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Some Facts about Indian Innovation in the Twenty-First Century§

ABSTRACT Innovation is a key driver of growth and development, and understanding its evolution in developing countries can provide important insights into the development process. Drawing on Kala, Lerner, and Liu (2025), which assembles novel data on Indian patents, this paper describes several key stylized facts of Indian innovation in the twenty-first century. We find considerable variation in patenting by geography; Indian versus foreign inventors; ownership of inventing organization (public versus private); and type of organization (academic institutions versus firms). Given the rapid growth of patenting and venture capital in India and the intense interest in innovation in developing countries more generally, it is our hope that this work will stimulate research in this area by numerous economists and other innovation scholars.

Keywords: *Innovation, Patents, India, Intellectual Property*

JEL Classification: *O31, O34, O38*

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1. Introduction

Innovative activity is key to the development process and is getting increasingly common in developing countries. In India, for instance, R&D expenditures, have climbed twenty-five times in rupee terms (though only six times over in U.S. dollars) between 1990-91 and 2020-21 (Department of Science and Technology, Ministry of Science and Technology, Government of India 2023). Furthermore, the venture capital sector has been strongly linked to innovation in both developed (Akcigit et al. 2022; Kortum and Lerner 2000) and developing (Lerner et al. 2024) economies. This sector has also grown sharply in India in recent decades. Investment climbed from a level of $67 million in 2005 (0.2 percent of the world total) to $14.5 billion in 2021 (5.2 percent of the world total).[1]

This rapid growth in innovation has been facilitated by internal and external factors. Domestic firms, such as Tata Motors, Sun Pharmaceuticals, and Dr. Reddy's, have been increasingly undertaking R&D. The government-owned National Investment and Infrastructure Fund and Indian high-net-worth families have similarly become important investors in local venture funds. The other driver has been the inflow of capital from global investors who recognize the deep pool of technical talent, a large domestic market, and widespread adoption of information technology as critical strengths. This trend has accelerated as Western investors and corporations have increasingly looked for alternative investing opportunities than those in China, and recent policies have tried to encourage innovative activity at the state and national levels (many of these policies are summarized in Department of Science and Technology, Ministry of Science and Technology, Government of India, 2020).

In this paper, we drew on an Indian patent dataset that we constructed in Kala, Lerner, and Liu (2025), to showcase some stylized factors about the levels and trends of innovation between 2005 and 2024. We constructed this data using the methodology pursued with the U.S. patent data since the inception of the first patent project at National Bureau of Economic Research (Griliches 1984). It emulates many of the key steps undertaken in the literature using the U.S. Patent and Trademark Office (USPTO) data, such as the compilation of citations (Jaffe and Trajtenberg 2002); calculation of measures of patent importance (Kelly et al. 2021); analysis of patent text (Kalyani et al. 2025); Myers and Lanahan 2022; construction of international patent families (Putnam 1997); disambiguation of assignees (Jaffe and Trajtenberg 2002); Magerman et al. 2006; and identification of venture-backed patents (Bernstein et al. 2016).

We examined patents granted between the effective date of the Patents (Amendment) Bill 2005, and the time that the data were downloaded at the end of 2024. Following the conventions of the economics of innovation literature (Jaffe and Trajtenberg, 2002), we focused exclusively on the most important

1. These statistics are based on the authors' analysis of the PitchBook data.

patent class–that is, utility patents. We did not consider design patents and India does not issue plant patents. Finally, we covered the lack of comprehensive availability of Indian patents in international data sources like WIPO in Kala, Lerner, and Liu (2025), which necessitates construction of this dataset.

We documented seven stylized facts about Indian innovation in recent decades. First, there is a large increase in patenting activity—the total patents increased from just over 5,000 in 2005 to over 25,000 in 2018, signifying a five-fold increase. Second, amongst the top twenty contributors to Indian patents during this time period, thirteen are firms, six are academic institutions, and one is a non-academic government organization, with the Indian Institutes of Technology prominently represented in academic organizations. Third, the number of patent citations has been increasing over time but remains well below U.S. levels and is driven largely by the extensive margin of patents citing any other patents. Fourth, geographically, innovative activity is dispersed, but some states like Maharashtra have consistently been responsible for large amounts of patent grantees, with patenting quite concentrated in a few districts within these states. Fifth, firms (and in particular, private firms rather than state-owned enterprises) are the largest source of innovative activity, followed by academic organizations. Sixth, innovation by sector is quite dispersed, with the top innovative sectors ranging from software, pharmaceuticals, telecommunications, and motor vehicles. Seventh, innovation has become more collaborative over time across individuals and organizations, and private sector-academia collaborations constitute an important source of cross-organizational collaborations.

2. Background

The promulgation of the World Trade Organization's Trade-Related Aspects of Intellectual Property (TRIPS) Agreement in the mid-1990s coincided with a period of economic liberalization in India. While India signed the TRIPS agreement in 1994, it was not until 2005 that a fully compliant patent law was enacted.[2]

In particular, the Patent Law of 2005, which came into effect at the beginning of that year after a protracted legislative process, modernized the Indian patent system. It extended full patent protection (including product awards) for pharmaceuticals and food, as well as those involved in chemical processes and extended patent life to 20 years from the application date, bringing India into

2. In April 1995, the Indian Government agreed to receive patent applications for pharmaceutical and agricultural products and to store them for processing once the Indian patent law to make such subjects patentable took effect. For details, see https://www.wto.org/english/tratop_e/dispu_e/79r.pdf

compliance with the minimum standards established by the TRIPS Agreement. It did retain some provisions from the earlier Acts. In particular, the ability of the state to impose compulsory licensing for essential patents that were not being put into practice and the creation of a library to document the prior art associated with traditional Indian medicinal knowledge, and thus prevent its incorporation into patents in India or elsewhere, as had happened in the case of turmeric (Jayaraman 1997), reflected long-standing concerns about the potential abuse of the patent system.

3. Data Assembly

The main source of our data is IP India, the official website of the Indian Patent Office. We scraped every granted patent with a filing year from 2005 to 2022, along with all documents attached with each patent. Details about the dataset are documented in Appendix A.

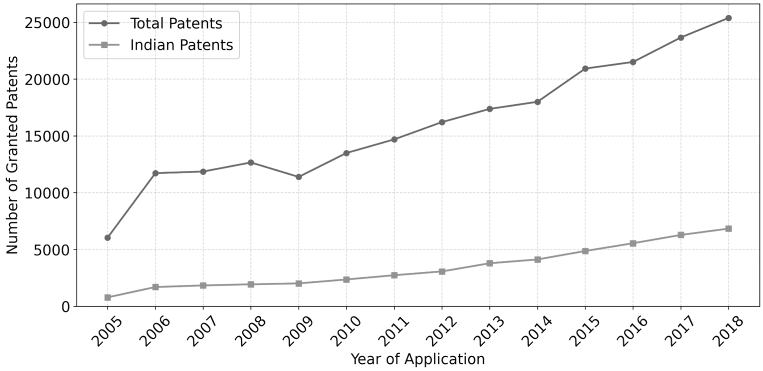
We extracted most information directly from the website data, including patent filing information (year of filing, year of grant, inventors, grantees) and patent content information (title, abstract, complete specification). We conducted disambiguation of patent grantees and link business grantees to the Prowess database (compiled by the Center for Monitoring the Indian Economy (CMIE)) to trace firms' financial performance. Finally, we also geo-located both grantees and inventors to the district-level.

We additionally leveraged attached documents of each patent. First, where the complete specification from the website was incomplete, we directly extracted the complete specification from Form 2 document. Second, we extracted backwards citation information of each patent from the First Examination Report (FER) document.

In total, we scraped a total of 295,743 granted patents from IP India for patents awarded between 2005 and 2022 and granted before 2024. For the subsequent versions of analyses, we will extend the sample to include all patents awarded from the beginning of the modern Indian patent system in January 2005. We will also use the entire body of patent awards, whether domestic and foreign, to create textual measures of patent importance (Kelly et al. 2021).

A large number of patents recorded in the Indian Patent Office are patents originally granted in other countries and transferred to the Indian Patent Office through Patent Cooperation Treaty (PCT) or other arrangements. To focus on localized Indian innovation, we created a specific Indian patent dataset by including the following patents of either of the following types: (1) patents with at least one assignee whose address is in India; and (2) patents with at least one inventor whose address is in India. We identified 67,369 Indian patents using this definition. We documented the details on the process of identifying Indian patents in Appendix B. We plotted the number of all patents and Indian patents over time by application time in Figure 1 and by date of grant in Figure 2.

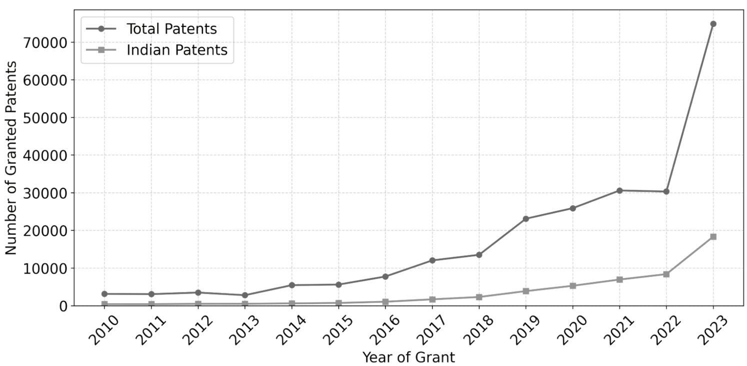
FIGURE 1. Number of Patent Awards in India, by Application Year



Source: Indian Patents Database, compiled from InPASS by the authors.

Note: This figure plots the number of patent awards by patents' application year. Indian patents are defined as either (1) patents with at least one assignee whose address is in India; or (2) patents with at least one inventor whose address is in India. We omit the years in 2018 to 2023 in this figure, since only a fraction of patents applied in these years have been examined - the median wait time between application to grant in India is over five years.

FIGURE 2. Number of Patent Awards in India (by Grant Year)



Source: Indian Patents Database, compiled from InPASS by the authors.

Note: This figure plots the number of patent awards by the year of grant. Indian patents are defined as either (1) patents with at least one assignee whose address is in India; or (2) patents with at least one inventor whose address is in India. We omit the years from 2005 to 2010 since we have only scraped patents applied from 2005, and the time between application to grant means that we do not have complete coverage for the early years yet.

While our scraping ends for the year of 2023, even if we have scraped all granted patents applied from 2005 and 2022, the time lag between the date of application and the date of grant means that we will have an incomplete coverage for the later years. In Figure 3, we document the very long wait time between application to grant: for most of the years, the median wait time for patents granted in that year is more than five years. Therefore, for analysis of time trends based on application date, we cut off our data in 2018 to avoid the distortion in trends in later periods.

3.1. Grantee and Inventor Information

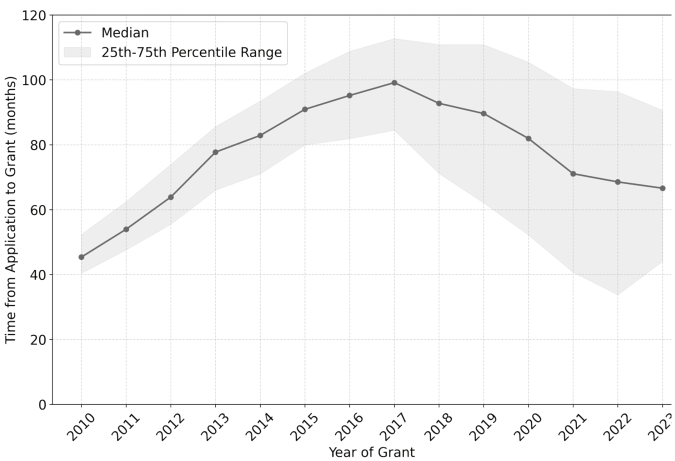
In the Indian context, the grantee is the original organizational or individual owner of the patent rights according to the Indian Patent Act 1970, similar to the concept of "assignee" in the U.S. context. From the IP India website, we obtained the Grantee Name, Grantee Type, and Grantee Address. Each patent can have multiple grantees.

