The Role of Foreign Direct Investment in the Internationalization of Innovation: China and India compared

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1. Introduction

The internationalization of research and development (R&D) and innovative activities is an important component of the ongoing trend towards the globalization of the economy. Technological activities are involved in the globalization trend, although they are probably somewhat lagging behind. At a high level of generalization, the internationalization of technology means that inventions, the people generating these inventions, and the ownership of these inventions tend to cross national borders more frequently.

The objective of this paper is to measure the extent to which R&D activities are implemented on an international basis, and in particular in China and India. Among the various dimensions of the internationalization of technology (Narula and Zanfei, 2004), this chapter will focus on the cross border ownership of technology: an invention made in country A is owned by a firm based in country B, and an invention owned by a firm in country B is commercialized in country C.

An increasing share of technology is owned by firms from a different country than the one of the inventors, which mainly reflects the fact that companies have research facilities abroad. The importance of this phenomenon is not really new. Cantwell (1989) reported an increasing share of patents with the owner and inventor located in different countries. Several reasons explain this phenomenon (Patel and Vega, 1999; Dunning and Wymbs, 1999; Lichtenberg and van Pottelsberghe, 2001). First, international mergers and acquisition often end up with research laboratories located in different countries. Second, some multinational firms might set up research facilities abroad in order to adapt their products to local markets and to provide technological support to local subsidiaries: the so-called home-based innovation exploiting strategy. Third, multinationals want to monitor new technology developments occurring in foreign countries and want to tap foreign subsidiaries: the so-called host-based innovation augmenting strategy. This is an attempt to develop technology which complements the firm's core technology.

The following issues are the primary concern of this paper: Has the internationalization of technology increased over the last 10 years? Does it affect various countries to a similar or different extent? What is the role of inward and outward foreign direct investment in this process?

The next section introduces the importance and extent of the internationalization of R&D. The third section describes country patterns of the internationalization of technology. Concluding remarks are reported in the final section.

2. Internationalization of technology: Extent and importance

Innovative activity and capabilities are essential for economic growth and development. Empirical studies suggest a direct relationship between R&D and growth. The long-term impacts on economic growth of public R&D and business R&D have been found to be strong and significant (Guellec and van Pottelsberghe 2004). Business R&D undertaken

in other countries also plays an important role through the international use of technology. Moreover, increased domestic business R&D accentuates the positive impact of both public and foreign business R&D. In other words, business R&D (either domestic or foreign-funded) has both a direct impact on a country's economic growth and an indirect one through improved absorption of the results of public R&D and R&D performed in other countries.

This is true for the industrialized countries that are at the technology frontiers, as well as for developing countries that need to catch up in terms of technology. Given the large gap between the developed and developing countries in terms of technological advancement, the latter continue to rely heavily on technology transfer from the former in their development process. However, sustainable economic development requires that countries do more than simply "open up" and passively wait for new technologies to flow in. It demands active, continuous technological effort by enterprises, along with government policies that help firms attract technologies, use them effectively and innovate. Greater openness to trade and capital flows does not reduce the need for local technological effort – on the contrary. Technologies are changing more rapidly, falling transport costs and liberalization are intensifying competition, and TNCs are seeking locations with strong capabilities to produce efficiently. Moreover, it is not just export-oriented manufacturing that needs to be competitive; manufacturers selling to domestic markets have to compete against imports. Export-oriented services and primary activities also need to use new technologies to remain competitive in world markets.

Enterprises are the principal agents of innovation today, but they do not innovate and learn in isolation. They rely on intricate (formal and informal) links with other firms and with public research institutions, universities and other knowledge creating bodies. In undertaking innovation, they react to government policies on trade, competition, investment and innovation. They seek human resources for innovation from the education and training system, and they draw upon the financial system for funding innovative efforts. The complex web within which innovation occurs is commonly referred to as the "national innovation system" or NIS.

