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Patenting and co-invention in BRICS countries

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Abstract

Abstract
Patenting activity has been increasing consistently in some emerging economies. In some cases, this increase is above the historical trends of the so-called ?patent surge? (Hall et al. 2001) observed since the last decade. The growth of inventive activities in the so-called BRICs is recognized in the literature.
This paper addresses to the influence of co-invention as an explaining factor that may contribute to this increase in the patents granted to these emerging economies. Past contributions provide some examples on the analysis of co-invention among headquarters and subsidiaries in developing countries (Singh 2007), offshoring of innovative activities in to the host countries (Lewin et al. 2009) and also the consistent increase in the patents obtained by developing countries (Tseng 2009; Bagchi 2011).
With exception to the recent work of Godinho and Ferreira (2012), fewer studies have been done about the process by which inventors collaborate to obtain a patent working from two different countries. From the perspective of developing countries two types of collaboration are possible: co invention with inventor in a technologically advanced country and the ?South-South cooperation? cooperation with an inventor in another developing economy.
Analysis of aggregated figures reveals that the first type of cooperation is substantially higher than the latter. In other words, the South-South cooperation is to date more a wish than a real phenomenon. More interesting than that is to understand why does cooperation takes place mainly among technologically advanced and developing countries?
We believe that the some mechanisms that might explain it involves at the individual level complementarity of knowledge bases meaning that cooperation happens when the two inventors posses different types of knowledge (Cantner et al. 2011). From the firm perspective the motives stated by Dunning and Lundan (2008) seem also to take hold for the R&D activities tough the theory was created in the context of offshoring of productive activities.
A multi logit specification will be applied in to test which factors affect the probability of an inventor in a developing country to (a) cooperate only with inventors in his country of residence, (b) choose and inventor located in a technologically advanced country or (c) chose a co inventor in another BRICS country. The regressors are traditional measures on patent studies such as the stock of patents granted for the inventor in the past (PastInv), number of inventors per patent, controls for technological class, binary control for triadic patents.

With a two level specification (Snijders and Boske 1999), we are able to control for endogeneity and quantify the effect of context variables such as the gross domestic expenditures in R&D (GrossRD), the number of scientists per 100 thousand inhabitants (CAPAB), access to infrastructures (ICT_infra).
The data from patents is extracted collected from the USPTO as well as the control variables constructed. The data from the contextual elements stems from the World Development Indicators by the World Bank and the UNESCO science and technology indicators.

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Patenting and co-invention in BRICS

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1. Introduction

In this paper we investigate the growth of technological capabilities of the BRICS (Brazil, Russia, India, China and South Africa) by observing their patents granted by the United States Patent and Trademark Office (USPTO) from 1976 to 2011. Although established literature on patents has mostly relied on studies about advanced economies with developed Innovation Systems, BRICS countries have presented an increased level of patenting activities in the past two decades (Godinho and Ferreira 2012, Bagchi 2011 and Tseng 2009).

If by one side, some studies have stressed that China and India have more impressive rates of patenting, by the other side fewer studies have concentrated on the activities of all the BRICS. Brazil, Russia and South Africa have shown less success in their rate of invention receiving less attention of scholars. However these countries still have a considerable growth in their R&D activities and a large stock of patents (Bagchi 2011). Mahmood and Singh (2003, p.1031) state that the increase in number of patents granted make this type of data statistically meaningful conducting new studies.

Apart from this rapid accumulation of technological capabilities, we are also interested on growing internationalization of R&D activities in the BRICS. Griliches (1998), Hall et al. (2001) and Ma and Lee (2008) report that in 1960, foreign companies owned 19% of the patents granted by the USPTO while in 1988 this share has increased to 48% and has continuously increased in recent years.

Aiming to better understand this internationalization process, we focus on the role of co invention as a mechanism that affects the growth of patenting activities as a proxy for cross border knowledge flows. Co invention[2] for the purposes of this study is the process by which two or more inventors residing in different countries cooperate for receiving a patent. The study distinguishes between domestic patents (those in which all the inventors reside in the same country; cooperation between a BRICS country and a

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2 We resort to co inventorship for two main reasons: (1) the number of patents in BRICS is higher as measured by inventor criterion than by assignee (firm) criterion and (2) we follow the finding of Meyer and Bhattarcharya (2004) who state that a co invention is more frequent than co assignment and that co invention presumes some formal agreement of cooperation between two or more parts expressed in the patent document.

technologically advanced country; cooperation between two BRICS; and cooperation among more than two countries.