On average, each patent has 1.24 grantees, though 87.7 percent of the patents have only one grantee. In comparison, patents granted between 2005 to 2022 in the U.S. have, on average, 1.04 assignees, with 96.43 percent of the patents having only one assignee.

An inventor is the individual(s) who contributed to the claimed invention. From the IP India website, we obtained the Inventor Name, Inventor Address, Inventor Country, and Inventor Nationality information. Each patent can have multiple inventors. On average, each patent has 3.18 inventors. In comparison, patents granted between 2005 to 2022 in the U.S. have, on average, 2.80 inventors.

3.1.1. Disambiguation of Grantees

FIGURE 3. Time from Application to be Granted Patent (by Grant Year)



Source: Indian Patents Database, compiled from InPASS by the authors.

Note: This figure plots the median and inter-quartile range of time (in months) from patent application date to patent grant date for Indian patents, grouped by year of grant. Indian patents are defined as either (1) patents with at least one assignee whose address is in India; or (2) patents with at least one inventor whose address is in India.

As in many other nations, assignee names in India can be difficult to work with. In some cases, assignees can be subsidiaries of other firms. In others, names can be mis-spelt or abbreviated. We disambiguated the grantees to combine different names for the same entity due to typographical errors, alternative spellings, and different localities. We focused on the set of grantees that are organizations or enterprises (grantee type is not a "Natural Person"). We document the detailed disambiguation procedures in Appendix C.

The raw Indian data contain 32,868 unique grantee names, of which 11,236 are organizations or enterprise grantees (that is, not individual persons). After disambiguation, the number of unique organization or enterprise grantees reduces from 11,236 to 7,129.

3.1.2. Identifying Grantee Types

While data from IP India do provide information on grantee types, the variable is very inconsistently defined. For instance, the Indian Institute of Technology is sometimes classified as an "Academic Institution," but at other times classified as "Other than Natural Person". Therefore, we conducted our own identification of grantee types by using keyword matching.

Specifically, for all grantees that are not "Natural Persons", we searched for possible keywords that could identify them as academic institutions or government entities. We regarded the remaining grantees as commercial firms (business) grantees. We describe the detailed process of matching in Appendix D.

Among the disambiguated grantees that are not natural persons, we were able to identify 1,497 academic institutions, 79 government organizations, and 5,553 businesses. We report the top patent grantees by number of patents and their type in Table 1. If considering the first grantee of each patent, among the 67,061 patents that have grantee information, 36,507 patents are granted to grantees which are identified to do businesses, 15,380 are granted to academic institutions, 13,797 are granted to individual (natural persons), and 1,375 are granted to government entities. The heavy representation of university assignees (22.9 percent) and individuals (20.6 percent) can be compared to the 4.5 percent and 1.0 percent seen in the U.S. (for patents awarded between 1985 and 2023) and the much more similar 17.6 percent and 14.0 percent in China (again for 1985 to 2023) (Lerner et al. 2025).

3.1.3. Geolocation of Grantees and Inventors

In order to understand the spatial distribution of Indian patents, we parsed postcodes, districts, and states from grantee and inventor addresses. Indian postcodes were provided in about 90 percent of the addresses, which allowed us to extract corresponding district and state information at a higher level. For the remaining 10 percent of addresses without postcodes, we were able to extract the district (and, thus the state) information using a combination of natural language processing detection and manual checks. Overall, we extracted district and state information for 98 percent of the inventor and grantee addresses. Appendix E provides further detail on our process for extracting location information.

Our data show the wide variation in the location of inventors and grantees across India, illustrated in Table 2. About 22 percent of the inventors are located in Maharashtra (which includes Mumbai and is the third most populous state in India), 16 percent in Tamil Nadu (including Chennai), and 15 percent in Karnataka (which encompasses Bengaluru, "the Silicon Valley of India"). Grantees show a similar distribution, with about 25 percent of the addresses in Maharashtra, 14 percent in Tamil Nadu, and 13 percent in Delhi. The remaining addresses for inventors and grantees are spread across 37 other states.

TABLE 1. Top Patent Grantees in India

Rank	*Organization*	*Type*	*#Patents*
1	Council of Scientific and Industrial Research	Academic Institutions	2154
2	Bharat Heavy Electricals	Business	1779
3	TVS Motor	Business	1679
4	Tata Service	Business	1635
5	Samsung Electronics	Business	1186
6	Mahindra & Mahindra	Business	1100
7	Samsung R&D Institute India Bangalore	Business	1065
8	Tata Steel	Business	1032
9	Tata Motors	Business	1029
10	Indian Institute of Technology Bombay	Academic Institutions	944
11	Indian Institute of Technology Madras	Academic Institutions	925
12	Schneider Electric India	Business	822
13	Wipro	Business	721
14	Director General of Defense R&D Organization	Government	649
15	Maruti Suzuki India	Business	624
16	Indian Institute of Technology Delhi	Academic Institutions	535
17	Hindustan Unilever	Business	517
18	Indian Institute of Technology Kanpur	Academic Institutions	484
19	Indian Institute of Science	Academic Institutions	436
20	Reliance Industrial	Business	429

Source: Indian Patents Database, compiled from InPASS by the authors.

Note: This table reports the top patent grantees for Indian patents. A patent is defined as an Indian patent if either at least one of the inventors or at least one of the grantees has an address in India. The number of patents calculates the total number of patents for which a given grantee appears in the list of grantees, not necessarily the first grantee.

TABLE 2. Inventors and Grantees by State

State	*Inventors*	*Inventors (%)*	*Grantees*	*Grantees (%)*	*Patents (%)*	*Population*
Maharashtra	40,672	22	16,490	25	22	112,374,333
Karnataka	28,341	15	6,982	11	15	61,095,297
Tamil Nadu	30,517	16	9,509	14	14	72,147,030
Uttar Pradesh	11,125	6	3,413	5	6	199,812,341
Telangana	11,080	6	2,690	4	6	35,003,674
Delhi	8,168	4	8,632	1	5	16,787,941
Gujarat	8,203	4	2,839	4	4	60,439,692
Haryana	9,268	5	1,781	3	4	25,351,462
West Bengal	6,241	3	3,408	5	4	91,276,115
Kerala	4,094	2	1,005	2	2	33,406,061
Jharkhand	6,036	3	1,379	2	2	32,988,134
Punjab	4,239	2	1,232	2	2	27,743,338
Andhra Pradesh	2,592	1	999	2	2	84,580,777
Rajasthan	2,349	1	852	1	2	68,548,437
Madhya Pradesh	2,606	1	725	1	2	72,626,809
Uttarakhand	3,546	2	771	1		10,086,292
Odisha	1,936	1	625	1	1%	41,974,218
Bihar	962	1	347	1		104,099,452
Assam	1,501	1	612	1	1	31,205,576
Chandigarh	1,114		540	1	1%	1,055,450
Himachal Pradesh	1,149	1%	384	1	1	6,864,602
Chhattisgarh	527	0	265	0	0	25,545,198
Puducherry	489	0	208	0	0	1,247,953
Jammu & Kashmir	636	0	168	0	0	12,541,302
Goa	399	0	110	0	0	1,458,545
Tripura	61	0	30	0	0	3,673,917
Manipur	48	0	39	0	0	2,855,794
Meghalaya	84	0	37	0	0	2,966,889
Nagaland	57	0	33	0	0	1,978,502
Dadra & Nagar Haveli & Daman & Diu	37	0	13	0	0	586,956
Mizoram	38	0	30	0	0	1,097,206
Sikkim	29	0	22	0	0	610,577
Arunachal Pradesh	17	0	10	0	0	1,383,727

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Andaman & Nicobar Islands	24	0	8	0	0	380,581
Total	188,185	100	66,188	100	100	1,245,794,178

Source: Population information provided by the 2011 Census: https://censusindia.gov.in/census.website/data/census-tables. For Telangana, population retrieved from state website- https://www.telangana.gov.in/About/State-Profile/. Patent information provided by Indian Patents Database, compiled from InPASS by the authors.

3.1.4. Identifying the Inventor's Organization

While grantee information documents the property of the patent, it is often the case that multiple inventors collaborate on a single patent. To identify inventor organizations from patent filings, we analyzed the free-form addresses provided for each inventor, as these data often reveal the organization of the inventor.

We utilized a Large Language Model (LLM) to parse these unstructured addresses. The model extracts and standardizes organization names when present. Furthermore, for cases where the address does not reveal an organization, but is indeed a well-known organization address, the LLM can infer the organization correctly based on the public knowledge it has. We document how we extract, post-process, and validate the results in Appendix F.

3.1.5. Linking Grantees to Prowess

In order to investigate the firms' performance and innovation, we linked business grantees (as opposed to natural persons, academic institutions, or government entities) to firms in Prowess data, one of the largest databases of the financial performance of Indian companies. We describe the detailed process of matching in Appendix G.

There were 5,553 unique firm grantees and we were able to match 1,239 of them with Prowess data. Since we manually checked all the grantees with more than ten patents, this set of matched firms should cover the most important firms and represent a large portion of the total patent grants: among the 36,507 patents whose first grantee is a Business, our matched grantees were granted a total of 28,704 patents as the first grantee, representing 78.6 percent of the total.

3.2. Patent Information

3.2.1. Patent Full Text: Complete Specification

The textual information of the patents will be used to perform various analyses. We obtained the complete specifications (that is, the full text description) for most of the patents and conducted quality checks for complete specifications. Some of the complete specifications downloaded from the website are missing, corrupted, or refer to attached PDF files. For these cases, we went to the attached document for the complete specification and parsed from the PDF directly. We also checked each parsed complete specification: whether they have a minimal length and whether they contain keywords that are common in most complete specifications. We documented details on our parsing and quality check procedures in Appendix H.

We sought to extract complete specifications for the full set of granted patents in India (295,743 patents) and succeeded in extracting 97.8 percent of the patents (289,832 patents).

3.2.2. Backwards Citations

In order to assess the relative novelty of each patent, we extracted backward citations—the patent literature referenced—from the First Examination Report (FER) of each patent. Citations may serve an unsatisfactory purpose of indicating quality for patents in India, as in many other developing countries, because of the scarcity of citation activities. This scarcity of citations by domestic applicants seems to be a characteristic of emerging market patent offices. For a discussion of citation practice by Chinese inventors, see Lerner et al. (2025). Despite the paucity of these citations, we extracted backward citations to patent literature for all patents.

Among the entire set of 295,743 granted patents, 244,431 of them have the FER attached. Patents without FER files (51,312 patents) are predominantly confined to the early period—49,516 of them are in the years between 2005 and 2010. We extracted citation records for 233,319 patents, representing 95.5 percent of all the patents with FER reports. Unsuccessful cases are mostly due to the patent not citing any patent, with a small number of FER reports having PDF quality issues. Appendix I provides details on our extraction process.

On average, each patent cites 2.28 patents, where non-Indian patents make 2.29 citations and Indian patents make 2.24 citations.[3]

4. Stylized Facts about Indian Innovation

4.1. Large Increase in Patenting Activity

One of the most striking facts about Indian patenting activity has been its fast growth over time—the total patents increased from just over 6,000 in 2005 to over 25,000 in 2018, signifying a nearly five-fold increase. This is largely driven by foreign patents, with the share of Indian patents increasing from less than 800 in 2005 to almost 7,000 in 2018.