Most of the NIS literature focuses on frontier invention in industrialized countries, rather than on mastery and adaptation of technology that take place in developing countries. However, the innovation system concept is just as relevant for the latter (UNIDO 2003). Most learning, mastery and adaptive activity requires close and continuous interaction with other enterprises like suppliers, subcontractors, competitors and consultants, as well as with other actors such as public R&D institutes, universities, venture capital funds and export marketing or training institutions. A good supportive institutional infrastructure is therefore important for effective innovation. Incentive structures that foster entrepreneurship, risk-taking and innovation at the firm, industry and university level are also important. As the internationalization of production deepens and communication costs decline, each NIS increasingly draws on knowledge created in other systems. Rapid technical progress and the rising costs and risks of innovation force innovators to seek centers of scientific excellence internationally. Global production networks – in which TNCs play the leading role – link together the productive activities that underlie

innovation. Parent companies are instrumental in such networks, providing the initial technology to their affiliates and helping them absorb, adapt and subsequently upgrade it. As a result, the innovation systems of more and more countries are becoming interlinked in a global network in which technological activity is international and information networks span the world. From an economic development perspective it is becoming increasingly important to take part in this international exchange. Those countries that are in a position to do so stand a better chance of accessing new technologies at an early stage, as well as commercializing innovations developed in their own NIS. However, the capabilities needed for participating are unequally distributed among countries, which increases the risk of a further widening of already large development gaps. While there are different ways for countries to participate in the international exchange of innovation, this article focuses on the role of TNCs in this process, with special emphasis on the internationalization of R&D and the role of FDI.

TNCs are playing a major role in global R&D, not only through activities in their home countries but also increasingly abroad. The internationalization of R&D is not a new phenomenon. What is new is its faster pace in recent years and its spread to developing countries (albeit to only a few, mainly in Asia). Moreover, R&D activities in developing countries are no longer aimed at adapting technologies to local conditions only; they increasingly involve "innovative" R&D, including developing technologies for regional and world markets. At the same time, TNCs from developing countries are themselves investing in R&D abroad, primarily in order to access advanced technologies and research capabilities in developed countries, as well as to adapt products to new markets and tap sources of specialized expertise in other developing countries. In all, we can derive four "strategies" of R&D internationalization.

Table 1. Four strategies of R&D internationalization

Home Country \ Host Country	Developing	Advanced
Advanced	**Type 2** **MODERN** *(e.g., US → China, EU → India)*	**Type 1** **TRADITIONAL** *(e.g., US → EU, JP → US)*
Developing	**Type 4** **EXPANSIONARY** *(e.g., China → Brazil, India → China)*	**Type 3** **CATCH-UP** *(e.g., China → US, India → EU)*

Source: von Zedtwitz, 2005

The increasing internationalization of R&D by TNCs is also reflected in the growing role played by foreign affiliates in the R&D activities of many countries (UNCTAD, 2005). In 1993, the R&D expenditure of foreign affiliates in host countries worldwide – the operations equivalent of inward FDI in R&D – amounted to about $29 billion (i.e. 10% of global business enterprise spending on R&D). Within a decade, by 2002, that spending had more than doubled to $67 billion or 16% of global business R&D. This growth was more than twice as fast as that of global spending by enterprises on R&D, spending that grew by about 49% over the same period. The share of foreign affiliates in host-country R&D varies by country. In 2003, it exceeded 50% in Ireland, Hungary and Singapore, and 40% in five other countries (Brazil, the Czech Republic, Sweden, the United Kingdom and Australia in descending order). Conversely, it remained under 10% in the Republic of Korea, Japan, India, Chile and Greece. China is in between with a share of 18% in 1998, rising to about 25% currently. The share of foreign affiliates in the business R&D of developed countries is close to the world average and has been growing gradually, from 11% in 1996 to 16% in 2002. In the developing countries for which data are available, the share of foreign affiliates rose faster than in developed countries (from 2% in 1996 to close to 18% in 2002. In fact, more than two-thirds of the 30 countries for which data were available experienced a rise in the share of foreign affiliates in business R&D after 1995, and this rise was larger in developing countries.

The large number of majority-owned foreign affiliates with R&D as their main activity (2,600 in 2004) reflects the spread of the R&D activities that TNCs are conducting outside their home base. Close to 70% of these affiliates are located in the Triad, but the presence of such activities in various developing economies is increasing, especially in Asia. The kind of R&D being undertaken by TNCs in developing countries is also changing. While it has traditionally involved mainly product or process adaptation to meet local market demands, recent developments suggest that some developing markets are emerging as key nodes in the global R&D systems of TNCs.

