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31 May 2012

Online at https://mpra.ub.uni-muenchen.de/39284/
MPRA Paper No. 39284, posted 06 Jun 2012 16:29 UTC

A framework for assessing innovation collaboration partners and its application to India

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Abstract

We develop a framework for assessing innovation collaboration partners. Based on the evidence from existing empirical studies, we identify four elements relevant as drivers of innovation collaboration. These elements include inventive capacity, technological specialization patterns, openness to international innovation collaboration and economic potential of technology. In order to make the framework operational, we propose a set of patent-based indicators that capture the relevant elements. In a second step, we apply the framework to analyse the attractiveness of India as a partner for innovation collaboration. Except for mapping India's technological specialization patterns evolution, we show that it is a country very open to international collaboration. Moreover, as a lion's share of India's inventions is patented outside of the country, it can be expected that the technology developed in India has supranational commercial potential.

Keywords: collaborative innovation, science and technology collaboration, globalisation of technology, patent analysis, India
JEL classification: D8, F23, O14, O30, O57

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1 Introduction

Innovation collaboration is becoming an important model of the innovation process (De Prato & Nepelski, 2012; Narula & Hagedoorn, 1999). Whenever there is a research problem that spans the globe, such as global climate change or infectious disease control, there is motivation from different countries to join forces and to work towards a common goal. The development of cross-border innovation collaboration is additionally driven by corporations that seek knowledge sources and opportunities worldwide (Archibugi & Iammarino, 2002; Bartlett & Ghoshal, 1990; Doz, Santos, & Williamson, 2001; Dunning, 1988, 1994; Grevesen & Damanpour, 2007). Thus, whether motivated by synergy effects, access to specific resources or a panacea to skill shortages, indicators show that the amount of collaborative research is rising rapidly (De Prato, Nepelski, & Stancik, 2011; UNESCO, 2010). One of the important changes is the entry of new countries that are becoming both important players in the field of knowledge and technology development and potential partners for innovation collaboration. In this framework, that of how to select an innovation collaboration partner is becoming a more and more relevant issue, in a twofold perspective: that of searching the most appropriate collaboration partner, and that of the appreciation of the possible benefits of collaboration. However, despite the relevance of this issue, there is no methodology that would help either policy makers or business executives to address these questions.

In this paper, we develop a methodological framework to *ex ante* assess innovation collaboration partners and propose patent-based indicators in order to analyze specific cases. The assessment framework helps to profile potential innovation partners in the following steps: measuring their inventive performance, mapping the technology specialization patterns, assessing their openness to innovation collaboration with foreign partners and, finally, the economic potential of technology developed by an assessed country. The application of this framework is meant to provide help to policy makers who design science and technology collaboration programmes as well as companies that look for suitable partners for technological joint-ventures. By making an *ex ante* evaluation of collaboration benefits, they benefit from improved definition of collaboration needs and selection of suitable partners with relevant capabilities. In order to test this methodology, we apply it to study the case of India.

In order to provide a set of indicators that capture the concepts used in the assessment framework, we use patent data. Even though a number of shortcomings of patent data as a proxy of innovation or technological progress have been pointed out by the literature (de Rassenfosse, Dernis, Guellec, Picci, & van Pottelsberghe de la Potterie, 2011; Turlea et al., 2011), this source of data is still considered as one of the best measure of inventing capability and considered to be an important method of assessing various aspects of technological change (Griliches, 1990). Consequently, a large body of literature uses patent statistics as tool for studying issue of the research and innovation process (Bosworth, 1984; De Prato & Nepelski, 2012; Smith, 2005). Moreover, this type of information is also used by firms to assess the level of technology development in a particular sector or a firm (Archibugi & Planta, 1996; Patel & Pavitt, 1997). Patent statistics are also used to analyse the strengths and weaknesses of competitors (Narin, Noma, & Perry, 1987), which resembles the use of this source of information for the purpose of the current study.

Regarding the choice of a country of analysis, it was motivated by the fact that India belongs to the group of the most expanding economies at present and, what is more interesting, also destination of R&D-related investments by foreign companies and countries (De Prato et al., 2011). Despite a large amount of attention India receives (Abraham & Moitra, 2001; Simon, 2011), to our best knowledge, there has been no attempt to assess the prowess of this country as a innovation collaboration partner.