3. We assume patents without FER files or FER files having PDF quality issues to have cited zero patents here. If conditional on patents with any citation, each patent cites 2.90 patents, where non-Indian patents make 2.95 citations and Indian patents make 2.74 citations

4.2. Top Contributors to Innovation by Patent Numbers and Their Composition

Which organizations are most responsible for this large amount of innovation in recent decades? Table 1 shows the identity, type, and number of patents granted to the top twenty organizations by the number of patents (we focused on the first listed grantee for this exercise). Thirteen of them are firms; six are academic institutions; and one is a government (non-academic) organization. The Council of Scientific and Industrial Research (CSIR) received the largest number of granted patents in this period at 2154, representing 3.2 percent of the total Indian patents, followed by Bharat Heavy Electricals at 1,779 patents. Large firms that are part of conglomerates are in this list of top innovators, with three of the twenty being Tata firms, and two Samsung firms. Moreover, prominent Indian academic institutions also form part of this list, with four Indian Institutes of Technology (IITs) in this list, as well as the Indian Institute of Science.

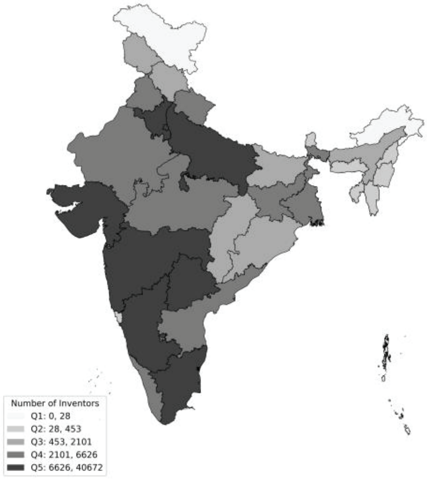
4.3. Stability of Geographical Distribution of Innovation

How geographically concentrated is Indian innovation? Geocoding grantees' and inventors' addresses allowed us to analyze the levels and trends in the geography of innovation. First, Figure 4 shows state-level as well as district-level maps of where grantees and inventors are located, by quintile of the occurrences of grantee/inventor appearances in patents. Grantees are usually the organization to which the patent is granted, and inventors are the individuals involved in developing the patent. In terms of aggregate innovation (number of patents), several southern states are in the top quintile, including Karnataka and Tamil Nadu, though some central and northern states are also in the top quintile (Uttar Pradesh and Gujarat). Panels c) and d) show district-level maps which bring out that within states, innovative activity is highly concentrated - for instance, in Maharashtra, only a few districts are responsible for a larger number of innovations like Mumbai and Pune.

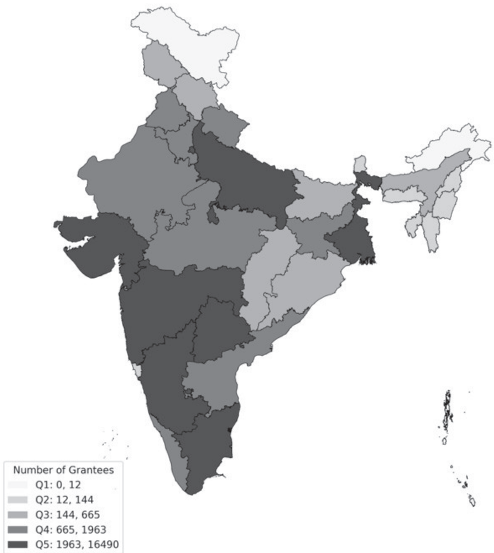
How stable is this spatial distribution of innovative activity in recent years? Figure 5 presents trends for the number of appearances for the top five states for grantees and inventors, respectively. It shows that the relative ranking of these five states (in order of patenting activity) Maharashtra, Tamil Nadu, Delhi, Karnataka, and Uttar Pradesh, is quite stable for grantees with Tamil Nadu being an exception, going from rank four to two between 2015 and 2018. For inventors, there are more changes in ranks, but Maharashtra is consistently the highest across time. Overall, the relative contribution of these two states seems relatively stable in recent years.

FIGURE 4. Spatial Distribution of Innovation in India

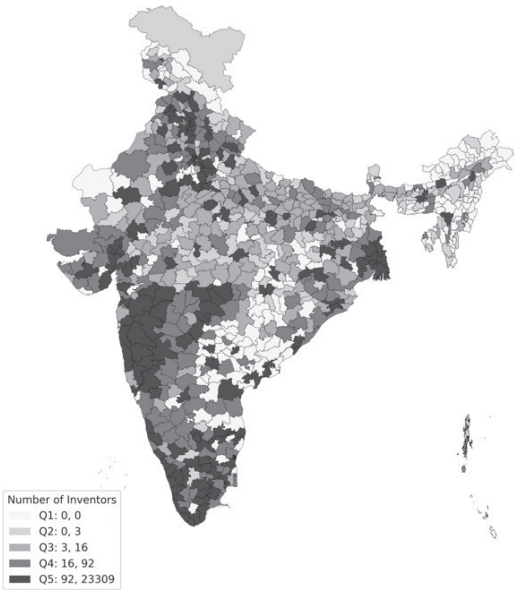
(a) Inventors by State



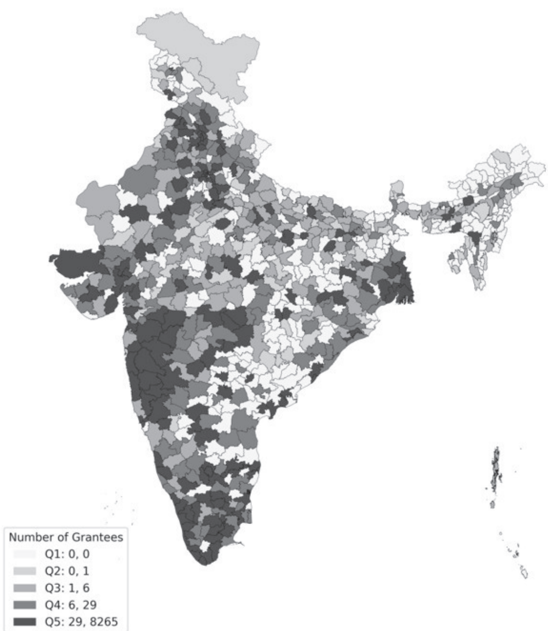
(b) Grantees by State



(c) Inventors by District

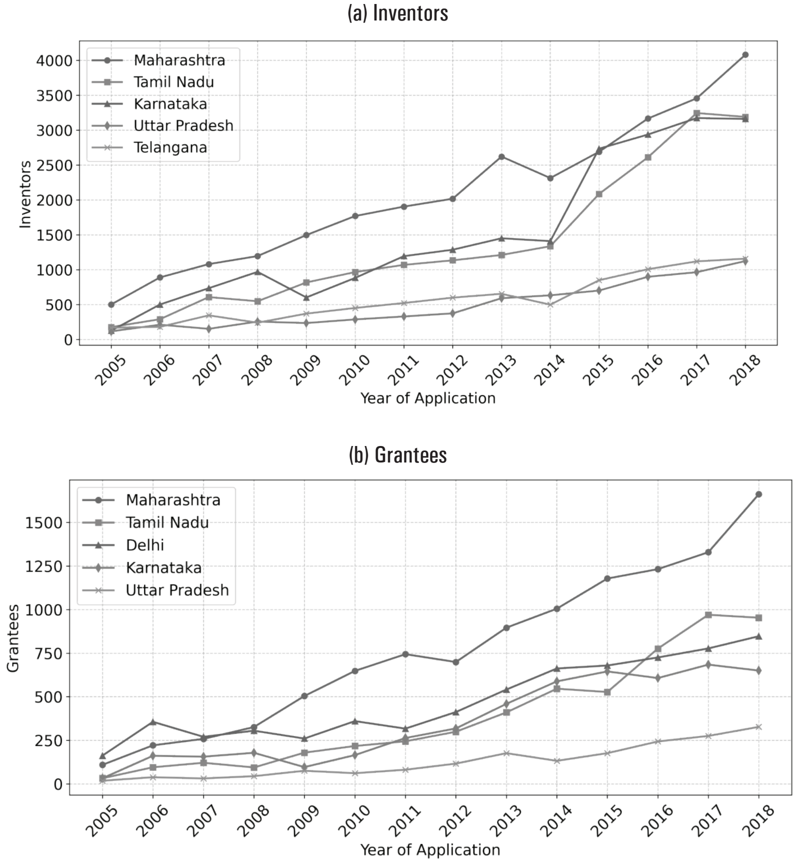


(d) Grantees by District



Source: Indian Patents Database, compiled from InPASS by the authors.
Note: This figure plots the distribution of inventors and grantees by state and district in quintiles for Indian patents from 2005 to 2022. The legend denotes the range of inventors and grantees in each quintile. Each observation is an inventor/grantee-patent pair. Indian patents are defined as either (1) patents with at least one assignee whose address is in India; or (2) patents with at least one inventor whose address is in India.

FIGURE 5. Number of Patent Inventors and Grantees by State



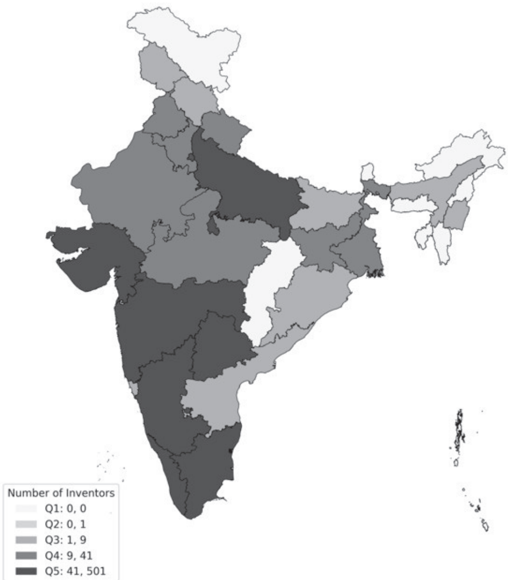
Source: Indian Patents Database, compiled from InPASS by the authors.

Note: This figure plots the number of patent inventors and grantees of Indian patents by state in the top 5 states between 2005-2018. The X-axis represents the application filing year. The legend presents the states in descending order of total inventors. Each observation is an inventor/grantee-patent pair. Indian patents are defined as either (1) patents with at least one assignee whose address is in India; or (2) patents with at least one inventor whose address is in India. We omit the years from 2018 to 2023 in this figure, since only a fraction of patents applied in these years have been examined - the median wait time between application to grant in India is over five years.

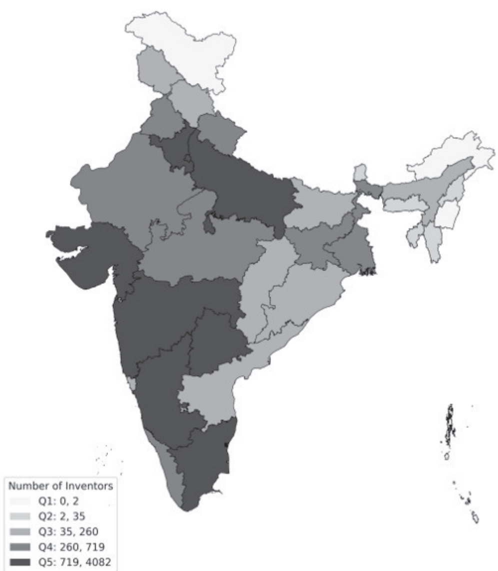
Finally, Figures 6 and 7 present results for the level and growth in patent applications for granted patents for both inventors and grantees. In terms of levels, from 2005 to 2018, there is general stability in leading states like Maharashtra, Karnataka, Gujarat, and Uttar Pradesh, in both the absolute number of patents and density. In terms of growth, Andhra Pradesh and Chhattisgarh are amongst the top quintile states for patenting growth. Some other states have a high growth rate of grantees, such as Madhya Pradesh, but not of inventors. Overall, these figures indicate that the states where innovative activity is already high are different from states where it is growing fast. Furthermore, a few districts drive a large share of innovative activity.