China and India have been the main beneficiaries of this trend. Of the 885 R&D-oriented greenfield FDI projects announced in the region in 2002-2004, three-fourths (723) were concentrated in these two large economies. In China, some 700 foreign-affiliate R&D centers had been established by the end of 2004. In India, more than 100 TNCs have established R&D facilities. Microsoft launched its sixth global research centre in Bangalore in early 2005 after opening one in Beijing in 1998. Other such Microsoft R&D centers outside the United States are located in the United Kingdom and the Republic of Korea. In the case of Motorola, 6 of its 19 main R&D centers are located in developing countries: five in Asia (China, India, the Republic of Korea, Malaysia and Singapore) and one in Brazil. The number of large pharmaceutical TNCs that have a research presence in India in particular is growing fast. Astra-Zeneca inaugurated a large facility for research on tuberculosis in 2003 and subsequently expanded it to include pharmaceutical development. Pfizer started clinical research in India in 1995 and added a biometrics unit in 1998 along with a formulation development group in 2004. On the whole, Eli Lilly, Sanofi-Aventis, Novartis and GlaxoSmithKline had clinical research units and Novartis and GlaxoSmithKline had biometrics centers in India (Mukherjee 2005).

Furthermore in India, over three-quarters of affiliates' R&D expenditures ($61 million) were in non-manufacturing industries in 2002, compared to only about 20% in 1999, probably reflecting a focus on software development in that country. A number of firms from Malaysia, the Republic of Korea, Singapore, and Thailand have set up R&D activities in India related specifically to software development (Reddy 2000). In 2003 Samsung Electronics (Republic of Korea) announced plans to open R&D centers in China, India and the Russian Federation; and LG (Republic of Korea) has expanded its R&D activities into India.

A study of large Chinese TNCs found that they operated 77 R&D units at the end of 2004, including a surprisingly high 37 units abroad (von Zedtwitz 2005). Of these foreign R&D units, 26 are located in developed countries, predominantly in the United States (11) and Europe (11), mostly serving as listening posts or in product design roles. The remaining 11 units, located in developing countries, are typically small in size. Two Chinese TNCs, Huawei and Haier, are illustrative of the trend of R&D units being located mainly in developed countries. Other Chinese companies from the electronics industry, such as ZTE and UTStarcom, have also established R&D centers in India aimed essentially at offshore software development.

Indian TNCs are also globalizing their R&D, focusing mainly on serving their customers in specific regional markets. The leading software firms have all invested abroad, mostly in developed countries. For example, Infosys, Wipro, Birlasoft and HCL Technologies have operations in the United States. They are also moving into selected developing-country locations where they have major customers, especially China and the CIS. Some Indian software R&D affiliates are located in other developing regions (e.g. Tata has invested in Uruguay) as well as in new EU member countries (Hungary). Indian firms in other industries such as pharmaceuticals and chemicals are also investing in R&D abroad.

TNCs from the Republic of Korea started establishing R&D affiliates abroad only in the 1990s. In 2005, a survey carried out by the Korea Industrial Technology Association identified 60 foreign R&D centers owned by Korean firms. The United States was the main target of such investment (17 R&D centers) followed by China (15), Japan (7), the Russian Federation (5), and Germany (5). The majority of R&D centers in China (12 of the 15) have been operating since 2000. Some of the Korean firms investing abroad in R&D also figure prominently on the list of the 700 largest R&D-spending companies of the world: these include Samsung Electronic (33rd in world ranking and the largest R&D spender in the developing world), Hyundai Motor (95th) and LG Electronics (110th).

3. Internationalization of innovation: Patent analysis

The role of domestic and foreign firms in the R&D activities of a country can be gauged from measures related to the output of R&D activities. The analysis in this section draws on information on patents from the World Intellectual Property Organization (WIPO). Patents are increasingly recognized as a rich source of information regarding technological performance. The patent-based indicators of internationalization of technology are calculated at the macroeconomic level. They relate to the research activity

abroad of domestic multinational firms and to the domestic activity of foreign multinationals. They also relate to the resident and non-resident commercialization of granted patents.

