" for large firms (see figure B.5 in appendix). Other challenges, namely lack of skilled personnel and difficulty in monetizing innovations were also relatively important for firms, however, on our 1-5 scale of response, none of the challenges stands out as a particularly significant hindrance to innovation. Weak enforcement of intellectual property rights, long considered as a most important barrier to India industrial innovation and growth strategy, was found to be the least important challenge to innovation.

4.2 Reasons to patent product and process innovations

To develop data on the uses of patents and the patent system in India, we asked respondents to report the reasons why they file patents. The reasons considered include: to obtain licensing revenues, to exclusively utilize inventions, to improve their position in negotiations (e.g. cross-licensing negotiations), to attain a higher market value (reputation of the affiliation), to avoid possible litigation, to keep degree of freedom in future R&D ("Technologies not blocked by others"), and to prevent others from patenting around relevant technologies ("Block technologies from others"). The aggregate (patent application-weighted) results are presented in Figure 6.

From Figures 2 and 3 presented earlier in the paper, we broadly understand the basis of the strategy behind use of patents in India. As the two most common reasons to patent product and process innovations are (a) to prevent others (usually existing or potential competitors) from designing around own patents, and (b) to ensure that others do not block off technologies that are crucial to own business. From this we infer that patents are filed mainly for own protection. And, the third most common reason is to avoid possible litigation. This indicates that respondents consider patents as a defense tool when sued by others rather than as a tool to make money directly from them. That interpretation is also supported by the fact that they don't expect licensing revenues (same figure). Contreras and Lakshany (2016) found a striking lack of patents held by Indian firms in the dynamic (both in terms of the nature of the Indian market and the conventional intensity of patenting) field of mobile communication. As mentioned by the authors, possible reasons include lack of a tradition of domestic patent filing (particularly in the mobile telecom industry) possibly due to cost factors and a lack of faith in the patent system. We test these in the next question.

Figure 6. Reasons to patent product and process innovations



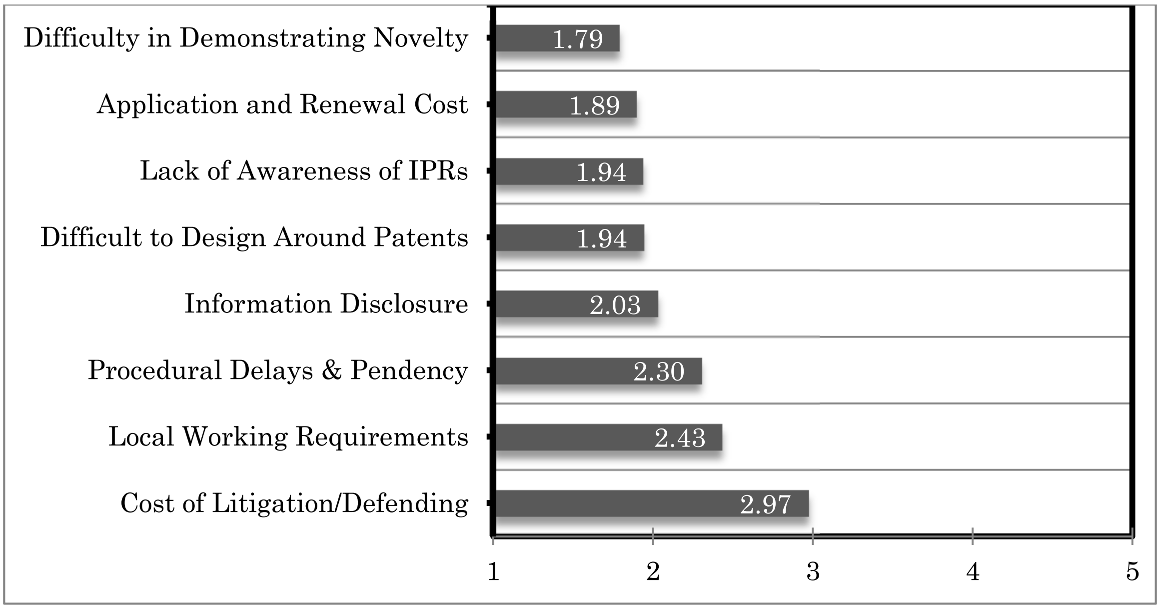
Note: Respondents were asked: "What are the reasons for your organization to patent innovations (products and processes) in India?" 0 (not in the figure) implied that the reason is either not relevant or not applicable to your organization, 1 implies very low importance, 2 implies low importance, 3 implies moderate importance, 4 implies high importance and 5 implies very high importance.