So far, not much attention has been devoted to the issue of *ex ante* comprehensive assessment of countries' innovation collaboration potential. It is mostly business literature that tackles the question of how to select an innovation collaboration partner and what is the benefit of such collaboration. For example, examinations of the impacts of technological life-cycle and competencies on a successful joint-venture confirm that these are crucial factors that determine the final outcome of a joint undertaking (Chen, Farris, & Chen, 2011; Santamaria & Surroca, 2011). A country level perspective of how to find a perfect match for joint collaboration seems to be missing in the discussion. At best, studies of individual emerging countries exist, e.g. India or China (Abraham & Moitra, 2001; Liu & White, 2001), which usually focus only on the innovation performance measured by, for example, the number of patents, publications or R&D expenditures. A notable exception is a study proposing a framework for exploring pathways to innovation in Asia (Ernst, 2005). However, by focusing on a single industry and the diversity of specific country trajectories, its application is rather limited.

All in all, the lack of a comprehensive analysis of how to assess an innovation partner is quite surprising, as the number of potential innovation partners is increasing with the growing importance of Asia and other developing countries, on the one hand, and as the right match between innovation collaboration partners have a strong impact on the innovation performance, on the other hand. Hence, our contribution is to provide a framework that can be applied to assess an innovation collaboration partner, independently of industry or origin. Moreover, due to the fact that the set of provided indicators is also independent of a particular context and is publicly available, the framework is very flexible in its application.

The remaining of the paper proceeds as follows: Section 2 describes the innovation collaboration assessment framework and proposes patent-based indicators. Section 3 introduces the data and measures used in the study. Section 4 applies the assessment framework to India. Section 5 concludes.

2 A framework for assessing innovation collaboration partners

The main objective of this paper is to develop a methodology of innovation collaboration partner assessment and to apply it to India. To this aim, we introduce some concepts that are relevant for innovation collaboration and a set of indicators that describe and assess a country's capacity and attractiveness as a partner for innovation collaboration. In conceptual terms, this framework includes four main aspects: First, the *inventive performance* is taken into account to allow for quantification of the inventive mass and dynamics of a country’s inventive performance. Second, in order to reveal a country's innovation capacities and profile, we consider its *technological specialization* patterns. Third, we consider a country's *openness to international innovation collaboration*. Lastly, we include in our framework an aspect that focuses on the *economic potential of technology* produced by a country. Each step makes use of indicators derived from the information included in patent applications. Below, we describe each step of assessing a country's attractiveness as a partner for innovation collaboration in detail. Table 1 summarises the assessment framework together with relevant indicators.

Inventive performance

What is the inventive mass and dynamics of a country’s inventive performance? In the context of the current study to understand better the inventive capacity of a country as a producer of knowledge and technology allows us to assess its potential attractiveness as an innovation collaboration partner. The motivation to introduce the inventive performance measure in our methodological framework is motivated by the fact that it has been found an important factor stimulating and attracting innovation collaboration (De Prato & Nepelski, 2012). Expecting that not only distance hiders and economic factors facilitate international innovation collaborations (Picci, 2010), a country's inventive performance indicates the inventive capacity which might attract innovation collaboration partners.

Measuring innovation performance is, however, far from being straightforward. Thus, despite their limitations, we use patent-based measures of innovation performance (OECD, 2008). Patent data provide increasingly detailed and wide information on the expected results of research and development efforts and of inventive activity in general. Moreover, the type of information they provide is seen as 'objective', and it offers quantitative results that can be effectively combined with other indicators for cross-validation.

In practical terms, we capture innovation performance of a country by the total number of patent applications of a country. This measure is computed through fractional counting of inventors residing in that country independently of the patent office to which application was submitted.

Technological specialization patterns

One of the drivers behind the emergence of international innovation collaboration is the access to complementary resources and assets (Archibugi & Iammarino, 2002; Dunning, 1988, 1994; Sachwald, 2008). These resources are, in most cases, non-transferable and location-specific. The focus on the technological specialization patterns is additionally motivated by the fact that, as it was shown by a study at company level, technological competency and life cycle of potential partner play a role in the formation of alliances (Chen et al., 2011). This reflects the motivation to establish a technological joint-venture with the intention to find complementary resources and to explore new ideas (Santamaria & Surroca, 2011). Hence, the second aspect of our assessment framework is technological profiling. To this aim, we introduce measures that identify a set of technology fields and provide information on how strong a country is in each of the field. Hence, one of the most important points in the process of an innovation collaboration partner assessment is to get to know its strengths. One answer to this problem is to map a partner's technological competencies and specialization patterns.