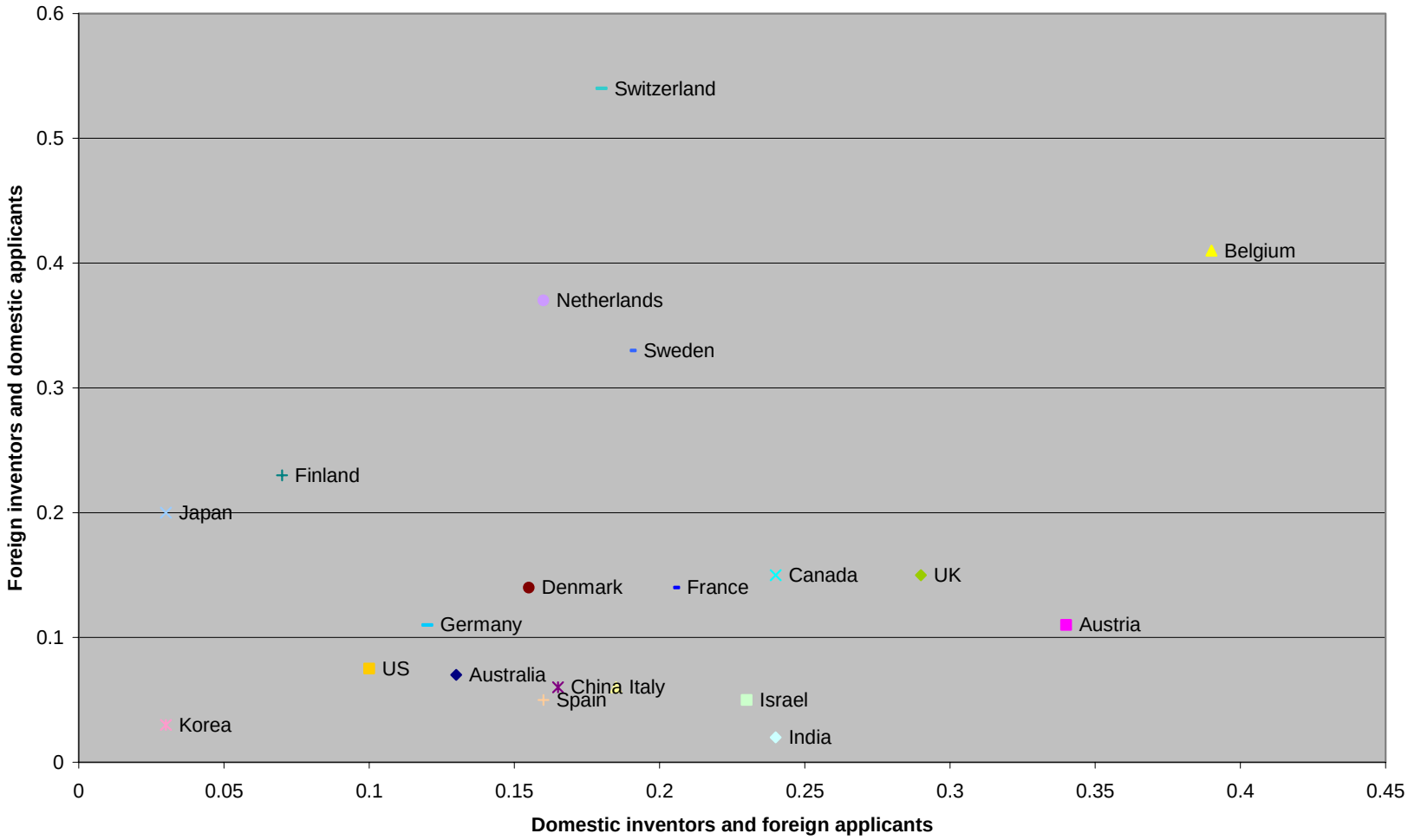
Among the information available from patent files are the inventor and the assignee's countries of residence. This information allows mapping some aspects of the technological internationalization process. Cross-border ownership of inventions happens when the inventor and the applicant reside in different countries. It is deemed to reflect the location of R&D activities of multinational firms. For most patents, the applicant is an institution, such as a firm, a university, a public lab. The inventor is always an individual, usually a researcher employed by the applicant. Most often, the address of the inventor is the address of the lab. Then, when the inventor and the assignee of a patent don't reside in the same country, this reflects the fact that the patent protects an invention performed for a foreign firm, mostly in a research facility of a multinational firm. Increasingly, however, innovation is also being outsourced.