In terms of differences across firms of different size (figure B.6 in appendix), we find that, compared to other companies of small and large size, medium size companies operating in India have embraced strategic patenting more than others and they also consider patents as a way to secure higher valuation of their company in the market. We also find, expectedly so, that compared to their larger counterparts, micro and small firms assign low importance to stronger negotiation and bargaining position as a reason to patent. In comparing these results with prior studies, we find that the cases of other countries such as Germany, Japan, and the U.S. (Cohen et al., 2002a; Blind et al., 2006) indicated that the most important reasons were to prevent copying and to prevent rivals from patenting related inventions. Other than this, various other reasons that were posed in the question were not found to be different (in terms of importance accorded by responding firms) between this and prior studies. Accordingly, it seems that strategic use of patents is not different between India and other countries.

We also asked respondents to report reasons why they do not file patents for product and process innovations. The reasons considered in the JIRICO survey include: difficulty in demonstrating novelty of an invention, cost of applying and renewing patents, lack of awareness of IP rights and/or IP system, ease of inventing around existing patents, information to be disclosed in a patent document, procedural delays and high patent pendency, working requirements, and high cost of defending a patent in court. Figure 7 presents the aggregate (patent application-weighted) results. It should be noted that all possible reasons presented in the figure are below the midpoint of the response scale i.e. 3 indicating moderate level of importance. The result indicates that the most common reason is high cost of defending a patent in a court. This finding is consistent with a finding in the previous figure where one of the main reasons to file patents is to avoid possible litigation. We attribute the result to the major actor with innovation activities in India is micro-, small-, and medium-sized enterprises.

In comparing results with prior studies, while the previous comparison showed a very similar result, the current comparison brings out a stark contrast. First, Cohen et al. (2000) indicated that the cost of defending a patent in court was the least important reason to not file a patent while our case shows a completely opposite result. Cost in court can be monetary and/or non-monetary. The pendency of cases in court adds to the litigation cost for parties, while high pendency in the Indian patent office adds to lengthy process of patent prosecution in India. Whereas Indian courts are chocked with cases due to their sheer volume and inadequacy of judges, the patent office is clogged with applications and requests for examinations. Even though delays in litigation and delays in patent prosecution are unrelated, they raise uncertainty about commercial potential of patents in the future. Interestingly, the reasons associated with functioning of the IP system i.e. demonstrating novelty as a criterion of patentability, cost of patent application and renewal, disclosure of information mandated in a patent application, and a general level of awareness of patent system were, on average, assigned low importance by responding firms.

Figure 7. Reasons to not (be able to) patent (product and process) innovations



Note: Respondents were asked: "What are the reasons for not patenting your innovation in India?" 0 (not in the figure) implied that the reason is either not relevant or not applicable to your organization, 1 = very low importance, 2 = low importance, 3 = moderate importance, 4 = high importance and 5 = very high importance.