In the current framework, to this aim, we measure technological specialization by computing the shares of individual technology fields in the total number of patent applications.

Openness to international innovation collaboration

Considering the phenomenon of international innovation collaboration, the openness of inventors from one country to collaborate with their counterparts from other countries, is at least as important as the inventive performance and innovation profile of a country (De Prato & Nepelski, 2011a). Hence, in our methodological framework, we include a measure of openness to international collaboration.

In order to capture the role of foreign partners in working with domestic inventors, being aware of the limitations of its limitations (Bergek & Bruzelius, 2010), we use the share of international co-inventions in the total number of a country's inventions, i.e. patents.

Economic potential of technology

Potential economic benefits of innovation collaboration might be of high importance when evaluating a collaboration partner. Hence, we are interested in potential economic value of a country's innovations and technology. An informative way of assessing the value of innovations would be to look at their potential market. Clearly, innovations for which there is a global demand would have a clear advantage over innovations that target only local, i.e. national, markets. Thus, we introduce a measure of economic potential of technology which is based on inventors' expectations concerning its value. Here again we make use of the information included in patent applications and distinguish between patent applications that have been filed to national or a foreign patent office. Our approach to the economic potential of technology follows the concept of patent family size, as defined by Grefermann and Röthlingshöfer (1974).

This approach assumes that patent applications submitted to a foreign office rather than to a national one have a relatively higher expected value. In other words, the interpretation of the patent family size as a proxy of patent value is that the owners of a patent believe that the invention has the potential to be exploited in a bigger market than the national one. A straightforward justification of this assumption is that protection will be sought beyond the local market only for inventions with sufficient expected value to their owners. This expectation has been confirmed by empirical studies of the relationship between patent size family and firm value, which found a positive relationship between the two variables (Harhoff, Scherer, & Vopel, 2003; Reitzig, 2004).

To proxy for the value of a country's innovation output, we use the share of patent applications filed to international patent offices in the total number of patent applications.

Table 1: Assessment framework for innovation collaboration partners

Assessment criteria	**Description**	**Indicator**
Inventive performance	What is the inventive mass and dynamics of a country's inventive performance with which collaboration is sought?	Number of priority patent applications
Technological specialization patterns	What technology does a country specialize in? Are its technological capacities and resources complementary?	Shares of each technology field in the total number of patent applications
Openness to international innovation collaboration	Do a country's researches have a record of collaboration with their foreign counterparts?	Share of international co-inventions in the total number of patent applications
Economic potential of technology	Are a country's inventions protected primarily in the domestic or international market? Hence, what is their potential market?	Share of patent applications filed to international patent offices in the total number of patent applications

3 Data and elaboration of patent-based indicators

We use patent data coming from the European Patent Office (EPO) Worldwide Patent Statistical Database 2010, known as PATSTAT. This database provides a worldwide coverage of patent applications submitted to around 90 Patent Offices in the world. The analysis takes into account priority patent applications filed at 59 Patent Offices.[1] The time period taken into account covers from January 1st, 2000 to December 31st, 2007.

The indicators proposed in this study aim to provide the best measure of the inventive capability of countries, rather than of the productivity of patent offices. To achieve this objective, we consider only 'priority patent applications'; this means that, to avoid double-counting, only the first filing of an application is considered and all the possible successive filings of the same invention to different patent offices are not counted again.

Regarding the assigning patents to countries, there are two common methodologies: it is possible to refer to either the declared country of residence of the inventor(s) ('inventor criterion') of a patent, or to that of the applicant(s) ('applicant criterion') (OECD, 2008). Several applicants could hold rights on a patent application, and they would have legal title to the patent once (and if) it is granted. In the same way, several inventors could have taken part in the development process of the invention, and be listed in the patent application. A