Patents assigned to foreigners may be the output of R&D outsourced by foreign TNCs to scientists in the listed economies or the output of R&D conducted by inventors employed by foreign affiliates in these economies. Regardless whether research is internalized or outsourced, inventions made by inventors resident in these host economies are assigned to entities (typically TNCs) based in other countries. Thus the share of patents assigned to foreigners in the total number of patents granted to residents in a country can be seen as an indicator of the role of foreign TNCs in the innovation activities of the economies (e.g. Guellec and van Pottelsberghe de la Potterie 2001, 2004). The current analysis is based on all types of patents, including those filed by small firms, large domestic firms, public institutions, and universities, which means that the degree of internationalization of a country is fully represented. However, the current methodology does not allow for the identification of the actual owner of the patent.

The X-axis (Figure 1) shows the share of patents for a given country with a domestic inventor and a foreign applicant in a country's total domestic inventions. It reflects the extent to which foreign firms control/own domestic inventions.

The Y-axis (Figure 1) is the share of patents for a given country with a foreign inventor and a domestic applicant in the country's total domestic applications. It reflects the extent to which domestic firms control foreign inventions.

Figure 1. Inward and outward internationalization of innovation (2006)



Source: PCT data, WIPO

A number of conclusions can be drawn from Figure 1. In terms of domestic inventors and foreign applicants, there is a striking heterogeneity across countries. It is clear that a significant proportion of patents are subject to cross-border ownership. Amongst the largest patenting countries, the UK is characterized by a relatively high degree of internationalization of its technology. Smaller countries, such as Belgium and Austria are highly internationalized in this respect. It is well known that small economies are more internationalized than large ones in terms of trade as well as foreign direct investment. It turns out that this applies to technology as well. A large share of all patents granted to inventors in these economies is assigned to owners abroad, notably TNCs. Therefore, since few foreign affiliates are owners of patents in these countries it would appear that TNCs tend to centralize the ownership of patents at headquarters.