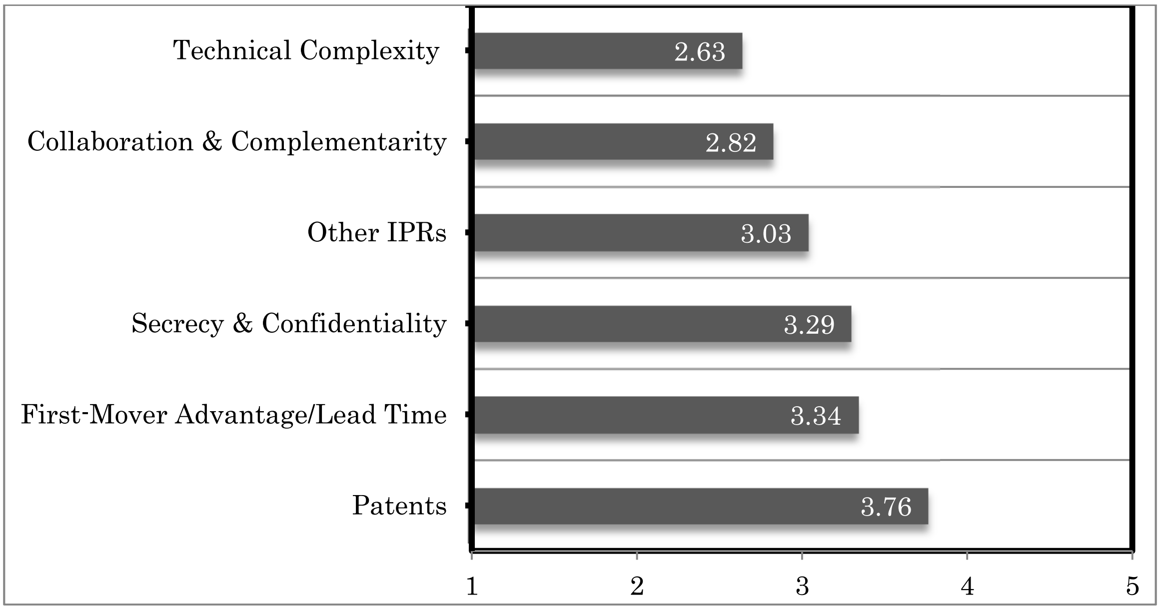
4.3 Management mechanism

In this section, we review our results on the effectiveness of different mechanisms through which firms seek returns on investment to their product and process innovations, including patents, first movers advantage (by cutting down the time between patenting and commercialization), trade secrets, other IP Rights, collaboration (with others that have complementary technologies), and complexity of technologies that render some degree of exclusivity to products of a company. To measure the effectiveness of these mechanisms for product and process innovations, we asked respondents to report how effective each mechanism is to appropriate returns on investment. The aggregate results in case of product and process innovations are shown in Figure 8 and 9, respectively.

The JIRICO survey indicates that patenting is still considered a very effective mechanism to seek returns on both product and process innovations. This is a striking result because other cases from prior studies, e.g. from Germany (Blind et al., 2006), Japan (Cohen et al., 2002a), and the U.S. (Levin et al., 1987; Cohen et al., 2000) indicated that the most effective mechanism to appropriate returns for product innovations was lead time, and lack of willingness to disclose information for process innovations. This is again a result different from a prior study. In Levin et al. (1987) showed that patents were rated the least effective mechanism because applicants didn't want information on new inventions to be disclosed by filing a patent. We attribute this difference to the nature of industries represented by the respondents. As shown in Table 1, chemical engineering and pharmaceuticals are the most represented technological fields in this survey, and they are also those industrial fields that are most prolific in patenting in India (Indian Patent Office, 2015).

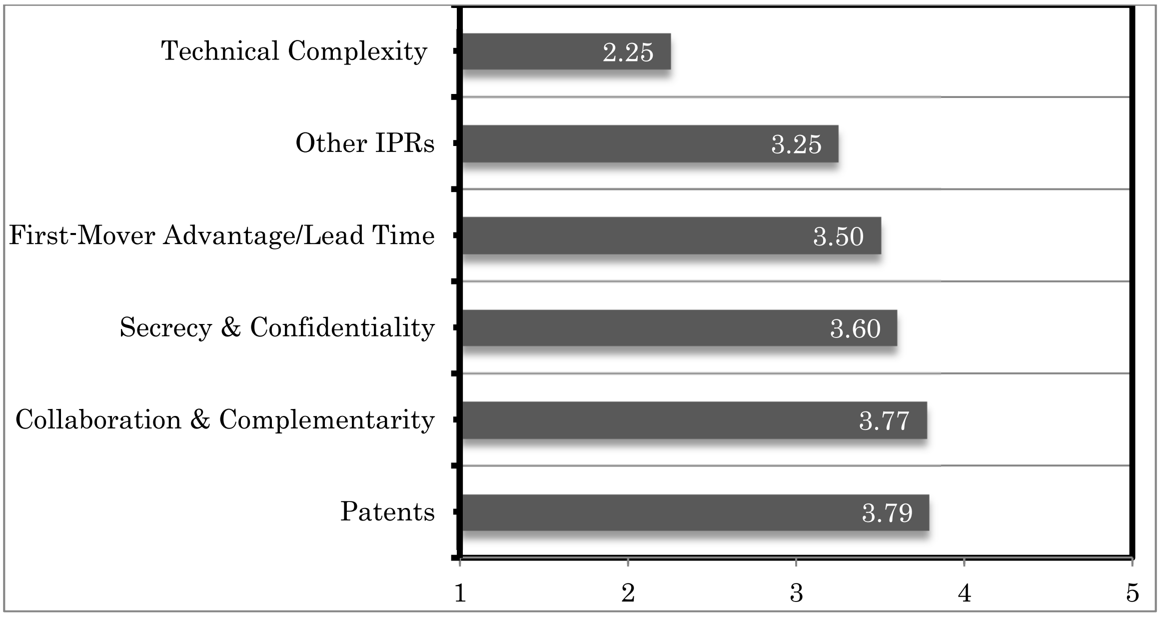
Several scholars have empirically examined the relationship between IPR regime and innovation and have found different results. Several studies have found a strong positive effect of stronger IPRs on domestic innovation (Kanwar & Evenson, 2003; Chen & Puttitanum 2005), with technology licensing (Yang & Maskus, 2001; Park & Lippoldt, 2005; Branstetter et al., 2006 and Kanwar, 2012a), and with FDI (Ferrantino, 1993; Lee & Mansfield, 1996; Javorcik, 2004). However, some other studies have found the opposite result that stronger IPRs do not positively induce domestic innovation (Sakakibara & Branstetter, 2001; Lerner, 2002; Qian 2007). More recently, it was found that stronger patent protection is indeed associated with increased royalty and license fee payments, implying greater transfer to technology to developing cpuntries post TRIPS, including India (Kanwar, 2012).