Attention should be paid to the role of Multinational Corporations (MNCs). Traditional theories on international business have stressed the role of mergers, asset and advantage exploitation of the host country to the MNCs. More recently, given the increasing complexity of innovative activity, developing countries have gained some importance in the innovation strategy of the MNCs whereby their subsidiaries in developing countries also perform R&D activities. In many cases, the subsidiaries are granted rights as the assignee.

Besides of that, some of the BRICS have created their own MNCs which developed their own R&D activities obtaining patents and developing technological capabilities (Amman 2009, Wells 2003, Goldstein 2009).

We pay special attention to the patents which the primary inventor resides in any of the BRICS since we stress the role of creation of indigenous technological capabilities by assuming that primary inventors usually perform a leading role in the process of invention. This is a distinctive feature of this study once the majority of the studies with patents address to the issue of co invention between OECD countries.

The data used in the paper comes from the USPTO covering a period from 1976 to 2011 and includes details about the inventors, firms, technological fields among others.

The remainder of this paper is divided as follows. Section two reviews the existing bibliography concerning: the use of patent as innovation indicators; the previous studies that use patent data and co invention as well as its respective functions and objectives; the role played by multinational corporations in the diffusion of knowledge. Section three describes the data and modeling issues. Section 4 discusses the results and brings a conclusion.

2. Theoretical background

Patents as indicators of innovation

Patents have been largely used as indicators of inventive activity. The pioneering work on this field has been carried out by Schmookler (1966) and Scherer (1982). The underlying assumption of this type of application is that patents are output measure activities of the R&D process carried out by firms.

There are some advantages in the use of patent data that are worth noting. They are publicly available and are constantly updated; they cover a large period of time resulting in large quantities of data available. The data is standardized by technological classifications allowing for aggregation and comparisons between countries (Griliches 1998; Archiburgi and Pianta 1996; Hall et al. 2001).

Moreover all the patents granted have been under the scrutiny of trained examiners who assess their novelty and non obviousness meaning that all inventions should pass a certain quality threshold. It should also be noted that the firms who obtain a patent have invested a large amount of time and money refuting the idea any type of idea can be easily patented. From the applicant side, there are considerable costs involved in the application including expenses with legal representatives. In other words, it is likely that applications are filled only for inventions which are expected to provide benefits that outweigh these costs (Archiburgi and Pianta 1996, p. 454; Mahmood and Singh 2002).

The existence of patenting activity is highly correlated with the presence of R&D activities therefore the firms that obtain patent are almost certainly performing in house R&D activities and have a strategic interest on engaging into innovative activities and reaping potential profits arising from their inventions.

The benefits of obtaining a patent go beyond the sheer market value or revenues from technological licensing. Cohen and Levinthal (1989) point out that carrying out R&D activities not only increase the inventive capacity of firms but also increases their absorptive capacity. In other words, firms that patent have an additional benefit arising from their ability to assimilate and exploit new information.

Like any other technological indicator, patents also have their own drawbacks. In the case of patents, the main point is that not all inventions are patented and not all patents are turned into innovations (Griliches 1998). Cohen et al. (2000) state that firms also adopt other mechanisms to protect their inventions. This includes industrial secrecy, lead time, complementary goods and complementary manufacturing. Industries also do not patent all alike. The patenting behavior is highly dependent on the appropriability conditions and on the technological opportunities.

In the context of BRICS countries patenting activities are related to two major concerns of firms. On the one hand, firms from developing countries are concerned with the internationalization of their activities and expansion in foreign markets not only for goods and services but also with markets for technology.

The recent increase in patenting in BRICS allow to carry out studies based on higher counts and more meaningful in statistical terms giving rise to an emerging strand of literature which assesses the technological of some of these countries.

Tseng (2009) studied the patenting activities of the Brazil, Russia, India and China (BRIC) using patent data from the USPTO. He finds that Brazil, China and India have an increasing tendency to patent over time while in Russia the growth rate is smoother. Patent quality in terms of citations is higher in Brazil and Russia and lower in India and China. Finally he points that Indian technological activities are more related to science activities while in Russia, China and Brazil technological activities seem to be more related to applied innovations.