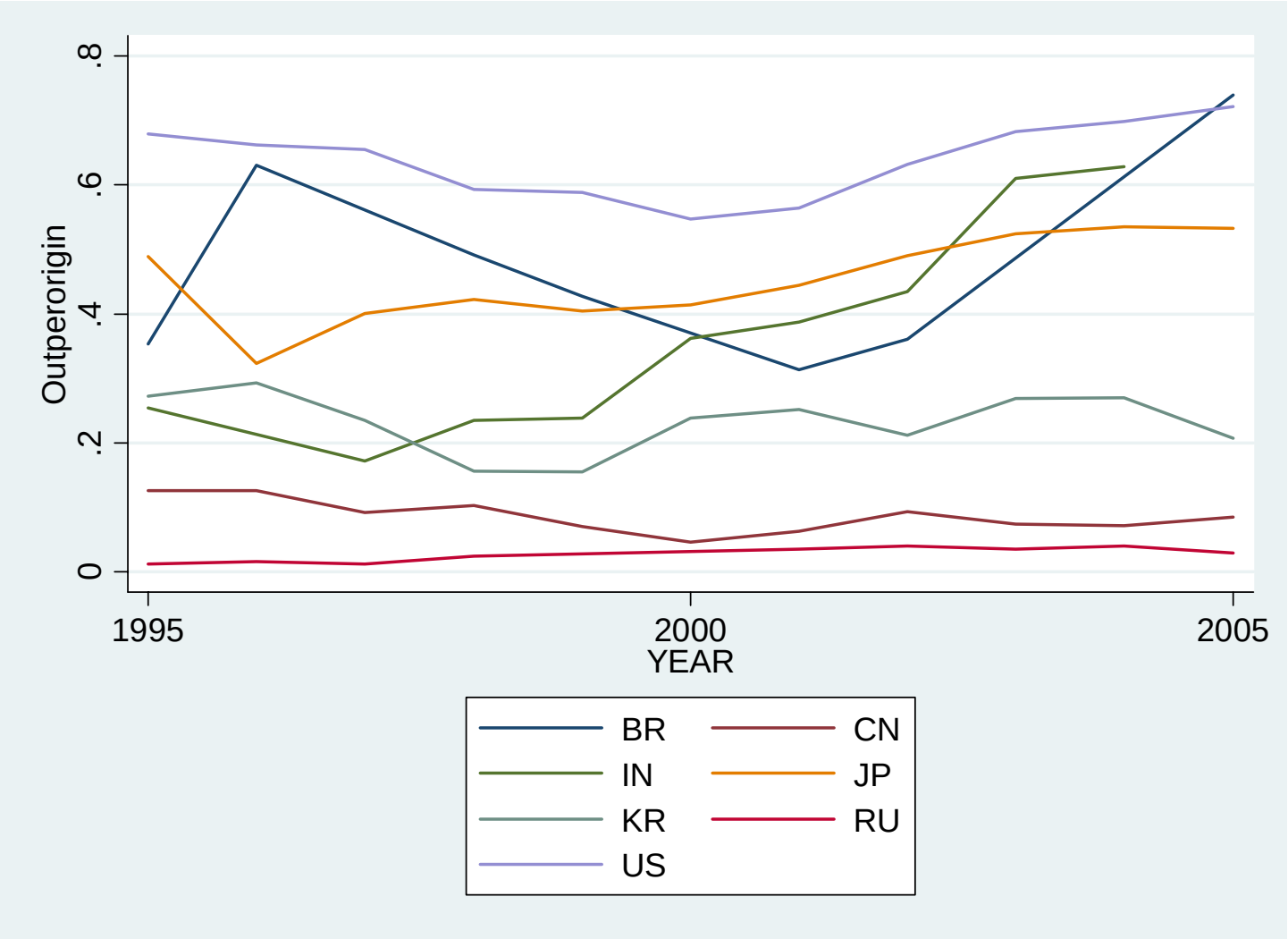
However, R&D intensive countries are much less internationalized than the other countries. For instance, very few inventions made in Japan are controlled by foreign firms. But this is also true for countries like Germany or the US, although less so. In fact, in most countries the share of domestic inventions owned by foreign firms is substantially higher than the share of foreign inventions in total domestic applications. The reverse is true for only a few countries, like Japan, Finland, Sweden, the Netherlands, and Switzerland. Belgium has a high incidence on both accounts.

In fact, Belgium and Korea are on opposite sides of the quadrants. Belgium has a high share of both outward and inward internationalization of technology, with an approximate share of 40% of domestic inventions for foreign applicants and foreign inventors for domestic applicants. This is fully in line with its top transnationality index position (UNCTAD, 2007). In a similar yet contradictory vein, Korea has a low percentage of inventions controlled by foreign applicants and a low percentage of foreign inventions controlled by Korean residents. In fact, Korea is the most inward-oriented country, especially given its high incidence of patents per gross domestic product at more than 100 for each billion USD of GDP. Most countries only average between a few inventions (like India) over ten or so (like China) to about twenty (like the US or Germany) per billion USD GDP. The only other exception being Japan, with about 100 patent filings by residents per billion USD GDP.

India has a fairly high incidence of domestic inventions for foreign applicants, at about 25 percent. China has a somewhat smaller percentage, but from a significantly higher number of patents. Both countries score rather poorly on their use of foreign sources of technological capacity.