[1] We include patent applications submitted to 59 patent offices, which in 2007 accounted for 99.7% patent applications submitted worldwide. The list of considered Patent Offices includes: EPO, EU27 Member States, USPTO, JPO, Arab Emirates, Australia, Brazil, Canada, Chile, China, Columbia, Croatia, Hong Kong, Iceland, India, Indonesia, Israel, Korea, Malaysia, Mexico, New Zealand, Norway, Pakistan, Philippines, Puerto Rico, Russia, Singapore, South Africa, Switzerland, Taiwan, Thailand, Turkey and Vietnam.

fractional count is applied in order to assign patents to countries in cases where several inventors (or applicants) with different countries of residence have to be considered for the same application. In general, the choice of the criterion depends on the perspective from which innovative capability is being investigated. In this study, the adoption of the inventor criterion has been chosen, as it allow to provide a more accurate picture of activity of a country's inventors (de Rassenfosse et al., 2011; Turlea et al., 2011).

With regard to the identification of technology fields, patent applications are grouped into eight groups by using 35 IPC technological fields based on the WIPO classification table (WIPO, 2010). The fractional counts approach has also been applied in case of applications referring to more than one technology field.

In order to derive a measure of openness to international collaboration, we make use of a patent-based measure of internationalisation. This measure is based on the concept of co-invention, i.e. an invention developed by more than one person. The measure of international innovation collaboration is defined as the share of a country's inventions with inventors residing in the country and inventors residing outside of the country, in the country's total number of inventions (according to the inventor criterion). Here, we follow Guellec and Van Pottelsberghe de la Potterie (2001),[2] and define algebraically the measure of co-inventions of country *i* as:

$$CoInv_i = \frac{P_i^{II}}{PI_i} \tag{1}$$

where P_{ij}^{II} is the number of patents co-invented be residents of country *i* and country *j* and PI_i total number of patents invented by residents of country *i*.

Finally, when speaking of the economic potential of technology, we proceed in two steps. First we count all the patents applications which include at least one national inventor, i.e. in this case Indian. Second, we distinguish between priority and subsequent applications and between patents filed to the national patent office and those filed to an international patent office. This way, we distinguish between the following patent applications:

i) Priority patent applications submitted to the national patent office, i.e. in the following example Indian Patent Office, which can be divided into:

[2] For an extensive description of the methodology and its application to study various types of R&D internationalization using patent-based indicators please refer to the 2011 Report on R&D in ICT in the European Union (Turlea et al., 2011) and to the Report on Internationalisation of ICT R&D (De Prato et al., 2011).

    a) Priority patent applications without subsequent patent applications and
    b) Priority patent applications with subsequent patent applications to foreign patent offices.
- ii) Priority patent applications submitted to any international patent office, which again can be divided into:
    a) Priority patent applications without subsequent patent applications and
    b) Priority patent applications with subsequent patent applications to foreign patent offices.
- iii) Subsequent patent applications to any foreign patent office.

As described in the previous section, for the purpose of the current study, we are interested in knowing what was the potential of inventions expressed in the share of patent applications submitted to any foreign patent office, i.e. the sum of (ii) and (iii), in the total number of inventions co- or developed by Indian inventors.

4 Assessing India as a innovation collaboration partner

In order to demonstrate the value of the framework for assessing innovation collaboration partners described above, we apply it to study India. This way we intend to show what kind of insights can be obtained by using our framework and, at the same time, to cast some light on India as an innovation partner and on the potential benefits that can result from collaborating with Indian inventors.