FIGURE 6. Spatial Distribution of Innovation in India, 2005 and 2018

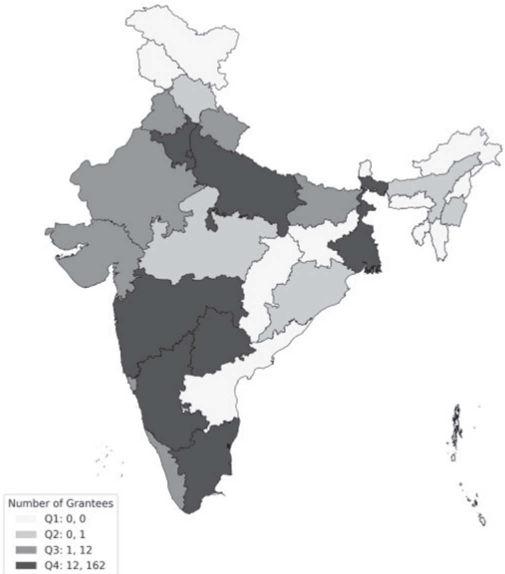
(a) Density of Inventors by State (2005)



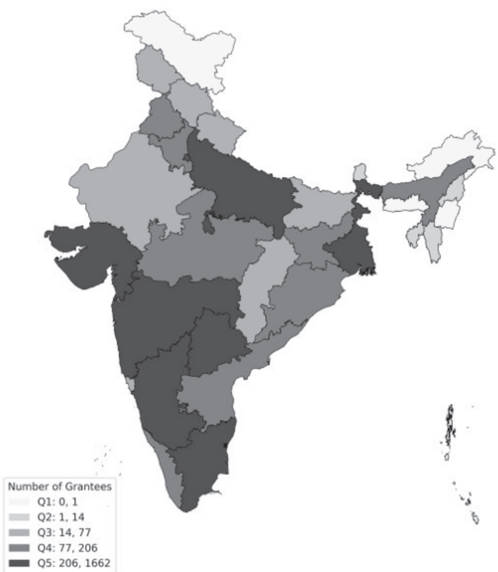
(b) Density of Inventors by State (2018)



(c) Density of Grantees by State (2005)



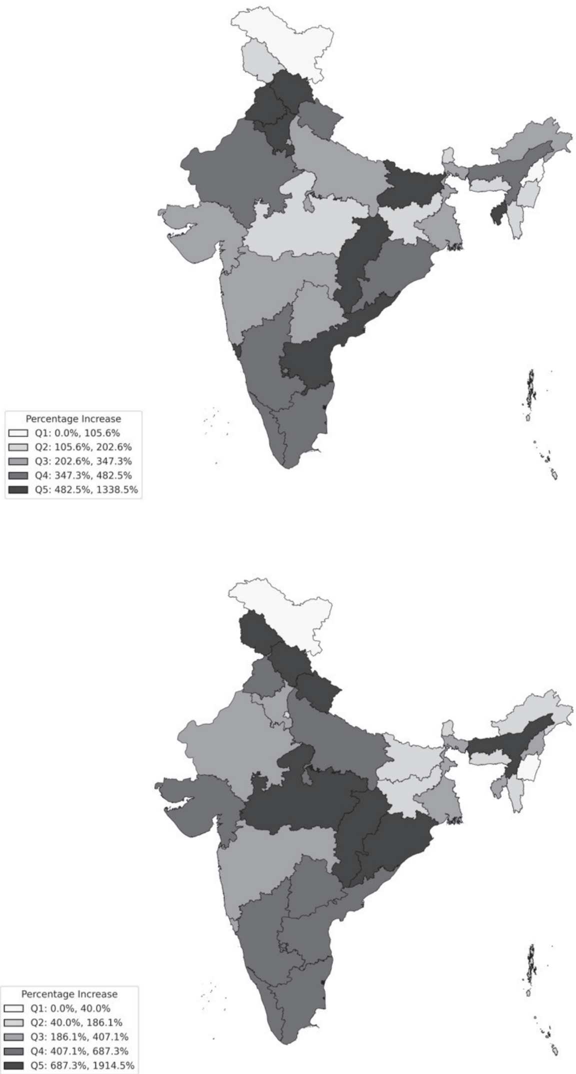
(d) Density of Grantees by State (2018)



Source: Indian Patents Database, compiled from InPASS by the authors.

Note: This figure plots the distribution of inventors and grantees by state in application filing years 2005 and 2018 for Indian patents. The legend denotes the range of inventors and grantees in each quintile. Each observation is an inventor/grantee-patent pair. Indian patents are defined as either (1) patents with at least one assignee whose address is in India; or (2) patents with at least one inventor whose address is in India. We omit the years of 2018 to 2023 in this figure, since only a fraction of patents applied in these years have been examined - the median wait time between application to grant in India is over five years.

FIGURE 7. Spatial Growth in Patent Applications from 2005 to 2018



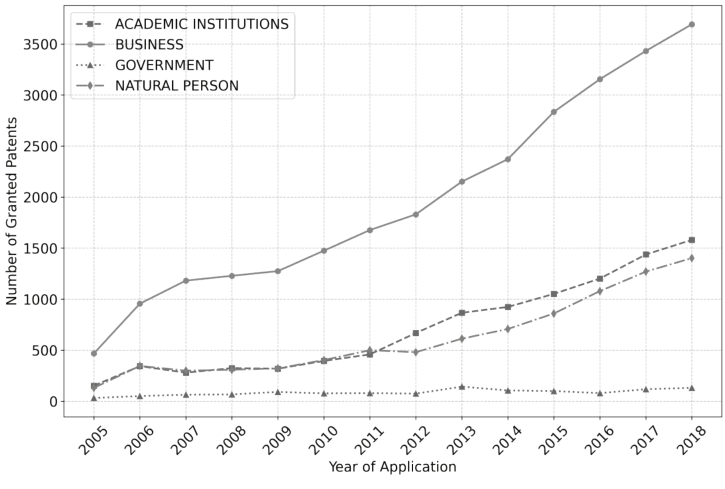
Source: Indian Patents Database, compiled from InPASS by the authors.

Note: This figure plots the quintiles distribution in the growth rate of inventors and grantees by state for Indian patents. We calculate the growth rate from the average number of patents in the first five years of our data (2005-2009) to the average in the last five years (2014-2018). States are classified into quintiles based on growth, and states with an average of 0 in the first five years are treated as 1 in the growth calculation. The legend denotes the range of growth in each quintile. Each observation is an inventor/grantee-patent pair. Indian patents are defined as either (1) patents with at least one assignee whose address is in India; or (2) patents with at least one inventor whose address is in India. We omit the years from 2018 to 2023 in this figure, since only a fraction of patents applied in these years have been examined - the median wait time between application to grant in India is over five years.

4.4. Business Innovation's Large and Increasing Share of Innovation

Figure 8 shows trends in the composition of the types of organizations that are conducting innovative activity, namely academia, firms, government organizations (other than academic organizations and state-owned enterprises), and individual inventors not affiliated with any organization (labeled "natural persons") in the data. The figure shows that across the 2005-2018 time period, firms have been, by some distance, the largest drivers of patenting activity, followed by academic institutions (this considers the first grantee in the patents). Moreover, the growth rate for patenting activity for firms has been higher over time, and in 2018, the number of patents issued to firms was over three times of what had been issued to academia. Third, while patenting activity by firms, academia, and individuals have increased over time, those by other government institutions has been relatively more stable over time. Overall, the trends point to robust and growth patenting activity in both the private sector and academia.

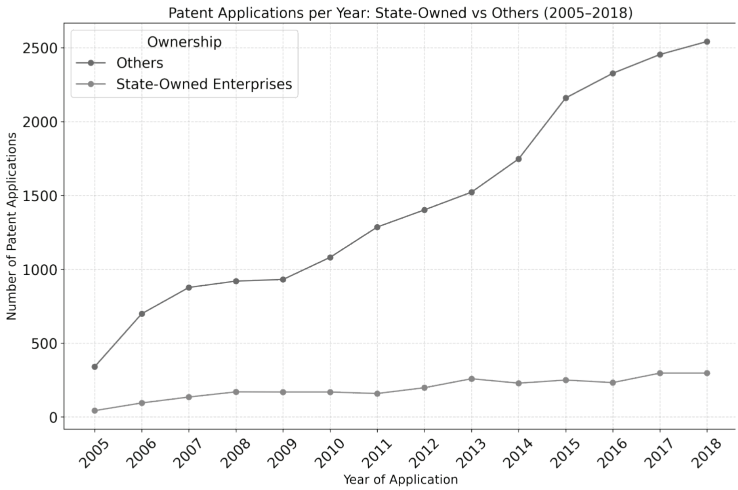
FIGURE 8. Number of Indian Patent Awards, by First Grantee Type and Application Year



Source: Indian Patents Database, compiled from InPASS by the authors.
Note: This figure plots the number of Indian patent awards grouped by the type of each patent's first grantee and by the year of application. We describe how we classify grantees into the four groups in Appendix D. Indian patents are defined as either (1) patents with at least one assignee whose address is in India; or (2) patents with at least one inventor whose address is in India. We omit the years from 2018 to 2023 in this figure, since only a fraction of patents applied in these years have been examined—the median wait time between application to grant in India is over five years.

With firms, we can also see the relative contribution of patenting activity between state-owned enterprises such as public sector undertakings versus other firms (which are predominantly private firms). Figure 9 presents trends in innovation by these two types of firms. The gap between private sector firms and state-owned enterprises has increased over time, with the growth rate for the latter being relatively stable. For the former, the number of patent awards grew relatively faster, especially after 2009.

FIGURE 9. The Number of Indian Patent Awards, by First Grantee's Prowess Ownership



Source: Indian Patents Database, compiled from InPASS by the authors, and the CMIE Prowess database.
Note: This figure plots the number of Indian patent awards grouped by the ownership of each patent's first grantee, if the first grantee is matched to Prowess data. Indian patents are defined as either (1) patents with at least one assignee whose address is in India; or (2) patents with at least one inventor whose address is in India. We define a grantee as a State-Owned Enterprise if its ownership-group name in the Prowess data contains "Govt" or "State". We describe how we match patent grantees to Prowess company names in Appendix G. We omit the years from 2018 to 2023 in this figure, since only a fraction of patents applied in these years have been examined - the median wait time between application to grant in India is over five years.

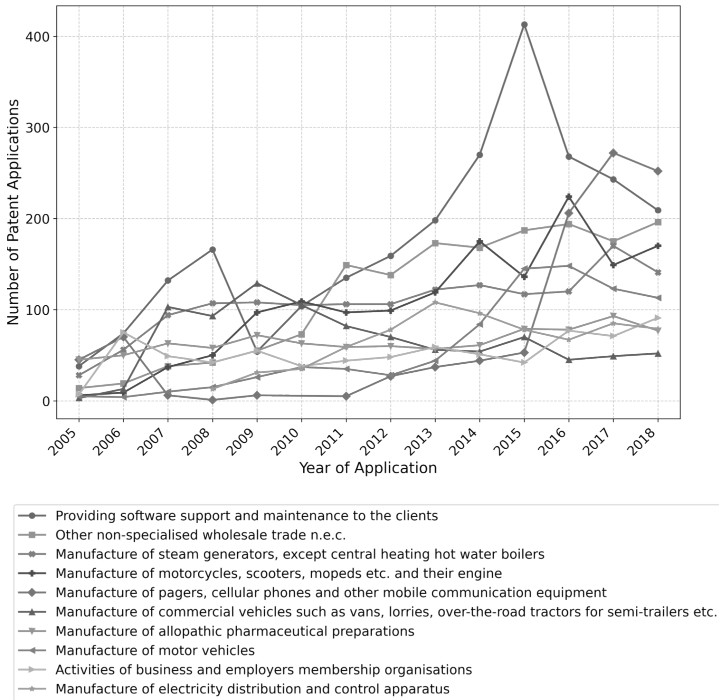
4.5. Top Contributors to Innovation by Sector and Trends over Time

Which sectors in the Indian economy are drivers of innovation in the private sector? To understand this, we looked at the five-digit National Industrial Classification (NIC) codes, in the merged patents-Prowess data.[4] We focused on the top ten sectors (by first grantee) by the total number of granted patents. Figure 10 presents trends in innovation over time for these sectors, as well as which sectors these are. First, the list of top ten sectors by the number of patents is diverse, and shows that innovative activity is occurring in a wide swathe of sectors ranging from pharmaceuticals, motor vehicles, and energy to telecommunications. Second, it shows that while growth has been rapid in several of these sectors, it is quite heterogeneous, with some sectors like software growing faster than others like the manufacturing of motor vehicles.