Bagchi (2011) analyses the performance of the BRICS by assessing input and output technological indicators. He shows that China and India have increased their share of high tech exports while the Brazil, Russia and South Africa face a temporary decrease in high tech exports in recent years. The author also finds that patent applications per thousand inhabitants have increased in all the BRICS since the year 2000.

Godinho and Ferreira (2012) study the take off of India and China in patenting and registration of trademarks in the USPTO. They observe that China and India are currently the 1st and 5th largest applicants for trademarks in the United States. Also, they show that China is the 3rd country that most apply for patents while India is the 5th largest applicant. Their main conclusion is that those countries will be able to catch up with the most advanced countries in one decade if the current growth rates are sustained.

Thomas et al. (2011) evaluate the efficiency of R&D activities in the United States and compare it to the performance of Brazil, Russia, India, China and South Korea by applying three measures of R&D efficiency namely patents, scientific publications and R&D expenditures. They found that R&D efficiency has been declining in the United States and has been increasing in Brazil, India, China and South Korea while in Russia R&D efficiency is slightly decreasing.

Co-invention and cooperation for R&D

Cooperation in innovative activities occurs mostly because technological development is a rather complex task that requires in many cases the coordination among specialized actors and a certain division of labor.

Besides of that, it is also argued that risk and uncertainty involved in such activities is mitigated whenever cooperation takes place. Another argument put forward by Cantner et al. (2012) is that the knowledge required to innovate may be found outside the boundaries of a firm. Since variety of

knowledge is one of the key sources of innovation, firms will tend to cooperate in order to obtain some knowledge they do not own.

As Cowan et al (2006, p. 156) state if countries have access to a wider variety of knowledge innovation and growth can be fostered. In many cases, the type of knowledge required to invent and to innovate can come from other country which owns the knowledge required to patent. Co-invention consequently serves as a channel for the transmission of both tacit and codified knowledge.

Hascic et al. (2012) provide data confirming that co invention has increased for the majority of OECD countries between 1970 and 2010. For some of the studied countries, the rate of co invention is above 30% of the total patents.

Guellec and Pottelsberghe de la Potterie (2001, p. 1257) study the internationalization of technology by using indicators based on patent data. They show that over the 1980–1995 period, the degree of international R&D collaboration has more than doubled. For countries like Poland, Greece, Turkey and Hungary the share of patents with cross country co invention is above 40% of the total patents.

This study also finds that in general the higher the country R&D intensity, the lower the degree of co invention and also that smaller countries tend to be more prone to co invention. Lastly the authors suggest that sharing a common language facilitates co invention.

A key question behind co invention is *why* do firms in different countries engage in collaboration. The answers provided by Guellec and Pottelsberghe de la Potterie (2001, p. 1254) and Haščič et al. (2012) are:

-**Mergers and acquisitions**: a firm that acquires a competitor acquires eventually the R&D facilities. If the merging firms are in different countries, co invention will arise
-**Adaptation of products:** a multinational firm may start R&D activities abroad in order to adapt products for the markets of the host country aiming at increased market access
-**Advanced hearing posts:** co invention that arises when a firm wishes to observe the technological developments taking place in the recipient country given its comparative advantage in a technological field that the headquarters does not dominate
-**Tapping talents**: hiring R&D personnel in a different country usually taking advantage of lower labor costs.

Given this scenario, international co invention becomes a key channel for the mobilization of knowledge between borders.

The data from patents refer to a specific type of knowledge flow confined within a formal cooperation agreement between two individuals mediated the organizations to which they are affiliated. In this study, the focus is on international co invention meaning that the inventors reside in different countries.

By working with co invention, this article assumes that firms make a formal type of cooperation among inventors that reside in different countries. There reasons stated in the literature claiming that the patent itself is a document that represents a formal channel of knowledge flows between two units.

The parts involved benefit each other from different knowledge bases and can learn from each other on different demand structures of the countries where the inventor reside.

Countries like the BRICs have some features that would lead to more gains from cooperation. Among them: their innovation systems are well developed meaning that domestic industries can offer supplies locally, they have large pools of trained labor force at lower costs in comparison to technologically advanced countries, and last but not least firms in these countries have a reasonably high level of capacity which can lead to gains from the process of co invention.

