# India and China: their role in the global R&D economy

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## Extended abstract:

The dramatic increase in patenting by Indian and Chinese firms has received considerable attention in recent policy papers and scholarly work. Policy attention has focussed on the question of whether this increased patenting, especially in international patent bodies like the USPTO indicates the emergence of new technology powers and if these are likely to threaten the technological positions of OECD economies (see for example OECD 2007, Economist 2007). The evidence reported appears reassuring in the sense that in most cases only a fraction of the economic activity in these economies and is often dominated by foreign firms in particular sectors.

However, in a global economy, focussing on issues of national technological competitiveness is only a starting point. In business, ultimately companies compete, not countries. The far more important question is what companies do, and how they utilise the global technology hotspots (small and large) to forge new competitive positions for themselves. As important is the question of whether domestic companies and public sector research institutions from India and China are harnessing local technological strengths and skills to generate patents that may be of a high enough quality to license to other firms or embody in new products to sell to the rest of the world. It is questions like these that encouraged us to focus our attention on the quality of patenting from Indian and China and describe the characteristics of such patents.

Since the acceptance of TRIPS and changes to their own patent laws, both India and China have seen a rapid growth of domestic patenting (references). To some extent these increases reflect the incentives to domestic and foreign firms provided by tighter IPR regimes. However, a subset of domestic patents is also patented in other countries and with organisations such as the USPTO and the WIPO. It is reasonable to assume that these patents in third countries represent patents of a better quality that may be utilised globally by both domestic and foreign firms.

Furthermore, there are problems with both India and China's domestic patent systems especially for foreign firms. The following statement made by a R&D manger of Eli Lilly sums up the problems for foreign firms 'Chinese patents are easy to get but unenforceable, while in India, you cannot get a patent, so there is nothing to enforce". [1] Of all the patent organisations the USPTO has the most stringent enforcement of patents and the US is the largest market for technology, making it more likely that the more valuable patents (from a company perspective), domestic or foreign, will probably be registered there. Figure 1a-c show Chinese and Indian patents grated at the UPSTO by application year - there is a rising trend for both countries though Chinese firms have been increasing their stock of USPTO patents more rapidly since 1985 when compared with Indian firms.

Thus, we focus our attention on patents in the USPTO where any one of the inventors is located in India or China. A popular convention in patent data analysis

[1] Soonhee Jang of Eli Lilly as cited by Pafumi (2007), Growth of China, India means challenges, opportunity for global Innovation, Federal Laboratory Consortium for Technology Transfer.

is to identify national patents on the basis of the location of the first inventor but this ignores the potential effects of global collaboration - an increasing trend in company R&D facilitated by recent advances in communications technology. We extracted data from the USPTO based on the criteria of any inventor being Indian or Chinese on June 1 2007, and this yielded information on 4332 Indian and 7661 Chinese patents.

Using this data, we aim to describe the following trends in Indian and Chinese patenting:

- Changes in the sector composition of patents overtime
- Changes in the composition of patenting activity, by type of patenting organisation ( viz. domestic firms, public sector organisations, foreign firms, universities, individuals)
- Changes in the regional concentration of patenting
- Changes in the incidence of global collaboration in patenting

A description of these trends also allows us to analyse the important differences if any in the innovative capacity of India and China. Following this, we use a multivariate analysis to analyse the characteristics of high impact patents (impact measured by the forward citations received by a patent) in India and China. A particular interest is in establishing the different influence of global collaboration and global investment in generating high impact patents.

At the moment of writing this abstract we are mainly able to report on findings from a very preliminary analysis of the Indian patent data - work on the Chinese data is in progress. However, we expect to complete analysis of the data by end of February.

**Some preliminary findings:**

Preliminary findings are summarised in Table 1 below. Although we started with a total of 4332 patents, only 3567 of them could be matched to technology classes and other data. Analysis of these indicate that a small number of technological classes account for a majority of Indian patents - thus for example over half of all Indian patents belong to just the four technology classes of organic chemistry, information technology, pharmaceuticals and telecommunication.

Sectors differed in terms of the extent to which they showed the incidence of global collaborations measured as the share of India-located inventors to all inventors on the patent. The lower the value of this ratio, the larger is the share of foreign inventors and so higher is the level of global collaboration. At 100% this ratio reveals that all inventors were India-located. Sectors such as Semiconductors and Optics reveal a high level of foreign collaboration whilst agriculture and food processing show the dominance of indigenous teams.

We distinguished between the different kinds of assignees based on web-searches. Over half of all patents were assigned to foreign firms, though very few patents came from the subsidiaries of foreign firms located in India. This finding is also reinforced by looking at the proportion of Indian inventors in each technology class. Sectors where foreign firms dominate are also sectors where global collaborations are higher and proportion of Indian inventors smaller. The technology classes where India firms dominated in patenting were mostly chemistry centred while these classes were not the ones where foreign firms played a major role.

Turning our attention next to the quality of patenting we see that average number of forward citations per patent in each technology class is rather small.  The exceptions are technology classes where there are a small number of patents (e.g. materials processing, medical technology optics).  At the same time the number of backward citations is high suggesting that Indian patents are drawing more on patented knowledge in the world economy than the contributions they have made to this stock of knowledge.