Figure 8. Effectiveness of appropriability mechanisms for product innovations



Note: Respondents were asked: "How effective are the following mechanisms to appropriate returns on investment in innovation activities for products?" 0 (not in the figure) implied that the reason is either not relevant or not applicable to your organization, 1 implies very low importance, 2 implies low importance, 3 implies moderate importance, 4 implies high importance and 5 implies very high importance.

Figure 9. Effectiveness of appropriability mechanisms for process innovations



Note: Respondents were asked: "How effective are the following mechanisms to appropriate returns on investment in innovation activities for processes?" 0 (not in the figure) implied that the reason is either not relevant or not applicable to your organization, 1 implies very low importance, 2 implies low importance, 3 implies moderate importance, 4 implies high importance and 5 implies very high importance.

5. Conclusion

This paper reported the results of the JIRICO survey to shed light on the drivers and obstacles to innovation in India, and how the intellectual property rights system, particularly patents, play a role in the larger innovation ecosystem of the country. Though several different ways exist to undertake innovation, it was found that in-house R&D is the most prevalent form of undertaking innovation activities in India, rather than starting out with localization of existing knowledge. It was surprising to find that those organizations that do engage in innovation are not quite responding to existing government programmes, which raises interesting public policy concerns. It could either be due to inadequate reach and targeting, or due to inherent weakness and ineffectiveness in them. This finding was corroborated by the result that basic research at a fundamental level is not considered a major reason to undertake innovation.

A lot has been written about reasons that may be holding back India's innovation potential. We found that weak enforcement of intellectual property rights is not an important consideration for innovators anymore, while ability to commercially exploit patent rights is still not being considered as a useful leverage for business. However, we need to be cautious in not generalizing this result because sector differences (and regional variations) in India may still exist in actual implementation and enforcement of IP laws, especially patents and copyright. Almost all reasons for not patenting inventions (except cost of defending), including the threshold of novelty to be demonstrated, prevailing application fee, awareness of how the patent system works (disclosure, examination and local working requirement under patent law) are related to knowledge of how the patent system generally works. Therefore, those organizations that do undertake innovation and have sufficient knowledge of how the patent system in India works, were perhaps responsible for assigning low importance to reasons of why they don't patent their inventions. One reason why cost of defending a patent in court is considered less important is because IP litigation is still not that common outside pharmaceutical and consumer-facing industries in India.

Even though process patents are considered more important in chemical, food and pharmaceutical industries, compararred to ICT, patents, for both products and processes, are considered the most effective mechanism to appropriate returns in India, while technical complexity of products or processes offered in the market is the least effectove mechanism. R&D-focussed organisations, by nature, understand the role patents can play to recoup investments and they also understand where the overall industry in which they operate currently stands. The current level of technological maturity of their industry is perhaps not allowing them to generate returns directly from patents and some of the organiztions may in fact be relying on non-IP factors mechanisms to succeed in business in India.