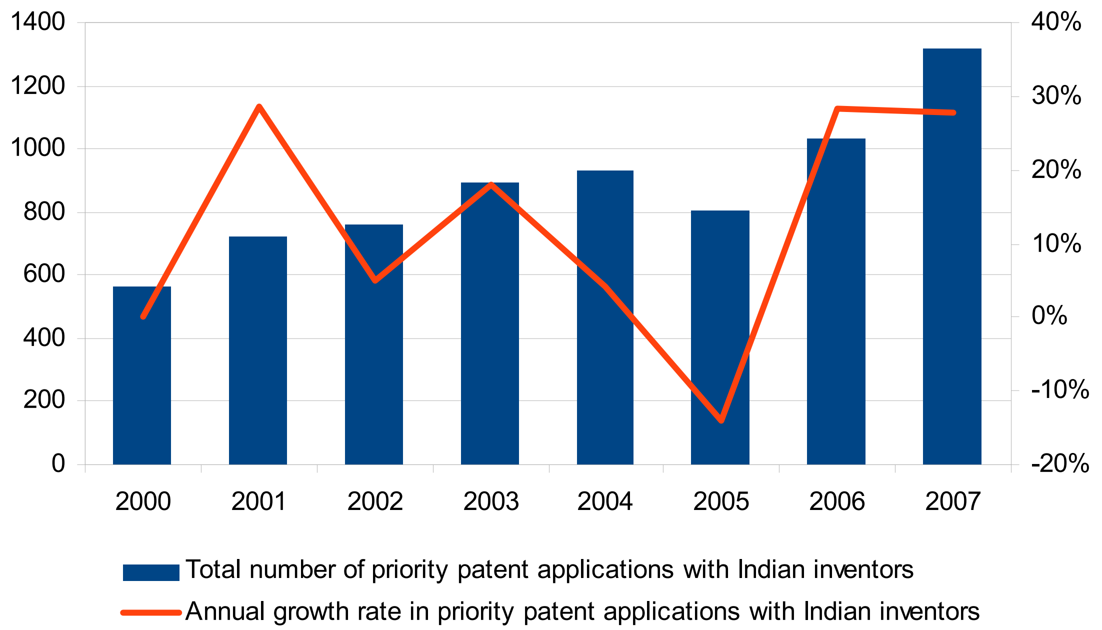
4.1 *Inventive performance*

Following our framework, India's innovation performance is captured by the total number of patent applications of a country. This number is computed through fractional counting of inventors residing in India independently of the patent office to which application was submitted.

According to Figure 1, the output of the Indian inventors increased from less than 600 patents in 2000 to nearly 1.500 patents in 2007 in all technology fields. In comparison, in 2007, there were around 60.000 and 100.000 patents developed by US and European Union (EU) inventors respectively. Thus, in absolute terms, the inventive performance of India is relatively modest. However, it must be noted that, due to a number of structural reasons, India's inventive performance started from a very low levels (Abraham & Moitra, 2001). Hence, it is rather the growth rate of the inventive performance than absolute number that calls for our attention. Here we can notice that in the analysed period the total number of patents more than doubled. With some exceptions, the India reported a two digit growth rate over the entire period.

The reasons behind the developments in India's patenting are manifold (Malik, 2012). First of all, as until the 1990s, the economy was under state control and there was no incentive for private companies to invest in R&D. Moreover, the state-run science and technology organizations did not aspire to compete at international levels as well. A change came with the liberalisation of the economy in the 1990s. Domestic firms faced global competition, on the one hand, and state research institutes were forced to generate revenues through technology commercialisation and to showcase their capabilities through patents. As a result, over the last years we can observe very dynamic growth in India's patenting.

Figure 1: Total number and growth of priority patent applications with Indian inventors, 2000-2007



Note: Priority patent applications including at least one Indian inventor. Own calculations using the inventor criterion based on PATSTAT Database, version 2010

4.2 *Technological specialization patterns*

In order to cast some more light on the technological specialization patterns of India, we analyse priority patent applications with Indian inventors by technological fields. According to Table 2, the most important technological fields in India's patents include computer technology, organic and fine chemistry, digital communication, telecommunications and pharmaceuticals. These five technological fields account for more than 60% of technological diversity of Indian inventions. Moreover, three fields belong to the broad category of information technologies (IT). This list clearly confirms the image of India's innovation activity focused on only two sectors, i.e. IT and pharmaceuticals. There are two major factors behind this concentration of inventive activity and relatively large innovation productivity in these two industries. First, these are mainly multinational enterprises (MNEs) that are the prime drivers of the increasing number of patenting. Hence, as a large share of the multinational firms with R&D activities in India belong either to the IT or pharmaceutical sector (Malik, 2012), it partially explains the dominant role of the two technological fields. However, also domestic companies operating in these fields are slowly but successfully entering the global high-tech industries (Bruche, 2012). One part of their strategy is to increase R&D expenditures to meet international competition. This additionally strengthens the focus on IT and pharmaceuticals R&D activity.

A closer look at the growth rate in patenting in all technology fields reveals that the dominant technologies are not necessarily the fastest growing ones. The fastest growing technological fields, i.e. with a compound average growth rate (CAGR) above 50%, include other consumer goods, optics, micro-structural and nanotechnology and thermal process and apparatus. At the same time, we can observe a relative decline in importance of such technological fields as basic materials and chemistry, pharmaceuticals and biotechnologies. Here it comes as a surprise a sharp decline in the pharmaceuticals or organic and fine chemistry.