We also performed some preliminary regressions (not reported here) to determine the characteristics of patents ( type of assignee, issue year, foreign priority patent or not and global collaboration) which characterised the high impact patents (as measured by the number of citations to an individual patent). A robust result in the pooled regressions was that patents that were patented elsewhere and the share of Indian inventors were both negatively significant in explaining impact.  The inference we draw from this is that global collaboration and patenting in the US first are both predictors of higher citations.  There was no impact of any of the ownership variables- suggesting the type of assignee did not matter.  This suggests that high impact patents are based on global collaboration rather than foreign R&D subsidiaries in the Indian case.  When we un-pooled the data and conducted individual estimations for the largest technology classes we found that global collaboration was a factor predicting citations in the Pharma sector but not in the sectors of IT and telecommunications where foreign firms are dominant.

**Future work**

The next steps in our analysis will conduct the same exercise for Chinese firms with a view to describing the broad characteristics of Chinese patents and understanding the characteristics of Chinese patents that have a high impact.  In further refinements of this analysis we will control for other factors such as location of inventors and the time period of significant IPR reforms.

## Figure 1: Patent applications over time

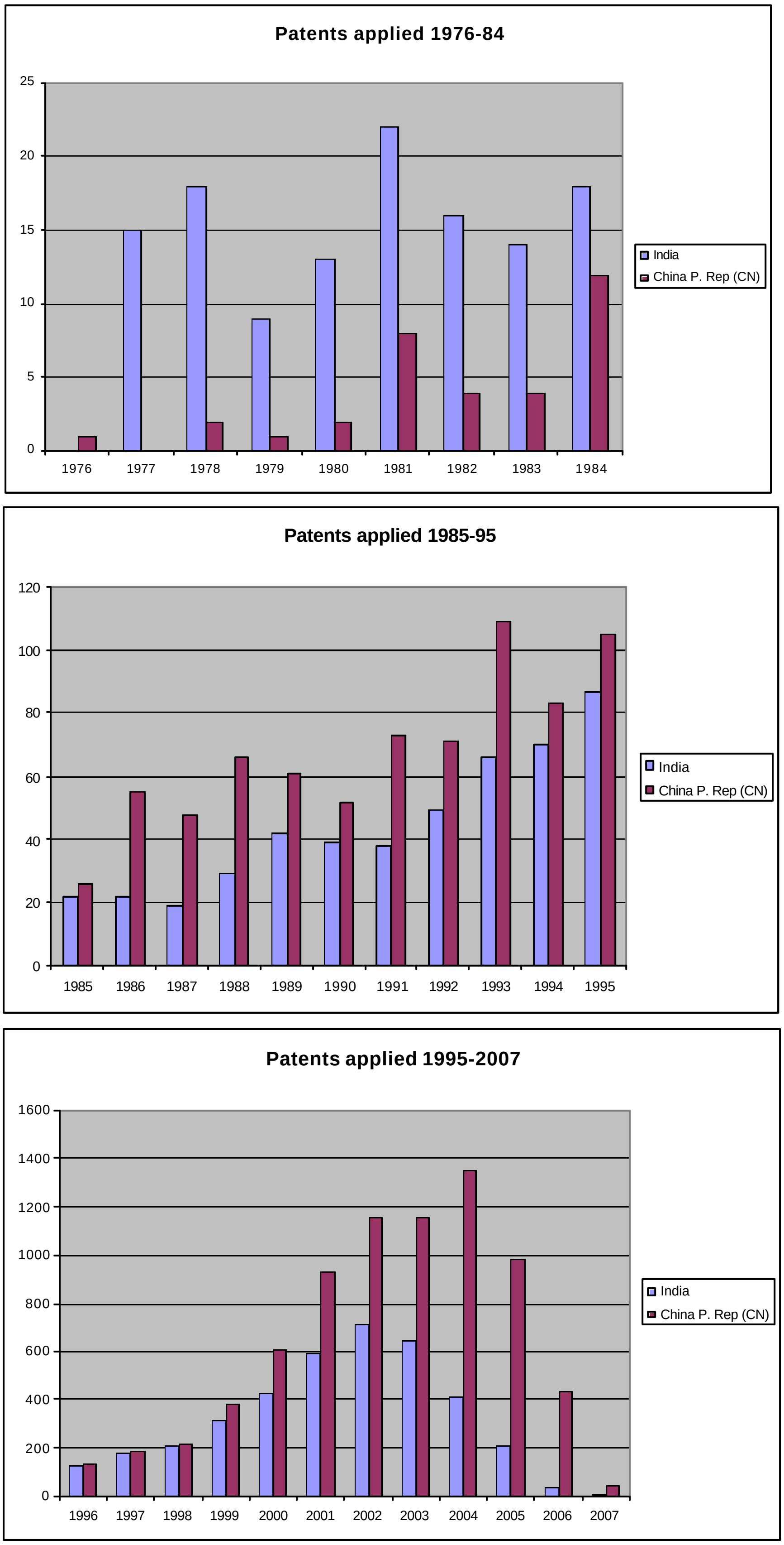

**Table 1: Preliminary analysis of Indian patent data**

| | | Patent share | Global collaboration | Avg. forward citations | Avg. backward citations | Patent share by type of assignee (% of patents in the class) Total patents for which assignee type could be identified= 3569 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sub-classification** | **Number** | **%of all patents** | **share of Indian inventors** | **Number per patent** | **Number per patent** | **Indian Firms** | **Indian Research institutes** | **Indian universities** | **Subsidiaries of foreign firms located in India** | **Foreign firms** | **Foreign research institutes** | **foreign universities** | **Individual assignees** |
| Agriculture, food chemistry | 105 | 2.42% | 92.6% | 1.4 | 3.7 | 5.7 | 66.7 | 1.0 | 0.0 | 13.3 | 0.0 | 0.0 | 13.3 |