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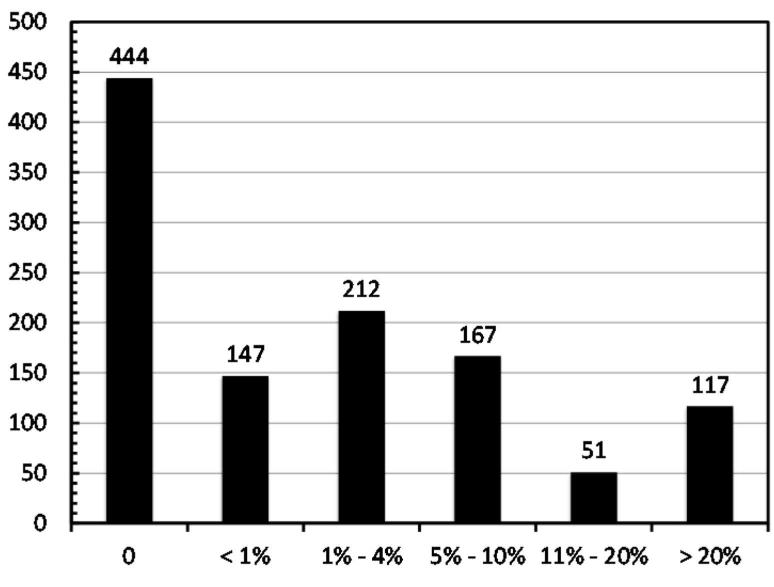
APPENDIX

Appendix A: Concordance method between industrial and technological classifications

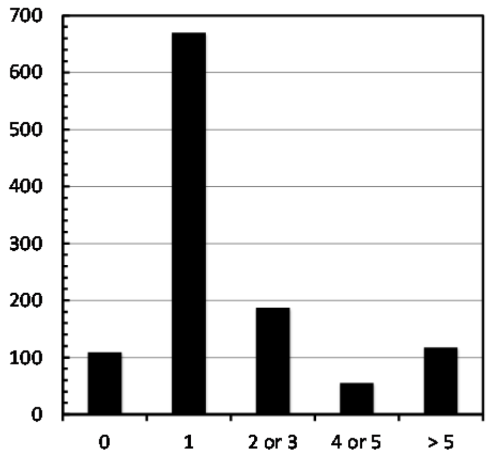
Tech field	National Industrial Classification (edition 2008)	Sample size	Domestic	Foreign
Chemical eng. & Pharm	Division10: Manufacture of food products	105	99	6
	Division11: Manufacture of beverages	5	4	1
	Division13: Manufacture of textiles	19	17	2
	Division14: Manufacture of wearing apparel	4	4	0
	Division15: Manufacture of leather and related products	2	2	0
	Division16: Manufacture of wood and products of wood and cork	2	2	0
	Division17: Manufacture of paper and paper products	5	4	1
	Division18: Printing and reproduction of recorded media	1	1	0
	Division19: Manufacture of coke and refined petroleum products	12	12	0
	Division20: Manufacture of chemicals and chemical products	130	123	7
	Division21: Manufacture of pharmaceuticals, medicinal chemical and botanical products	198	187	11
	Division22: Manufacture of rubber and plastics products	39	37	2
	Division23: Manufacture of other non-metallic mineral products	20	16	4
Mechanical eng.	Division24: Manufacture of basic metals	15	15	0
	Division25: Manufacture of fabricated metal products	13	12	1
	Division28: Manufacture of machinery and equipment n.e.c.	96	86	10
	Division29: Manufacture of motor vehicles, trailers and semi-trailers	51	47	4
	Division30: Manufacture of other transport equipment	24	21	3
	Division33: Repair and installation of machinery and equipment	11	6	5
	Division38 (partial): Waste collection, treatment and	1	0	1

	disposal activities; materials recovery			
Electrical eng.	Division26: Manufacture of computer, electronic and optical products Division27: Manufacture of electrical equipment Division35 (partial): Electricity, gas, steam and air conditioning supply	51 60 4	46 58 3	5 2 1
ICT	Division58: Publishing activities (including software package) Division59: Motion picture, video and television programme production, sound recording and music publishing activities Division61: Telecommunications Division62: Computer programming, consultancy and related activities Division63: Information service activities	4 4 8 89 27	4 4 6 62 18	0 0 2 27 9
Other eng.	Division31: Manufacture of furniture Division32: Other manufacturing Division38 (partial): Waste collection, treatment and disposal activities; materials recovery	3 45 1	3 43 1	0 2 0
Others	All the other divisions (mostly non-manufacturers)	89	80	9