The changes in the technological focus of Indian inventors clearly show that the entire innovation landscape of the country is going through some important structural transformations. Some results of these changes include a stronger focus on consumer goods, optics, nanotechnology or other fine apparatus at the cost of technological fields that have been so far considered as strength of the Indian R&D and innovation system. We can expect that further developments in India's technological specialization patterns will have an impact on its attractiveness as an innovation collaboration partner.

Table 2: Indian patent applications by IPC technology field, 2000-2007

	Technology field	Total number of patent applications 2000-07	Share in total	CAGR of patents 2000-2007*
1	Computer technology	2134	33%	38%
2	Organic & fine chemistry	559	9%	-18%

3	Digital communication	483	8%	19%
4	Telecommunications	401	6%	40%
5	Pharmaceuticals	372	6%	-24%
6	Electrical machinery	275	4%	33%
7	Biotech	228	4%	-23%
8	IT methods	186	3%	28%
9	Basic materials & chemistry	178	3%	-27%
10	Macromolecular chemistry	175	3%	8%
11	Food chemistry	165	3%	-16%
12	Measurement	139	2%	20%
13	Chemical engineering	124	2%	6%
14	Medical technology	105	2%	17%
15	Audiovisual technology	97	2%	27%
16	Semiconductors	85	1%	19%
17	Control instruments	84	1%	36%
18	Engines, pumps, turbines	81	1%	32%
19	Surface technology	62	1%	29%
20	Optics	53	1%	62%
21	Transport	52	1%	32%
22	Other special machines	49	1%	0%
23	Environmental technology	48	1%	6%
24	Mechanical elements	41	1%	48%
25	Other consumer goods	39	1%	81%
26	Machine tools	33	1%	40%
27	Civil engineering	30	0%	43%
28	Analysis of biological materials	29	0%	2%
29	Thermal process and apparatus	25	0%	56%
30	Handling	24	0%	27%
31	Furniture	24	0%	25%
32	Textile and paper machines	19	0%	10%
33	Micro-structural and nanotechnology	17	0%	57%
34	Materials, metallurgy	4	0%	-
35	Basic communication processes	0	0%	-
	Total	6419	100%	

* Compound average growth rate of the number of patents in a technology field between 2000 and 2007.
Note: Priority patent applications including at least one Indian inventor. Technology fields computed by fractional counting.
Own calculations using the inventor criterion based on PATSTAT Database, version 2010

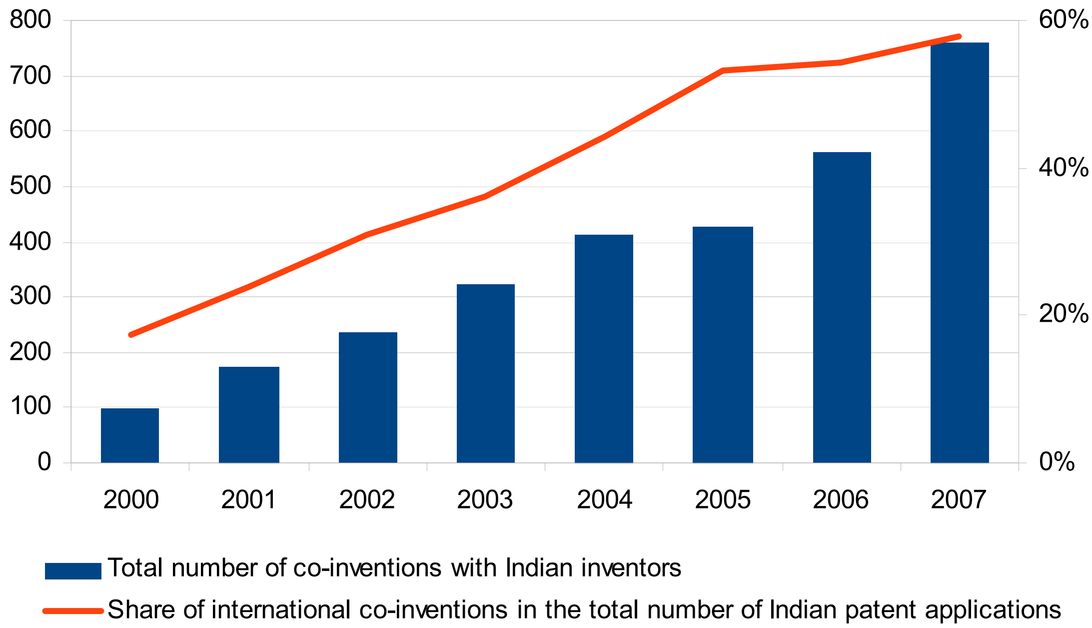
4.3 *Openness to international innovation collaboration*