| Audio visual Technology | 77 | 1.78% | 68.6% | 4.4 | 21.1 | 2.6 | 1.3 | 0.0 | 3.9 | 90.8 | 0.0 | 0.0 | 1.3 |
| Biotechnology | 185 | 4.27% | 82.8% | 0.6 | 2.5 | 4.9 | 56.8 | 1.6 | 0.5 | 18.4 | 2.2 | 7.6 | 8.1 |
| Chemical and petrol industry | 211 | 4.87% | 87.6% | 2.4 | 7.2 | 17.2 | 39.2 | 12.0 | 0.5 | 24.9 | 1.4 | 1.0 | 3.8 |
| Chemical engineering | 133 | 3.07% | 86.8% | 3.1 | 10.4 | 15.0 | 56.4 | 0.8 | 0.0 | 12.8 | 3.8 | 1.5 | 9.8 |
| Control Technology | 111 | 2.56% | 71.4% | 7.2 | 15.2 | 0.9 | 28.8 | 0.9 | 3.6 | 45.9 | 6.3 | 4.5 | 9.0 |
| Electrical machinery | 99 | 2.29% | 67.0% | 5.5 | 28.0 | 2.0 | 1.0 | 0.0 | 1.0 | 89.9 | 0.0 | 2.0 | 4.0 |
| Information Technology | 684 | 15.80% | 67.5% | 3.3 | 12.8 | 3.2 | 1.0 | 0.3 | 2.8 | 89.9 | 0.0 | 1.0 | 1.8 |
| MACROMOLECULAR Chemistry, Polymers | 153 | 3.53% | 71.2% | 2.1 | 10.5 | 7.5 | 33.3 | 0.6 | 0.6 | 42.1 | 8.2 | 1.9 | 5.7 |
| Materials processing | 12 | 0.28% | 79.0% | 36.4 | 49.8 | 8.3 | 8.3 | 0.0 | 0.0 | 33.3 | 0.0 | 0.0 | 50.0 |
| Medical Technology | 48 | 1.11% | 69.2% | 18.8 | 18.4 | 8.3 | 8.3 | 0.0 | 0.0 | 62.5 | 0.0 | 6.3 | 14.6 |
| Metallurgy | 77 | 1.78% | 86.4% | 4.3 | 8.1 | 7.8 | 58.4 | 0.0 | 0.0 | 13.0 | 2.6 | 3.9 | 14.3 |
| Optics | 11 | 0.25% | 58.9% | 19.1 | 33.5 | 27.3 | 9.1 | 0.0 | 0.0 | 54.5 | 0.0 | 9.1 | 0.0 |
| Organic Chemistry | 844 | 19.49% | 87.4% | 1.9 | 5.4 | 28.6 | 41.1 | 0.5 | 0.0 | 20.5 | 2.7 | 3.4 | 3.2 |
| Pharmaceuticals, cosmetics | 378 | 8.73% | 85.7% | 1.9 | 7.4 | 33.3 | 30.2 | 1.3 | 0.3 | 24.6 | 1.3 | 3.2 | 5.8 |
| SEMICONDUCTOR DEVICES | 49 | 1.13% | 54.5% | 8.0 | 9.9 | 0.0 | 10.2 | 0.0 | 4.1 | 65.3 | 8.2 | 10.2 | 2.0 |
| Surface Technology | 14 | 0.32% | 63.8% | 13.5 | 28.9 | 0.0 | 7.1 | 0.0 | 0.0 | 64.3 | 14.3 | 0.0 | 14.3 |
| Telecommunications | 376 | 8.68% | 73.3% | 4.4 | 11.0 | 2.1 | 1.1 | 0.3 | 10.9 | 84.3 | 0.0 | 0.0 | 1.4 |
| TOTAL | 4330 | 100.00% | | | | **14.5** | **24.9** | **1.2** | **2.2** | **48.7** | **1.9** | **2.2** | **4.3** |

Notes: (i) classification of assignees. Indian firms refers to corporate entities head-quartered in India; Indian Research Institutes refer to government funded laboratory networks such as the CSIR; Foreign firms refer to corporate entities not head-quartered in India, while foreign research institutes refer to laboratory networks (such as the NIH) located outside India. The category of Individual assignees lumps together individual assignees in India and outside. Other categories are self evident.