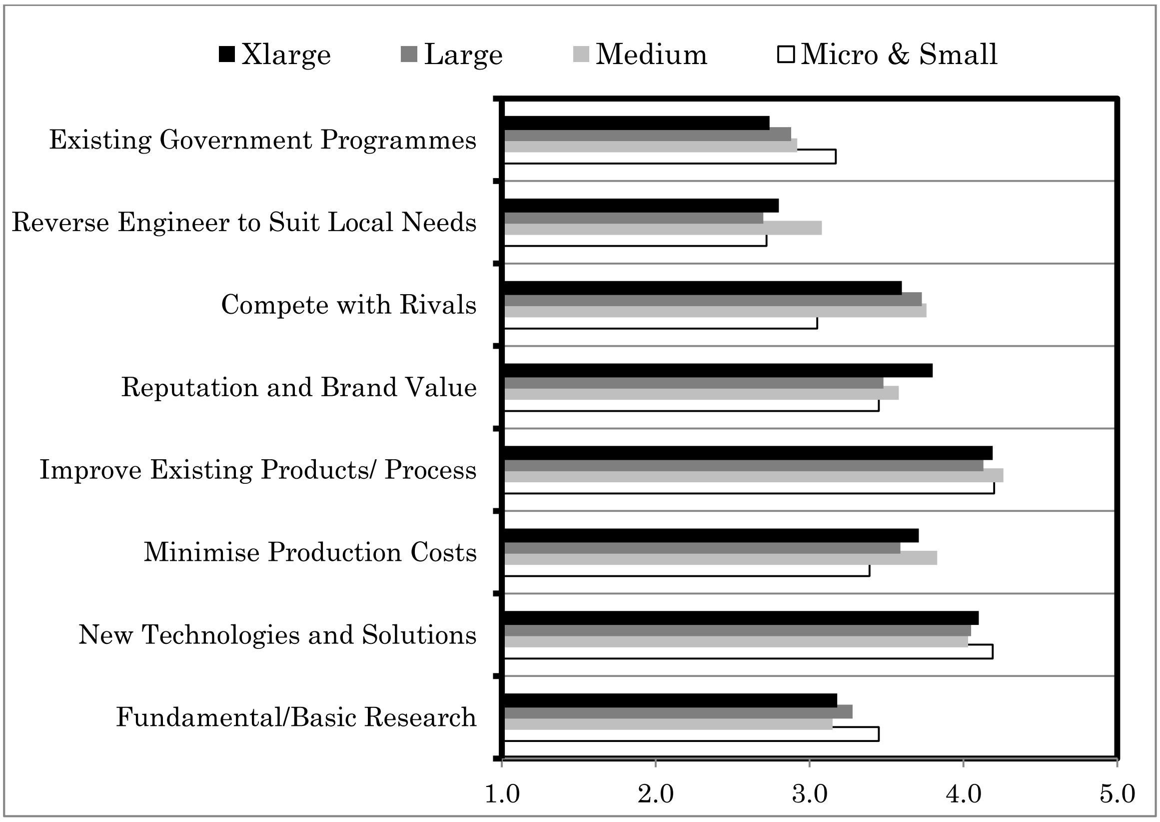
Appendix B.1: % annual turnover spent on innovation activity