4. This is the finest level at which NIC codes are available in the Prowess database.

Third, some sectors started with a lower relative ranking but climbed rapidly, such as telecommunications (NIC code "manufacture of pagers, cellular phones and other mobile communication equipment"), which goes from tenth rank in 2014 to second in 2018 in terms of the number of granted patents.

FIGURE 10. Number of Indian Patent Awards, by First Grantee's Prowess NIC Product

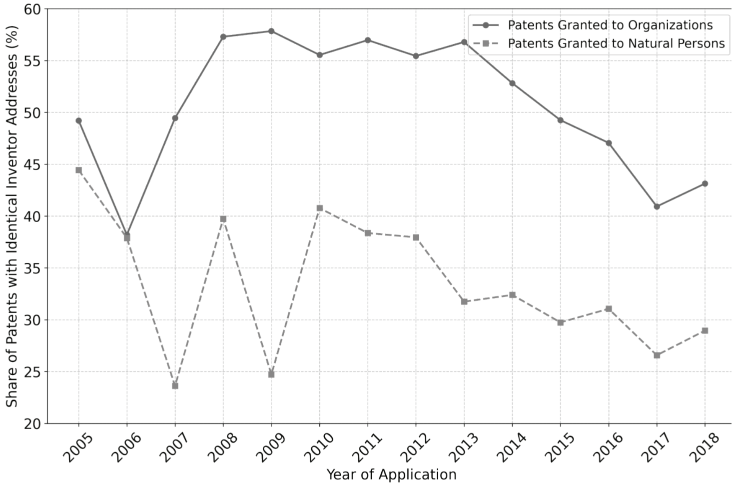


Source: Indian Patents Database, compiled from InPASS by the authors, and the CMIE Prowess database.
Note: This figure plots the number of Indian patent awards grouped by the NIC (National Industrial Classification) of each patent's first grantee, if the first grantee is matched to Prowess data. Indian patents are defined as either (1) patents with at least one assignee whose address is in India; or (2) patents with at least one inventor whose address is in India. We use Prowess' "nic_name" variable and list the top 10 groups. We describe how we match patent grantees to Prowess company names in Appendix G. We omit the years from 2018 to 2023 in this figure, since only a fraction of patents applied in these years have been examined - the median wait time between application to grant in India is over five years.

4.5. The Evolving Nature of Innovation Collaboration over Time

How have collaboration networks changed in recent decades? We explored this in several ways. First, Figure 11 depicts the share of patents where inventors have identical addresses for patents with more than one inventor. The solid line shows this for the patents granted to organizations (which are likely higher-value) while the dotted line shows this for patents granted to individuals. In both cases, we see that in recent years (after 2012), there has been a decrease in non-collaborative collaboration, that is, a decrease in the share of patents with identical inventor addresses. The magnitude here is economically significant, with such patents (with identical inventor addresses) comprising about 57 percent of patents in 2013, but about 44 percent in 2018 for patents granted to organizations.

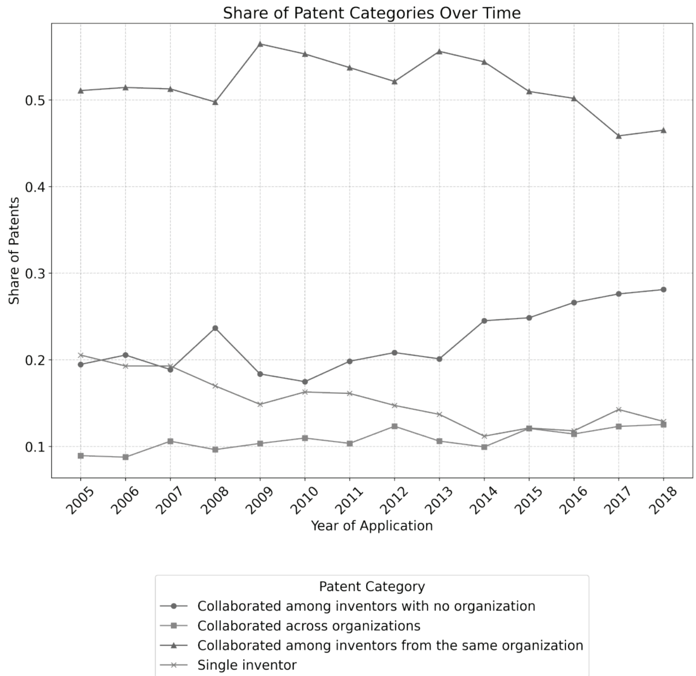
FIGURE 11. Share of Patents with Identical Inventor Addresses



Source: Indian Patents Database, compiled from InPASS by the authors.
Note: This figure plots the share of patents with identical inventor addresses, grouped by inventor collaboration types and year of application. Indian patents are defined as either (1) patents with at least one assignee whose address is in India; or (2) patents with at least one inventor whose address is in India. We omit the years from 2018 to 2023 in this figure, since only a fraction of patents applied in these years have been examined - the median wait time between application to grant in India is over five years.

Figure 12 shows trends in more detailed types of collaborations over time. The share of patents comprising collaboration among inventors from the same organization declined over time, especially after 2013. Interestingly, the share of patents from a single inventor also declined significantly and continuously over time, from over 20 percent in 2005 to under 15 percent in 2018. Both these patterns indicate an increase in collaborative innovation in recent years, which is shown with increases in the share of patents attributable to multiple organizations and multiple individuals.

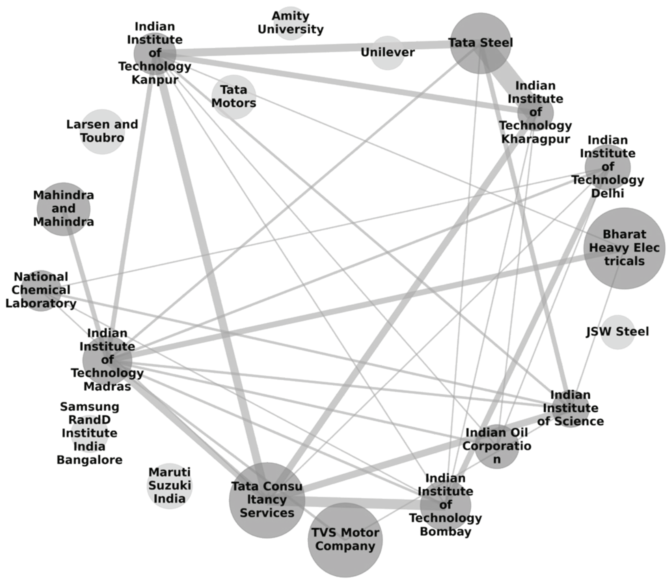
FIGURE 12. Collaboration Types for Patents Granted to Organizations



Source: Indian Patents Database, compiled from InPASS by the authors.
Note: This figure plots the share of patents granted to organizations (i.e., non-natural persons) grouped by inventor collaboration types and year of application. We describe how we infer inventors' organization in Appendix F. Patents are classified into "collaborated across organizations" if at least two of the inventors are from different organizations, or at least one of the inventors are from a certain organization and others are without organization. Indian patents are defined as either (1) patents with at least one assignee whose address is in India; or (2) patents with at least one inventor whose address is in India. We omit the years from 2018 to 2023 in this figure, since only a fraction of patents applied in these years have been examined - the median wait time between application to grant in India is over five years.

In order to better understand the types of cross-organizational collaboration, we focused on the top twenty inventing organizations, and plotted their networks. Figure 13 shows this network, with the width of the link representing the strength of the collaboration (the number of patents) they have together. The figure highlights several facts about the network of collaboration for these high-innovation organizations. First, while the majority of these organizations (thirteen of twenty) have collaboration networks with other high-innovation organizations, a significant fraction does not, including large private firms such as Maruti Suzuki, Unilever, and Tata Motors. Second, cross-organization innovation frequently takes the form of private firms collaborating with academia, such as Tata Steel's collaboration with IIT Kharagpur, Mahindra and Mahindra's collaboration with IIT Madras, or Tata Consultancy Services collaborating with the Indian Institute of Science, as well as with several IITs, including Kanpur, Bombay, and Kharagpur. Third, this type of academic-private firm collaboration is much more common than private firms collaborating with each other. Overall, the figure highlights the significance of collaborative innovation in India, and shows the importance of participation of frontier academic organizations with the private sector in recent innovation.

FIGURE 13. Collaboration Network



Source: Indian Patents Database, compiled from InPASS by the authors.

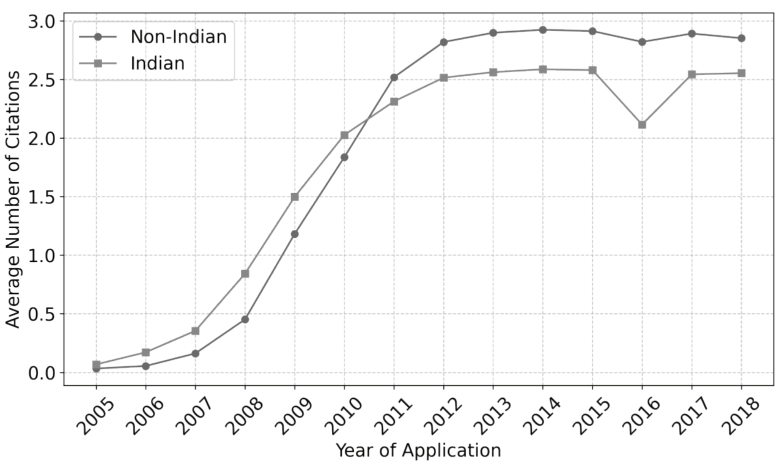
Note: This figure plots the collaboration network for the top 20 inventor organizations. The size of the node represents the total number of patents involving inventors from this organization, and the width of the link represents the number of collaborations between inventors from the two organizations. We document how we extract inventor organization information from inventor address in Appendix F. The black nodes represent singleton organizations while the grey nodes represent organizations with collaborations. A collaboration is defined as at least one inventor from each organization appearing on the inventor's list for a given patent. Indian patents are defined as either (1) patents with at least one assignee whose address is in India; or (2) patents with at least one inventor whose address is in India.

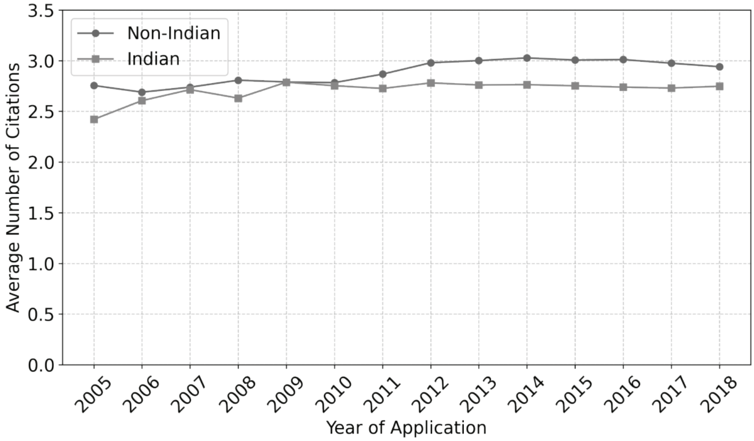
4.6. Increasing Trends in Patent Citations

While the number of patents is one measure of innovation, a long literature on innovation shows the importance of patent citations as measures of quality. We will focus on this in future work, but for now, note the general increase in patent citations over time as depicted in Figure 14. The average number of citations (shown in Panel 'a' of the figure) is negligible in 2005, for both Indian and non-Indian patents, but rises rapidly, especially after 2007, and stabilizes at about three for non-Indian patents by 2012 and at about 2.5 for Indian patents around the same time. Moreover, Panel 'b' of the figure shows that the average number of citations conditional on citing any patent has remained stable over time, at about 2.7 for Indian patents and 3 for non-Indian patents. However, note that a large number of patents in the early period does not include the FER (First Examination Report) files on IP India Website, making it impossible to determine whether they were indeed cited.