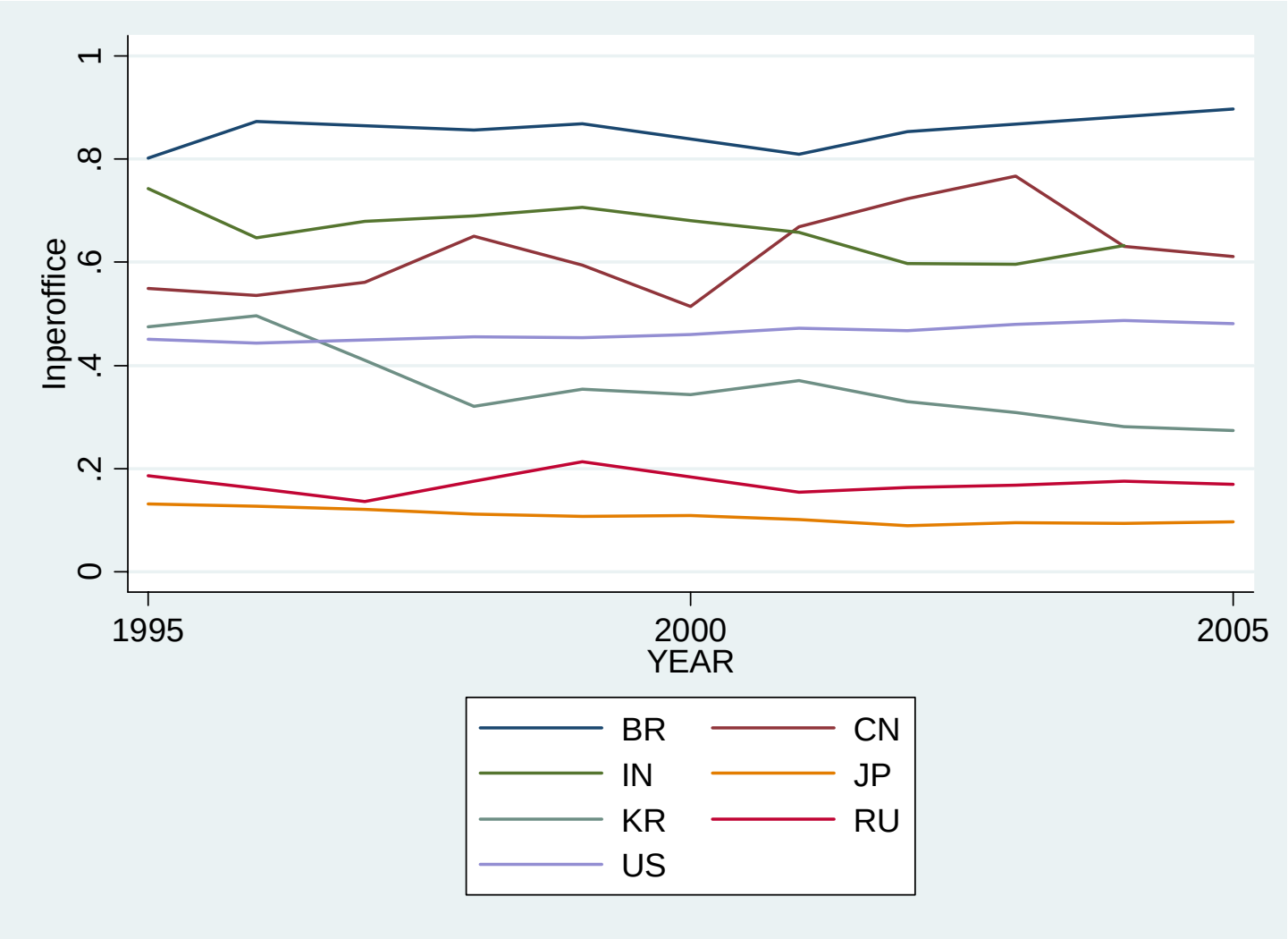
Although the generation of technology and patents is of paramount importance, the commercialization of inventions is mostly highly underrated. However, for every dollar of basic research you need a multitude to get it to market. In order to determine the use of patents granted, a second kind of analysis of the internationalization of innovation is also carried out. Once the patent has been granted in one office (origin), its use around the world can be followed through patent requests in other countries (office). Two indicators have been calculated to calculate the commercialization of patents.

Figure 2



Source:

Figure 3



Source: Author's calculations on the basis of WIPO (2007)

Outperorigin is the share of foreign patents for a given country of origin in the country's total patents. It reflects the extent to which firms exploit domestic patents internationally. Inperoffice is the share of foreign patents for a given country of destination in the country's total patents. It reflects the extent to which foreign firms exploit patents in the host market.