Turning to the question of how open Indian inventors are towards collaboration with their foreign counterparts, Figure 2 shows the number and the growth trend in co-inventions involving Indian and non-Indian inventors. According to this evidence, the level of international collaboration was relatively low at the beginning of the century. Fewer than 100 patented inventions involving an Indian inventor were developed together with at least one inventor from the outside of India. In other words, 17% of all Indian innovations were a result of international collaboration. This, at a first sight low number, is misleading, considering that at the same time the overall global share of international co-inventions was much smaller, i.e. below 2% of all inventions patented around the world (De Prato et al., 2011). Moreover, considering that the number of co-inventions produced by Indian and non-Indian inventors has experienced an intensive growth over the last years, India appears as a world leader in international innovation collaboration.

Like in the case of the rapid growth of patenting and the technological specialization patterns of Indian innovation activity, the relatively high level of openness to international collaboration of Indian inventors is related to the structure of the actors that dominate the R&D landscape of the country. For example, the increasing presence of multinational firms conducting R&D in India explains the high co-patenting level of Indian inventors. Moreover, policy measures directed towards foreign companies operating in India have created incentives for multinational companies to integrate R&D activities in their operations in India (Mazumdar, 2010), which increased the number of both patents and international co-inventions. Thus, it can be concluded that these companies seem to animate and activate the resources available in India and, by combining them with their assets, generate new types of knowledge and technology.

Regarding the technological fields, which dominate the international innovation collaboration with Indian inventors, like in the case of the overall patenting, we can observe a very strong concentration in only few technological domains. Computer technology, digital communications and electrical machinery account for 50% of all international co-inventions involving at least one Indian inventor. Moreover, the first field represents over one third of the co-inventions. Regarding the fields with the fastest growth rate in international co-invention, i.e. CAGR above 50% between 2000 and 2007, these are: machine tools, mechanical elements, micro-structural and nanotechnology, optics and macromolecular chemistry. Considering the important role of MNEs in the inventive activity in India, this findings show their twofold role. On the one hand, MNEs have very strong interest in the inventive potential of India and, on the one hand, they actively shape the country's inventive landscape.

Figure 2: Total number and growth of co-inventions between Indian and non-Indian inventors



Note: Based on fractional counting of priority patent applications including inventors residing in India and at least one inventor residing outside of India.
Source: Own calculations using the inventor criterion based on PATSTAT Database, version 2010

4.4 *Economic potential of technology*

The last point of the assessment framework is to evaluate the economic potential of technology developed in India. As outlined above, to this aim we track the destination of patent applications which include Indian inventors. Table 3 summarises the results of this analysis.

According to the presented information, only 1785 out of 12601 priority patent applications involving Indian inventors are filed to the Indian patent office. The remaining 10816 are filed to a patent office outside of India, i.e. around 50% to the USPTO (De Prato & Nepelski, 2011b). All priority patent applications result in over 21000 of subsequent patent applications. An interesting observation can be made with respect to the origin of the subsequent patent applications. Whereas nearly 3000 subsequent patent applications were preceded by a priority patent application filed to the Indian patent office, over 18000 were an offspring of an application filed first outside of India. Thus, in general, a priority patent application submitted to a foreign patent office is only slightly more likely to have a bigger family size than an application filed to the India patent office, i.e. 1,7 versus 1,6.

Reading these figures, we can observe the following: The disproportion between priority patent applications filed to an Indian and non-Indian patent office is very large, considering that in most of the countries we can observe a so called home-bias, i.e. where inventors file their patents to their national patent office first (OECD, 2008). This supports the hypothesis of a high expected value of a large share of Indian inventions.