Whether patent citations are as likely to measure quality in Indian patents as in U.S. patents is not clear, as citation behavior may vary across contexts. Suggestive evidence shows that there is very little activity in the field of citing Indian patents—the top three countries of patents cited by Indian patents are the U.S. (46.48 percent), China (14.10 percent), and the European Patent Office (6.13 percent), and on average, non-Indian patents cite 0.003 patents filed in the Indian patent office, whereas Indian patents cite 0.048 patents filed in the Indian patent office. By comparison, data from PatentsView for U.S. granted patents applied between 2005 to 2018, show that on average, U.S. patents cite 19.19 U.S. granted patents and 6.73 foreign patents. China is intermediate between the two extremes: patents ten or more years of age have on average 4.5 citations by other Chinese awards, while those granted between 2013 and 2017 have 1.3 citations (Lerner et al. 2025).

FIGURE 14. Trend in Citations





Source: Indian Patents Database, compiled from InPASS by the authors.
Note: This figure plots the average number of citations made for all Indian patents and Indian patents conditional on having cited any patent. We describe how we extract backwards citation information from patents' associated files in Appendix I. Patents filed in the early years tend not to include the file documenting citation information. Indian patents are defined as either (1) patents with at least one assignee whose address is in India; or (2) patents with at least one inventor whose address is in India. We omit the years from 2018 to 2023 in this figure, since only a fraction of the patents applied for in these years have been examined—the median wait time between application to grant in India is over five years.

5. Conclusion

In this paper, we draw on a newly constructed dataset covering all the granted patents in India from 2005 until the present, to uncover key stylized factors about innovation in India. The data show that innovative activity is growing rapidly over time, largely driven by the private sector and academia, and distributed in diverse sectors in the economy. Furthermore, private-sector and academic collaborations are an important source of patenting activity for the top organizations by number of patents, and innovation is becoming more collaborative over time.

In future work, we will test how recent policy changes have changed the rate and type of innovation over time, as well as build newer measures of innovation quality. Given the relative importance of the Indian economy, we also hope this work will be useful for academics and professionals in better understanding the innovation landscape in India, and the developing world broadly.

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Appendix

A. Data Source

We searched in IP India's portal at https://iprsearch.ipindia.gov.in/publicsearch. Each patent has three main sources of information from the IP India website: Details, Register, and Status. An example is as follows:

Application Number	Title	Application Date	Status		
202041004552	GLASS SHUTTER FRAME ASSEMBLY WITH SEAMLESS FRAME INTEGRATION DESIGN	01/02/2020	Granted	E-Register	Application Status

We obtained information on the various patents from their respective websites, and the variable of interest has a prefix of "Details/", "Register/", or "Status/". Details page refers to the patent detail information page when clicking on the application number. Register page refers to the E-Register providing information on register and grantees. Status page refers to the Application Status page. We also download all attached documents for each patent.

To determine the application year of each patent, we primarily used the variable 'Details/Application Filing Date' from the web-scraped data. If this field was missing or contained erroneous values (e.g., 1900), we used information from application ID: either the first four digit (where the application ID is all digits) or the last four digit (where the application ID follows the format of DD-OFFICE-YYYY) represents the year that the application is filed.

B. Identifying Indian Patents

To capture the localized Indian innovation, we included the following patents in our Indian Patents Dataset: (1) patents with at least one grantee whose address is in India; or (2) patents with at least one inventor whose address is in India. We identified 67,369 Indian patents in our dataset from the 295,743 patents that we scraped.

The India Patent Office records the nationality and country of inventors, so the determination of an Indian inventor is more straightforward. The listed "inventor country" information is associated with the address of the inventor. We consider a patent to have an Indian inventor as long as one of the inventors' "inventor country" is India. In total, there are 64,070 unique patents with an Indian inventor.

Grantees only have a "grantee address" field to document address but not following any specific format. To determine whether a grantee address is Indian, we used a combination of mapping address strings to India directly (through the named country or Indian states), filtering out addresses clearly based in another country, and name entity recognition (NER) via a Python package. First, we utilized the location tagger (NER) Python package to broadly extract country and related entities to location keywords in address string. Then, we determined that an address is Indian if it contained a standalone “India” or any states of India (53,930 addresses). We determined that an address is not Indian if it ended with any other country names, or states/provinces of U.S. and China (142,751 addresses). Among the remaining 128,819 addresses, 15,060 were mapped to India via location tagger, and 113,759 not. We consider the latter as not Indian. Overall, we determined 56,577 unique patents with an Indian grantee.

Combining the two sets (Indian inventors and Indian grantees), we obtained our Indian Patent Dataset, consisting of 67,369 patents.

C. Disambiguation

We closely followed the PatentsView’s disambiguation process on the U.S. patents’ assignees. Details can be found on the PatentsView’s website at https://patentsview.org/disambiguation. Our final pipeline proceeded in two main phases. In Phase 1, we closely followed PatentsView’s methodology in disambiguation. We first created “mentions” of grantees and aggregate processed mentions into what PatentsView call “canopies” using the first four character of the name to reduce the total number of comparisons needed. Next, we applied PatentsView’s Hierarchical Agglomerative Clustering (HAC) model with TF-IDF and location features through the Grinch library. Records are clustered based on whether they exceed the threshold that PatentsView’s code use (0.85) in terms of cosine similarity of these engineered features.

Phase 2 re-checked each cluster with similarity metrics after removing both “stopwords” and “industry” stopwords. In addition to PatentsView’s clustering model, we introduced an additional verification layer based on four distinct similarity metrics—BERT cosine similarity; TF-IDF cosine similarity; Jaro-Winkler distance; and Levenshtein distance. If at least two of these metrics register above a 0.9 threshold, we accept that cluster.

We applied this approach to an Indian patent dataset of 11,236 raw Indian organizations and enterprises grantee names. After cleaning and disambiguation, we ended up with 7,130 distinct organizations and enterprises entities.

D. Identifying Grantee Types

In the web-scraped data from IP India each grantee is indeed associated with a field called “Grantee Type”. This field takes one of the following values: Natural Person, Other Than Natural Person, Educational Institute, Small Entity, and Start-Up. However, upon further investigation, this field is defined very inconsistently.

To systematically determine each grantee's type, we conducted a keyword matching process for all grantees that are not 'Natural Person'. We started off with a probable set of keywords that identifies an educational institute, for instance "university", "Indian institute of", and check the remaining grantees sorted by their total amount of patents granted to add more keywords to the list.

Among the disambiguated grantees, we were able to identify 1,497 academic institutions, 79 government organizations, and 5,553 commercial firms.

E. Geolocation

E.1. Postcode Extraction

Indian postcodes are formatted in six digits, typically at the end of the address. They are either given as a full string (e.g., 123456) or delimited with a space in the middle (e.g., 123 456). We devised a regex command to extract postcodes based on these patterns from the Indian grantee and inventor addresses.

Out of 68,990 Indian grantees, we extracted postcodes from 60,050 (87 percent), leaving 8,940 (13 percent) without a postcode. Out of 196,064 Indian inventors, we extracted postcodes from 179,985 (92 percent), leaving 16,079 (8.2 percent) without a postcode. Those that did not have a postcode extracted were simply missing a postcode from their address. For example, "Perundurai, Erode, Tamil Nadu, India" and "Anusandhan Bhavan, 2 Rafi Marg, New Delhi, Delhi" are addresses that are missing postcode but contain district and state information. For these addresses, we proceeded with district extraction, outlined in the next section.

E.2. District Extraction

Of the 13 percent grantees and 8 percent inventors who did not have a postcode extracted, we attempted to extract district information. First, we took the ADM2 Indian district shapefile as an official list of Indian districts and their associated states. Then, we imported and cleaned the inventor and grantee addresses by removing line breaks and changing the address to lower case. Next, we matched the list of districts to the addresses by searching for the full district name in the string. The district name must be on its own. Then, we re-merged the ADM2 list to obtain the state corresponding to the matching district, if any.

We repeated these steps for the ADM3 Indian subdistrict shapefiles, as we noted some addresses were missing the district but contained the sub division's name. The final dataset coalesces the ADM2-matched district and state with the

ADM3-matched sub-division's corresponding district and state. So, if a district was matched, we used that district and state. Otherwise, we took the ADM3-matched district and state.

F. Identifying Inventor Organizations

Since the inventor address field is free-form texts that do not follow any templates or patterns, we leveraged OpenAI's latest o3 model to extract the most likely organization from each patent inventor's address and return a well-formatted full name of the organization. For cases which did not indicate any organizations, we asked the LLM to return "NA". In addition, if an address did not include specific organization name, we asked the LLM to infer based on its knowledge.

We carried out basic disambiguation to the returned organization names in similar procedures as we did in the grantee disambiguation process, including removing suffixes like "limited", replacing "&" with "and". In the end, we obtained 6,775 unique inventor organizations. We conducted a random check on 100 results and only found one error among them, yielding a success rate of 99 percent.

G. Matching with Prowess

Prowess is the industry-leading firm-level data on firms registered in India. We intended to link patent grantees to this rich dataset to obtain more information on firms.

Since Prowess data only includes commercial firms, we only matched on the set of grantees that are identified as "Business" in Appendix D. We began matching grantee names to Prowess by applying the same systematic cleaning and disambiguation procedures that we had originally used for patent grantees to the Prowess firm names. For any patent grantees who remained unmatched after these steps, we sorted them by their total number of granted patents and manually attempted to locate the best match within Prowess. We manually checked all grantees with more than 10 patents granted by searching through all possible variation of the firm name.

In the end, we were able to match 1,239 firm grantees to the Prowess data, which are granted a total of 29,387 patents, representing 78.5 percent of the total patents.

H. Parsing Complete Specification

"Complete specifications" are the main descriptive body of patents. They usually include the background, summary, and detailed description of the embodiments of the patents.

We initially used the complete specification text gathering from the IP India website. After parsing, we conducted several quality checks. We considered the provided complete specification to be invalid if the value was n/a or if the length of the text was under 1000 characters (most common cases are text stating "the complete specification is attached"). This round of processing generates 249,144 success cases. We also manually checked a random sample of 50 results and all of them were parsed correctly.

In order to resolve the remaining patents, we directly used the attached documents of each patent to parse the complete specifications and claims using OCR package pytesseract (due to cases of non-digitized complete specifications). We also applied the same length and keywords validation as in the first round. This step generates 37,373 success cases. We manually checked a random sample of 50 results and all of them were parsed correctly. For a small number of cases, the complete specification was actually in a file with a wrong name (most commonly, in the "Claims" file), or an unusual name. Therefore, for the remainder of patents, we further expanded our search to all files whose names contained "claim", "form 2", or "desc" for that application. This step generated 3,315 success cases. We also manually checked a random sample of 50 results and all of them were parsed correctly.

In total, we were able to identify 289,832 patents' complete specification information, representing 97.8 percent of all patents.