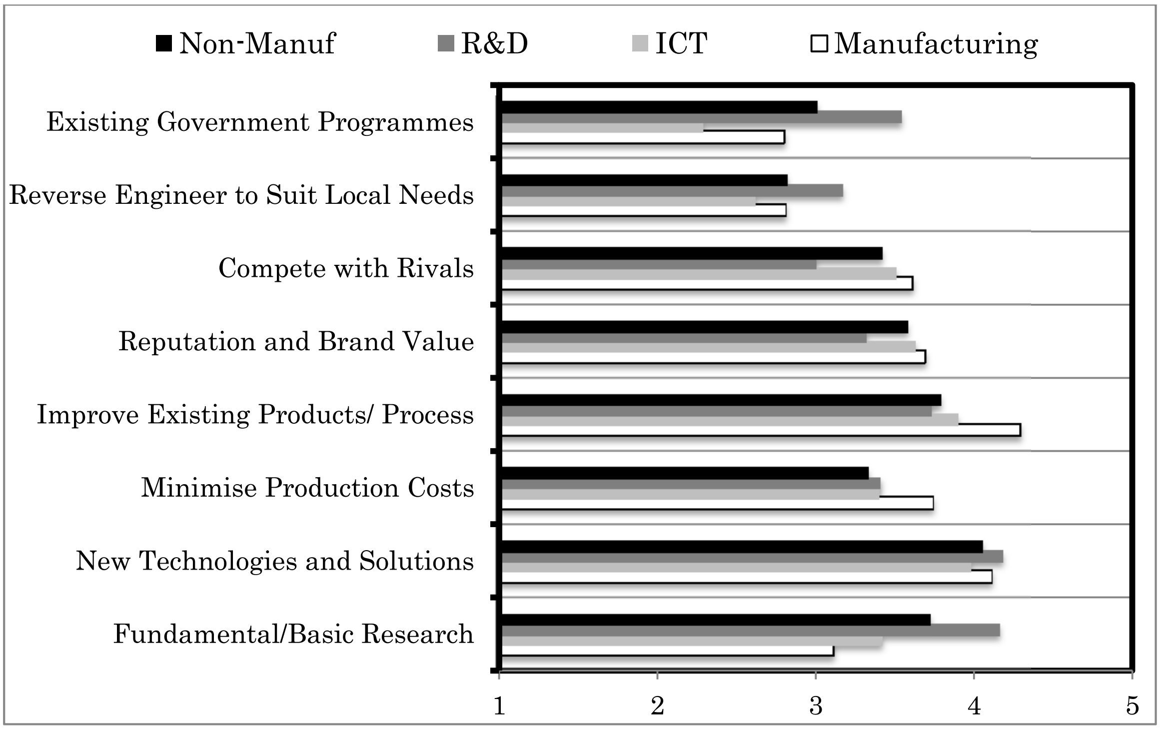
Appendix B.2: No. of R&D units



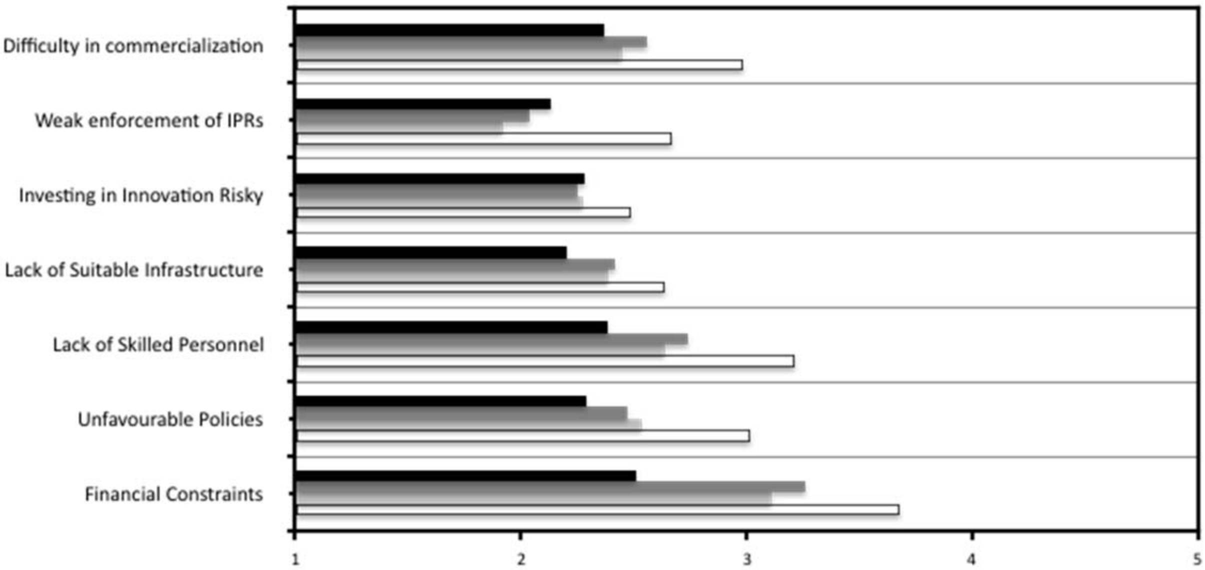
Appendix B.3: Reasons to undertake innovation, by firm size (sub-sample)



Appendix B.4: Reasons to undertake innovation, by industry (sub-sample)



Appendix B.5: Challenges hindering innovation, by firm size (sub-sample)



Appendix B.6: Motivation to patent, by firm size (sub-sample)