All this leads us to conclude that, due to a large share of patent filings submitted abroad, on average Indian inventions have supranational commercial potential. At the same time, however, we need to mention that it is very likely that it is not only the value of Indian innovations that drives the inventors to file patent applications outside of India first. There are a number of other reasons why such a large share of Indian inventions is patented outside of the country of origin. For example, the role of MNEs, already discussed above, plays a key role. The strength of intellectual property protection in the country might also be an issue. Nevertheless, the magnitude of the total number of inventions of Indian origins is striking and is a signal concerning their expected commercial value.

Table 3: Patent applications by the time of filling and patent office, total for 2000-2007

Priority patent applications	To Indian patent office		1785
		Without subsequent applications	381
		With subsequent applications	1404
	To foreign patent offices		10816
		Without subsequent applications	5068
		With subsequent applications	5748
	Total		**12601**
Subsequent patent applications	With priority applications filed to the Indian patent office		2887
	With priority applications filed to a foreign patent office		18494
	Total		**21381**
Total number of patent applications			**33982**

Note: Includes all patent applications with at least one inventor residing in India. Own calculations using the inventor criterion based on PATSTAT Database, version 2010

4.5 *A synthesis of the assessment*

In order to provide an overview of the results that were obtained after applying the framework to India, in this section we present a synthesis of the most important results concerning India's innovation performance, technological specialization patterns, openness to international innovation collaboration and the economic potential of technology. Table 4 provides the list of assessment criteria together with some stylised facts.

Table 4: The results of assessing India as an innovation collaboration partner

Assessment criteria	Result and description
Inventive performance	• Relatively low inventive performance. • Very high growth in inventive activity.
Technological specialization patterns	• High concentration in two technological fields, i.e. IT and pharmaceuticals. • Dynamic structural changes in the innovation activity. • Sharp increase of activity in such technological fields as nanotechnology. • Decline of activity in pharmaceuticals and biotechnology, traditionally considered as the strength of India's innovation system.
Openness to international innovation collaboration	• Extremely high level of international innovation collaboration. • Collaboration limited to few technological fields.
Economic potential of technology	• High expected value of inventions due. • The overall number of patent applications, including priority and subsequent applications, submitted to foreign patent office is outstanding. • The majority of all priority patent applications are filed to the USPTO. • Only a small fraction of priority patent applications with Indian inventors are filed to the Indian patent office.

5 Conclusions

To better understand the process of innovation collaboration, we tackle the question of how to assess a potential innovation collaboration partners and the benefits resulting from such collaboration. Drawing from the insights on the determinants of innovation collaboration, we develop a framework for assessing an innovation collaboration partner and provide a set of indicators allowing for applying the framework to study for an independent analysis. To demonstrate the usefulness of the framework, we apply it to assess India as a potential innovation collaboration partner.

Our work suffers from a number of drawbacks. First of all, patent data, despite its richness of information, suffers from its own obvious drawbacks. Moreover, our approach ignores the value of patents, and it takes into account neither a country's IPR environment nor a country's policy to the output of international collaboration. Second, due to the fact that there is no clear-cut theoretical foundation explaining the formation and evolution of innovation collaboration, we make use of a number of approaches to this issue in order to design the assessment framework and related indicators.

The above non-exhaustive list of limitations of our work provides some suggestions for future work in the subject concerning an *ex ante* assessment of innovation collaboration partners. It seems that the most critical points that need to be addressed in this area is the economic value of technology, a subject that has recently attracted the attention of researchers, business executives and policy makers. Moreover, it is relatively straightforward that the results of an exercise that would apply this framework to study a larger group of countries would help to better understand the determinants of innovation collaboration.

Despite its limitations, the presented framework provides a reflection on and a synthetic view of a methodology for innovation collaboration partner selection and for the assessment of innovation collaboration benefits. Based on the results of an assessment, relevant policy consideration can be drawn by profiling potential innovation collaboration partners by assessing inventive performance, openness to collaboration, and market potential of the joint inventive output. Therefore, it may help in designing science and technology policy by making an *ex ante* evaluation of collaboration benefits, and allowing for improved targeting of technology needs and selection of suitable partners. Moreover, besides providing a novel framework for assessing the benefits of innovation collaboration, the current work delivers valuable insights to the Indian innovation landscape and an analysis of collaboration perspectives in science and technology with India.

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