I. Parsing Backwards Citations

The First Examination Report (FER) of each patent documents the literature that this patent cites, which is issued by the Patent Office after review as it outlines any potential issues or objections regarding the application's patentability based on their initial examination. We read each patent's FER file and parsed information on citations to patent literature. The extraction process relied on Python package regex to identify two specific patterns within the FER files: (1) the marker indicating the start of the patent citation section (2) the publication date format. Cited patent IDs were located between these two patterns. After rounds of experiments, we also included more variants of such patterns in our regular expression matching. We conducted backwards citations extraction on our entire set of patents.

To extract the cited patent ID, we employed several cleaning steps. First, we removed formatting characters like "D1:", "D1-"; second, we extracted the leading two characters of the cited patent ID, which is usually the patent office identifier of the cited patent (e.g., U.S.); third, for the set of patents where the two leading characters were "WO" (international patent office), we tried to match the cited patent ID against U.S. patent IDs to see if there were any potential matches, and for cases where there was a square bracket at the end, we identified that country to be the patent's country of origin; fourth, for the set of Indian patents, we conducted another round of cleaning, including removing suffixes and prefixes, trying to match them to our Indian patent dataset. In the end, we were able to identify patenting country for 99.10 percent cited patents.

As Figure 14 demonstrates, the average citations grouped by application year increased over time, but this is mostly due to the fact that patents in early periods tended not to include patents. We do not observe the number of citations increased over time, if conditional on citing any patents.

We further extracted each cited patent ID and inferred the country of each cited patent. The top three countries of patents that Indian patents cite are U.S. (46.48 percent), China (14.10 percent), and European Patent Office (6.13 percent), whereas the top three countries with non-Indian patents being cited are U.S. (43.79 percent), Japan (12.68 percent), and European Patent Office (9.51 percent). As expected, citations made to patents filed in the Indian patent office are very scarce, though we do see that Indian patents tend to cite more. On average, non-Indian patents cite 0.003 patents filed in the Indian patent office, whereas Indian patents cite 0.048 patents filed in the Indian patent office.

Comments and Discussion*

Chair: Manish Sabharwal
TeamLease and NCAER

Franziska Ohnsorge
World Bank

Contribution of This Paper

The authors compile an extensive database on almost 300,000 utility patents granted by the Indian Patent Office during 2005-2023. Simply by creating this database, and thus unlocking patent data from a major economy that has not yet been covered in the literature, they make an important contribution to the literature. The authors meticulously describe the data collection process and the dataset. Few such comprehensive databases exist for emerging markets other than China. Hence, the database is sure to become a treasure trove of data for future research on innovation.

For the subset of about 25,000 patents that can be matched to company data in the Prowess database and that have Indian inventors or assignees, the authors offer some descriptive statistics. First, these patents grew almost nine-fold between 2005 and 2018; second, firms are the most prominent sources of patents; third, patenting activities are concentrated in a few districts but spread over a diverse range of sectors. Particularly valuable is the comparison of some of these statistics with similar statistics for China and the United States.

The database reflects a monumental data gathering and cleaning effort that will surely become the foundation of interesting future research. Meanwhile, a few more data explanations would be helpful. In addition, some of the authors' comparisons with Chinese and U.S. data point to interesting future research questions.

* To preserve the sense of the discussions at the India Policy Forum, these discussants' comments reflect the views expressed at the IPF and do not necessarily take into account revisions to the conference version of the paper in response to these and other comments in preparing the final, revised version published in this volume. The original conference version of the paper is available on NCAER's website at the link provided at the end of this section.

Additional Data Explanations

First, some of the charts suggest breaks in the data that warrant an explanation to instil trust in data quality. Here are a few examples:

- Why did granting suddenly more than double in 2023 (Figure 2 in the paper)? Because filings increase smoothly over time while awards granted jump in 2023, this trend suggests some sort of administrative backlog in the patent office. More clarity from the authors would be helpful here.

- What happened in 2015? Why did Indian patent awards by one of India's most successful industries, software support, collapse in 2015 (Figure 10 in the paper)? Why did the trend in patents by non-state-owned enterprises taper in 2015 (Figure 2 in the paper)?

- Does the prevalence of academic institutions among patent assignees matter? The authors document that 22.9 percent of Indian patents are granted to universities, compared with 17.6 percent of patents in China and 4.5 percent of patents in the United States. One implication of this difference may be that Indian patents are less readily commercialized than in China and the United States.

In addition, in a couple of areas, the paper's descriptive statistics raise some obvious questions that could probably be answered with the existing data and would help put these statistics into context.

Are Indian Patents by Firms Unusual?

The authors provide descriptive statistics only for about one-quarter of the full dataset: Indian patents by firms that can be matched to the Prowess database. Three-quarters of the patents, which also accounted for three-quarters of the patent growth since 2005, are not discussed. The focus on this narrow subset of the database raises the obvious question as to whether this particular subgroup is unusual. It would be helpful to compare the patterns for the sample used here with the rest of the sample: patents without Indian assignees, patents by academic institutions, or government institutions. If the data can be used to identify patents in the rapidly growing Global Capability Centers (GCCs), a deep dive in their characteristics would be of substantial broad-based interest. Patenting by GCCs is one of their most important roles, but GCCs also help in the commercialization of these patents, according to Bagri, Prakash, Ray, and Khandelwal (Forthcoming), and GCC patenting may, therefore, differ from patenting by other entities.

Do Productive and Strategic Patents Differ in Their Characteristics?

The authors describe only aggregate, regional, sectoral, and grantee trends. They do not distinguish between productive and strategic patents. Abrams, Akcigit, and Grennan (2018) differentiate between strategic patents, which exploit and ringfence existing research and stifle innovation, and productive patents, which expand the field and represent innovation in the traditional sense. They argue that these two types of patents differ in their citations. Strategic patents cite mostly their own predecessors in backward citations, with few forward citations; productive patents have a lot of forward citations. The authors note the unusually low citation counts by, and to, Indian patents, compared with U.S. and Chinese patents. An obvious question is also as to why Indian patents seem so isolated in citation networks. The authors could examine a further subset of their database of those patents that do have higher citations, distinguish between productive and strategic patents, and examine differences in their characteristics.

Suggestions for Future Research

The database will obviously be the foundation of a rich future research program. Here are some questions that readily come to mind:

Are There Spillovers between Indian and Non-Indian Patents?

For example, Branstetter, Glennon, and Jensen (2018) show that multinational corporations start by embedding a foreign inventor, n their case typically a U.S. inventor, in a local team. Over time, this generates knowledge spillovers and the team becomes independent. That analysis is based on U.S. patent data. The authors' database could test this spillover finding, almost in a mirror exercise, for patents filed in India. This could either confirm the results of Branstetter, Glennon, and Jensen (2018) in the Indian data or there may be something specific to U.S. patent data that cannot be traced back to Indian patent data.

Are There Differences in the Quality of Different Types of Patents?

Cockburn and Griliches (1987) argued that high-quality patents will raise stock market valuations upon approval. A firm has a certain stock of knowledge, including patents. When a new patent is approved, the firm's stock of knowledge increases. If this knowledge offers a future profit opportunity, the firm's stock market valuation should go up. This database would allow the authors to test whether a patent granted in India has the same stock market response here as elsewhere, for example in the U.S. or China.

Are There Differences in Economic Activity between Patenting and Non-Patenting Firms?

The presumption is that patents increase firm productivity, but whether this presumption is true in the data could be tested since the Prowess database also includes non-patenting firms. The authors could compare different types of firms' economic activity—productivity, exporting, foreign direct investment, employment—across patenting and non-patenting firms. The productivity impact of patents may materialize only gradually, and the speed of the impact could be compared against that in other countries. For example, Bloom and van Reenen (2002) have found that patents significantly increase firm productivity in the U.K., but with a delay.

Does Patenting Capture Innovation?

In a review of the historical evidence for 200 years of innovation, Moser (2016) shows that a lot of innovation happened outside the patent system. The authors could complement their database with other ways of measuring innovation—for example, the speed of production or some existing measure of patents in India—and test the correlation between this alternative measure and patenting (as a validation exercise) or compare the impact of either measure on firm productivity.

I am looking forward to reading the subsequent research based on this database.

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First, I want to commend the authors on the fantastic paper that is extremely timely. I think this is going to kickstart a lot of conversations, a lot of research, on a lot of the drivers and the consequences, and specifically on the causes of innovation and growth in India. So, I will be summarizing some of the results from the paper, but also discussing a little bit of the future work that can take place while building on the data set that they have so amazingly collected.

Before I actually do that, I wanted to talk about what the paper does. It collects data on all patents granted in India, from 2005 to 2022, and then it discusses seven stylized facts. But I think the most amazing part of the paper was the work that was undertaken in collecting this data. The authors highlight the work that goes into collecting the data set. For example, they start by first scraping the patent data from IP India for around 300,000 patents from 2005 to 2022. Then the next step is disambiguation and identification of grantees, and this is done through keyword matching algorithms. Next, they need to look at the spatial distribution of these innovators, and to collect the geolocation information, which they do through natural language processing. Next, they identify when organizations use large language models. Then they link back to Prowess to understand the financial implications of this innovation.

Since some of this data is in PDF, the authors extract this textual information using optical character recognition. And finally, in order to understand the quality of the patent, they parse the backward citations using the first examination reports through regular expression matching. So, if there is an ML tool that exists on this planet, they have used it in the paper. They show a rapid growth in patenting, and that the number of patents increased from 5,000 in 2005 to 25,000 in 2018. The proportion of Indian patents also went up from 800 to around 7,000 between 2005 and 2018. Therefore, the question that comes to my mind is: What has been the impact of this increased patenting activity on economic growth? And it is important to understand what is driving this growth. The paper does talk about new factors, the internal and the external ones, the internal being the increased R&D by domestic firms and the external being the capital inflows. I think it is important to disentangle what these two different effects could be. In terms of future work, there is an interesting paper by researchers from Ahmedabad University that looks at the role of tax credits. The paper looks at the R&D expenditure, trying to understand the problem of tax credits, which have gone from, say 100 percent to 125 percent to 250 percent. There has been a staggered rollout in terms of which industries get these tax credits, you can actually look at what has been the impact of tax credits on innovation.

Aghion, Benabou, Martin, and Roulet (2023) and a lot of other people have actually worked on the role of market competition. Now that India is opening up to foreign competition, to foreign players, what is the impact of market competition on innovation? The next issue is trade openness. In the context of protectionist policies in certain sectors, do they prevent innovation in those sectors? Mergers and Acquisitions (M&As) in India have actually gone up over the last 20 years, but on a 7.5 percent compounded annual low rate. An interesting paper by Cunningham (2021) asks: Do M&As basically lead to more economies of scale, which should drive innovation? Another idea pertains to something called killer acquisition. So, I basically acquire something that I know is going to outcompete me in the market later on. This idea about how M&As can actually go both ways is interesting to study.

Finally, let us come to Operation Sindoor. I was in the U.S. at the time and tried to understand how these geopolitical crises can actually lead to innovation. The Indian Government is talking about building a jet engine, they are talking about increased defense spending, about how rare earth minerals can be extracted because of the ongoing Trump trade war. All of this can now be done using the available data sets.

Next, I continue with the rapid growth in patenting. Like Franziska was saying, I was also surprised by the increased granting of patents in 2020. These were the applications, but if you could superimpose this with the policy changes during that particular year, you may be able to shed light on the spikes and why they happened in 2019 and 2023.

I really like the bell-shaped curve showing how the time taken to award these patents has changed over time. And the median seems to be somewhere in between, it is greater than almost five years. So, what has been the role of reputation? Is it different by sector? Is it different by who is applying for this patent? And also, what is causing this shape? First down, then it goes up, then it comes back again. So, trying to understand what is actually causing this would be interesting. And also, is India an outlier in the time taken or other developing countries and developed countries? Trying to understand that would also be pretty good.

The second fact that they talk about is private sector domination. Of the top 20 patent grantees, 13 are private firms, 6 are academic institutions, and the only place where there is a government organization is the Defence Research and Development Organisation (DRDO). The paper then talks about market competition and the role it has an innovation. I think it would be interesting to try to understand how this compares with other developing countries.