The role of MNCs in patenting

Patents are integral part of the activities of multinational corporations. Recent literature on their behavior show an increased use of subsidiaries in developing countries as means of taping talents to make up for a lack of technological competences and also for the adaptation of their products for the local demand in order to increase market access (Guellec and Zuniga 20006).

Narula and Dunning (2000) affirm that MNCs rely considerable more on the work of their subsidiaries once the advances in transports and telecommunications have lead to lower costs for coordinating the activities between headquarters and their subsidiaries.

The authors also state four main reasons why in a developing country can learn from the cooperation with the parent company. The first refers to the costs of acquiring technology via formal markets. This type of purchase is not only very expensive but may also require some degree of absorptive capacity from the subsidiary. The second point is about the competitive forces in liberalized economies:

incumbent firms are not willing to sell or to transfer their technologies unless they have total control the purchasing firm. Also, under the World Trade Organization (WTO) regime, developing countries are not more allowed to promote policies of infant industry protection. Lastly, some technologies, especially those applied in knowledge intensive industries; require the use of complementary assets.

3. Data and model

Data

Patents provide a rich source of information on invention comprising detailed information on inventors names and places of residence, assignees with their respective location, technological classifications, claims on their innovation as well as references to previous patents and relevant literature.

The patents used in this paper come from the United States trademark and Patent Office (USPTO) obtained from the bulk files covering the period ranging from 1976 until 2011 . The data is poled in 4 years windows in order to avoid unexpected fluctuations on the patent counts not arising from pure R&D activities.

The countries of the patents are decided by the first inventor criterion in order to avoid double counting problems. The total patents granted to BRICS make up to 38566 patents out of which 2217 were granted to Brazil; 22,075 to China; 7,772 to India; 2,990 to Russia and 3,512 to South Africa.

As for the purposes of this study, the fields concerning inventor's place of residence and assignees' location are of particular relevance.

Besides of that, information concerning the quality of each patent is also retrieved. We use the number of backward citations as an indicator of the quality of each patent excluding the self citations which could lead to spurious inferences. The dataset also allows discriminating between citations made by the inventor and those made by the examiners. We exclude the latter which are recognizably not related to the inventive process.

The International Patent Classification (IPC) is used for aggregating the data by subclasses allowing for comparisons over time and across the countries studied.

The multinomial logit regression

A multinomial logit is a model applied to categorical data when more than two choices are available. The coefficients of this regression can be interpreted as the effect on the probability of occurrence of an event in relation to the base category (Cameron and Trivedi 2005; Wooldridge 2001).

The dependent variable is expressed in categorical data.

The dependent variable Y can take three values: 0,1, 2 or 3 meaning:

0: no international co invention. All inventors reside in the same country

1: there is cooperation between an inventor in technologically proficient country and an inventor in an inventor in a technologically advanced country.

2: there is cooperation between inventors in a technologically proficient country and another inventor in a technologically proficient country

3: there are inventors residing in three or more countries. For the moment, we do not discriminate.

Technologically advanced countries are those characterized by production of high technology products and large investments on R&D. Technologically proficient countries are countries with relatively well established innovation systems some degree of industrialization and that are possible in engaging into international R&D cooperation. Oftentimes, these countries are able to patent their innovation abroad.

In the context of this paper, we resort to a set of technologically advanced countries based on the work of Archibugi et al. (2009). "Technologically proficient countries" is a term proposed and discussed in Basheer and Primi (2008). In the context of this paper it refers to the BRICS. The list of countries considered technologically advanced and technologically proficient for this paper is presented in the Annex 1.

Control variables:

- Technological classes (Categorical): classified by IPC codes
- Number of inventors(Count): the number of inventors per each patent in the dataset
- Number of claims (Count):

- Backward citations (count): the other patents cited

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Annex 1: Technologically advanced countries and technologically proficient countries

Country	Code
US	US
Japan	JP
Germany	DE
Taiwan	TW
South Korea	KR
France	FR
United Kingdom	GB
Canada	CA
Italy	IT
Switzerland	CH
Netherlands	NL
Sweden	SE
Australia	AU
Israel	IL
Finland	FI
Belgium	BE
Austria	AT
Denmark	DK
Norway	NO

Table 1: List of technologically advanced countries

Country	Code
Brazil	BR
Russia	RU
India	IN
China	CN
South Africa	ZA

Table 2: List of technologically proficient countries