Figure 2 and 3 show the latest levels and trends for a number of selected economies. Among the countries with a high incidence of patenting, the US and Japan succeed in successfully commercializing their innovations abroad. Korean firms and/or patents do not seem to be able to do so, perhaps due to a lack of competitiveness. Some emerging countries like China or Russia seem to suffer from the same weakness. Brazil and India have a much higher incidence of patent internationalization, but this is more due to the low absolute level of patents granted. China, for instance, outscores India by a factor of 10 in terms of patents granted.

In terms of incoming patents for the various countries, there is again a substantial heterogeneity. Among the richer countries, the Japanese market seems to be blocked and unable to benefit from the worldwide creation of innovation. Korea seems to open up more, although the share of inperoffice for Korea declined over the last few years. The US attracts a substantial number of foreign patents, without losing its own market share. For emerging countries, Brazil is swamped with foreign patents, indicating that progress in its technological capacity is lagging its market progress. A similar trend can be seen for China, although to a lesser extent. India also has a rather high percentage of foreign patents, but not to the same degree because the number of patents in India is again quite small.

4. Concluding remarks

This paper presented and analyzed several indicators of internationalization of technology derived from information available in patent data. The indicators witness an increasing trend towards the internationalization of technology for most countries. Innovation – and especially R&D – increasingly needs constant access to international knowledge. However, there are large differences in the extent of internationalization across countries.

Internationalization of a country's technological activities decreases with its size and with its R&D intensity. This partly explains the relative insulation of Japan, for instance. Another factor is, of course, Japan's policy not to open up to foreign direct investment; a policy shared by Korea. As the indicators of technological internationalization are closely linked with other indicators of internationalization, such as the share of output produced by foreign firms, Korea and Japan have a significantly lower incidence of "foreign" R&D in their country. Although they both score very high on the incidence of patenting in their country, they score fairly poor with regard to the global commercialization of these inventions. Japan does a bit better than Korea through its higher outward foreign direct investment. It would appear that their models of economic development have encountered a barrier, and that barrier, oddly enough, is technological. Japan has already tried its hand in outward foreign direct investment but is increasingly realizing that it

needs to open up to inward internationalization. The Japanese government has been trying to accomplish just that for the past few years, with limited success, however.

India has a fairly high incidence of domestic inventions for foreign applicants, at about 25 percent. India also has a high percentage of foreign commercialization of domestic patents, but the absolute numbers are pretty small. It would appear that India has received investment in R&D labs and also has some world-class patents of their own, but has not been able to technologically benefit from the regular investment channel. It is suggested here that foreign direct investment might be a useful conduit to jumpstart this process.

China has a somewhat smaller percentage of outgoing domestic inventions, but from a significantly higher number of patents. China seems to be doing better as it has better grasped the inward internationalization process. It has used foreign investment to jumpstart domestic firms into technological activity. The number of inventions and also patents has increased exponentially. Obviously it doesn't have a high percentage of outgoing inventions and patents, but their outward internationalization and commercialization process has just begun.

In sum, all "late industrializers" tap technical knowledge and skills from the early starters, though in different ways. While there are various ways to link up with global knowledge networks, inward and outward FDI in R&D is perhaps the most direct way in which a country can connect with centers of knowledge in other countries. National innovation systems are becoming increasingly interdependent. The absence of local capabilities can effectively limit interaction between one system and the rest of the world, and thereby condemn the system in question to isolation from the mainsprings of technical change and competitiveness. The extent to which developing countries can link up with global networks of learning and knowledge creation depends on their national innovative strengths.

While the early stages of development necessarily have to involve nurturing indigenous innovative capabilities in the public as well as in the private sector, TNCs can play a role in strengthening an NIS. But foreign affiliates do not always undertake high-level technological activities in host countries. Many developing economies have long had FDI in resource extraction, manufacturing and services without foreign affiliates doing R&D. What is new is that the trend is for more TNCs to spread R&D to some developing countries, to a degree and in ways not seen before.

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