The paper also shows an increasing gap between private and state-owned enterprises. Given the fact that state-owned enterprises have been a huge part of China's growth story, I think it would be interesting to examine if this pattern still holds in China. And if it does, it would actually shed light on two different forms of growth or two contrasting forms of growth, one that is state-owned enterprises-led and the other that is private sector-led. Another paper presented at this Conference has been on what the optimal IPPR protection policy should be. Who should be given this protection? And what should be a uniform IPR protection policy? Or should it be the case that the most technologically advanced firms should be given protection? The answer in that paper was that the most technologically advanced firms ought to be given protection because of the trickle-down effect.

There is something called 'spatial concentration', and I think it is really important to understand what is causing this concentration of patenting activities and agglomeration economies. It is an industrial cluster. Ufuk Akcigit spoke about higher education policy in his lecture yesterday. I think that would be an important factor to look at, especially the fact about persistence and path dependence. I am trying to understand if this is some accident of history. Perhaps a particular success story could be driving this. There is also a diverse sectoral spread in the paper, which looks at software and pharmaceuticals, among other things. An interesting point here, which is again based on the paper by Acemoglu, Ufuk, and Kerr (2016), was the question: Do innovation advances in one sector actually significantly impact other nearby disciplines? For example, telecommunication growth has been more recent but software growth has been going on for a long time. Given that some of these patents could be used in either sector, is it a fact that software growth actually helps the telecommunication patenting as well? Is this increasing collaboration driven by new sectors? Are more complex innovation processes requiring increased collaboration, or is this driven by new sectors, or is this driven by within sectors which then basically requires more collaboration? The only other question here is: Is this also driven by, for example, infrastructure and human capital constraints, where you do not have all the expertise under one roof, so you need to basically collaborate. That could be another factor that the authors could possibly look at it.

There has been a lot of talk about the role of Artificial Intelligence (AI), and I think it should be interesting to study the role of AI in driving innovation and economic growth. How has AI affected innovation? Who does it end up making the most efficient? Is it the superstar or productive innovators or is it also innovators that are at the lower end of the spectrum? Since I work mostly on climate change adaptation, I think it would be amazing to look at how innovation is responding to climate change. A paper by Long and Wang (2025) actually looks at how there has been an increase in climate mitigation patents and climate adaptation patents because of exposure to heat shocks. So how has this affected resilience? And is this directed innovation just for emerging market economies or can it actually be used? So basically, is the technological bias towards India or are other emerging market economies also going to benefit from this movement towards innovation and climate change?

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General Discussion

Swaminathan Aiyar flagged the issue of the role of Global Capability Centers (GCCs), suggesting that a GCC is a black box because it does not have separate accounts, and one cannot pin down anything on it. At the same time, according to various estimates, up to 2,000 multinational corporations (MNCs) are engaged in similar work. Latest research shows that 56 percent of the work of GCCs pertains to high-level R&D. For instance, General Electric is designing new turbine fans in India; and AI and robotics are also being pursued by Google and Meta Platforms Inc., among others, here. He raised the following questions: Do we know how many of their inventions are ascribed to India? Do we have the appropriate figures with regard to their India operations? Are Indian companies, which are hiring people from the GCCs, able to gain the benefits of the GCCs upskilling? And to what extent is that as good or better than merely getting a patent?

Rana Hasan alluded to the India-China comparison in the paper, and said that the conspicuous dip in the case of patents for motor vehicles in India was a notable finding. It would be worthwhile to assess if such dips are also seen in other countries, especially China. His second point concerned the Council of Scientific and Industrial Research (CSIR), wherein the review committee appointed by the Indian Government in 1986 and led by bureaucrat Abid Hussain, had heavily criticized the CSIR for deviating from its original goals, lacking direction, and failing to deliver indigenous technologies. In this context, he urged the authors to analyze the returns on investments (RoIs) for CSIR for private sector entities and even the Indian Institutes of Technology (IITs). Further, it would be interesting to compare the corresponding RoIs for universities versus CSIR laboratories.

Mausumi Das noted that the growth literature suggests that developing economies are probably better off imitating rather than innovating new products. She asked the authors that to the extent that patents are related to innovation and the frontier of knowledge, would their dataset be able to address this question, going forward? What is an optimal policy in that sense? She wanted to know if the authors were only focusing on innovation and patents, or if they were also considering examining firms that are imitating and bringing foreign knowledge or technology from elsewhere, and the relative benefits of such imitation.

Sadanand Dhume raised two questions. First, apropos the comparisons of Indian patents with those in the U.S. and China, he wondered if the authors had a sense of how India stacks up as compared to different countries, say Japan, Korea, and other Asian nations. Second, would an Indian scientist working on patents on chip design in a GCC in, say Bengaluru, also be captured in the authors' data?

Manish Sabharwal asserted the importance of patents for the Indian pharmaceuticals industry, especially the 35-year window from 1970 to 2005, which had a huge impact on developments in the genetics industry. He also flagged the issue of adjacency learning, whereby generics led to speciality generics, with the latter now leading to New Chemical Entity (NCE). So, how far back can the development be said to be original, and in this context, what should be protected through a patent?

Amartya Lahiri stated that both product patents and process patents are reportedly being granted in India. He wondered if this necessitated an analysis of the patenting patterns, and determining whether we are finding new things or trying to figure out new ways of doing things that we already know. This again speaks to the issue of innovation versus imitation. He advised the authors to utilize their comprehensive dataset to analyse what the Indian patenting space is really trying to achieve.

Karthik Muralidharan suggested that the measurement question could be addressed by studying the global patent filing patterns of 5-10 international companies with a large presence in India, and whether they mention the names and locations of the innovators associated with the particular patent. The authors could integrate this methodology in their study to arrive at more intuitive results. He also maintained that even if the innovations are happening in India, but the filing and documentation are being done in the U.S. because of the latter's market size, it would still be of value to India, at least from the point of view of scientific quantification and innovations achieved by the manpower based in India.

Ratna Sahay posed a question about the timing of patents and patenting practices across countries. She also noted that the culture of patenting is more prevalent in the developed countries in the West than in the developing countries. This could be one reason why there may be more innovation, but there are fewer patents in developing countries versus their developed counterparts. She also opined that an increase in the practice of patenting would motivate more people to seek patents for their innovations, especially if they find that patenting helps them to better safeguard their innovations.

Pravin Krishna wanted to know if it were possible to track information pertaining to royalties on patents. He also asserted that in view of the high concentration of patents and government entities in the Indian system, it may be prudent to locate where these patents are being documented and thereafter assess the value of each patented invention.

Saurabh Sahni commended the authors for compiling a formidable dataset. He also asked if they had looked at the data sectorally, as apart from the agricultural sector, a notable source of R&D is in the defense sector, especially since many of the innovations currently in civilian use, such as the Internet and GPS, were originally developed for defense purposes. He wondered about the status of defense R&D in India, especially in the context of Operation Sindoor, and whether the new defense technology in the country has been borrowed or indigenously developed.

Auguste Kouame revealed that one of the recent World Development Indicators (WDI) databases of the World Bank incorporated the following three I's representing the three different stages of using technology: imitation, infusion, and innovation. He suggested that India, having passed the stage of imitation, was perhaps in the stage of infusion, which entails much more than imitation, but understanding the technology that one needs to borrow, and then adapting and even improving it to cater to the needs of the process for which it is to be used. For future work on patents in India, it is important to distinguish between innovation and infusion, where the latter matters more for development than either imitation or pure innovation. An analysis of the growth in patents in India shows that maybe these patents are not for pure innovation, but are meant for adapting and fine-tuning the existing technologies or technologies that have been brought in decades earlier to current and future needs of various sectors in the country.

Kouame's second suggestion for future work was to extend the geolocation concept to not only determine where the inventors are located or registered but also identify the areas where the innovation is being used for both production and consumption. This would reveal a greater connection with development because the innovation may be taking place in GCCs in Bengaluru, or maybe in the U.S., or maybe where the patents are registered. Thus, even if the innovations are happening from one geography, the actual use of the technology for production may be happening somewhere else. For instance, more Apple phones are being produced in China but the patent is registered in the U.S. Most of the phones produced in China are probably not used in developing countries but used more in developed countries. The beneficiaries of the output may, therefore, be in countries that are not growing much from that technology because it is not creating jobs or value there. Hence, assessing the geography where the innovation is being developed, and used for production or consumption may give a sense of how it is contributing to development in a particular country, which would, in turn, provide interesting ideas on the linkage with development.

Pallavi Choudhuri asked the authors if they had data on design patterns versus patterns that are led by innovation, and how that compared across patents in India versus China versus the U.S. Since design patterns signify just tinkering with the existing technology, it does not really drive innovation, which may explain the slow growth in innovation or R&D. She also queried about patents related to joint ventures such as recent reports of DRDO joining hands with IIT Delhi for a project on quantum entanglement, or innovation in the defense sector with regard to the Akash missile, which is India's first indigenously produced medium-range, surface-to-air missile system, designed by DRDO and manufactured by Bharat Dynamics Limited (BDL). Data on such developments would give a flavor of how indigenous technology is combined with the drivers of innovation in India.

Vivek Johri inquired as to how many of the patents were getting commercialized, and how such commercialization in India would compare to corresponding international trends. Such an analysis is critical for converting patents into economic benefit. Additionally, it may be relevant to procure the names and countries of birth of the inventors, which would facilitate a documentation of the innovations developed by the Indian diaspora.

Franziska Ohnsorge proposed that it would be interesting to understand the purpose of the patent, and the kind of activity that is really driving patenting and stimulating the biggest pull for patents. For example, are the highest number of patents being sought for export markets?

In her response to the various questions and suggestions offered by the audience, the author Namrata Kala said that in the paper, she and her co-authors had focused on Indian patents, signifying patents for an innovation developed by an inventor, that is, an individual or an organization, headquartered in or based out of an address in India. Thus, when Microsoft, for instance, comes with an old patent that it wants to bind in India, it should be citing that original patent, which will provide a lot of information on the person and the patent itself that can be used to disentangle new versus a market size kind of old innovation.

On the issue of private versus social returns, she said that the CSIR laboratories may be generating a lot of social returns, which did not show up in a normal stock market return, but which can be accessed by looking at the sectors in which they are patenting and how those patents spill over into the private sector. However, since information on patents does not show up in private sector data, it is hard to assess profitability. Essentially, therefore, this data could be good for tracking patents over years, rather than in the short term. Regarding the issue of people filing a patent from outside, Kala said that in some sense, that is both a market-size as well as an inventor question.

Commenting on the Chinese patent regime, Kala noted that it was vastly different from its Indian counterpart in terms of its scale. The Chinese patent dataset that was being used by the authors partially to train some of the novelty measures in machine learning for the Indian dataset, has 16 million patents relative to the Indian dataset of 300,000, or 400,000 if we go back to the 1970s. Chinese firms have largely learnt about new technologies through joint ventures, which signify a convergence of products, technologies, and practices, making the sheer scale of Chinese patenting really high. Joint ventures have also been successfully used by Chinese innovators as a set of tools to rapidly disseminate technology in real time.

On the question of comprehensive information about the inventor, she said that while the name is available, the place of birth of the inventor is not mentioned in the patent applications. However, it may be possible to source information on networks by gender, and private sector-academia and academia-academia collaborations. A long-standing problem in the innovation literature is that of trying to identify the social returns of patenting. These could possibly show up in scientists' outcomes, among other things. But that necessitates taking a stand on the boundary of the social returns. She also appreciated the suggestion on commercialization of patents, which could be coupled with the use of the Prowess database, created and maintained by the Centre for Monitoring Indian Economy (CMIE), which is considered to be one of the largest and most comprehensive corporate intelligence and financial performance databases for Indian companies.

All presentations for this IPF session can be accessed by scanning this QR code or going to: https://ncaer.org/event/india-policy-forum-2025/