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Chapter 6

Host-Country Patenting and Inventorship in Emerging Countries

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Additional information is available at the end of the chapter

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Abstract

We analyze the increasing globalization of worldwide research and development (R&D) with a focus on emerging countries, by using patent data as a proxy. The number of host-country patents has skyrocketed in the emerging countries, for example, the number of US patents created with foreign inventors in China and India has more than decupled between 2000 and 2013. At the same time, emerging countries, such as China, Korea, India, Israel, Brazil, and Russia have significantly increased their patenting efforts, with China attaining rank 3 with more than 10% of all worldwide Patent Co-operation Treaty (PCT) patents in 2013, up from position 9 in 2000. Thereby, the former dominance of the Triadic countries has been reduced considerably. We conclude that the flow of innovation in emerging countries is not a one-way street anymore, but rather goes in both directions.

Keywords: host-country patenting, innovation, R&D, internationalization, patent analysis

1. Introduction

Globalization of research and development (R&D) and a rapid build-up of science and technology in many countries of the world can be observed during the period 2000–2016. An increasing number of emerging countries attempts to build-up science and advanced manufacturing and service sectors, in order to attract foreign multinational corporations (MNCs). Increasing R&D investments and the shortening of product lifecycles, together with the need to locate R&D close to markets and production environments, serve as additional drivers for multinational firms to establish distributed R&D centers in different countries, including uprising nations such as China, India, Singapore, Brazil, and many others.

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There is a lack of data on outward R&D investment, specifically with respect to emerging countries. While data on inward R&D investment by foreign multinationals in more advanced countries are made available within the Organization for Economic Co-operation and Development (OECD) Main Science and Technology database (MSTI), we still do not know enough about the size and performance characteristics of R&D labs within the uprising non-OECD countries.

One way of analyzing innovation activities in situations where R&D data are not available (or not reliable enough) is to use patent data as a proxy. The Center for International Management and Innovation has thus developed methods of host-country patenting and host-country inventorship. **Host-country patenting** analyzes to which extent multinational corporations file patents for which inventors located in specific countries have made a significant contribution. This information is used as a proxy for estimating the involvement of scientific and engineering work of a specific R&D location in the host-country.

Data on patenting activities of specific researchers in certain locations can then be used for further detailed investigations on **host-country inventorship**. This includes sample data on technical fields of discovery, application areas by product group, collaborative inventorship, as well as patent citations. Detailed patent analysis is then complemented by field studies and interviews.

We use data on patents filed under the Patent Co-operation Treaty (PCT) agreements and analyze changes during the period 2000–2013. As shown in Section 3, the total number of patents has doubled during this period. Furthermore, selected emerging countries as applicants are increasingly active with patents both at the national and the international level. China has attained rank 3 with more than 10% of all PCT patents in 2013, up from position 9 in 2000. Korea has risen from position 8 to rank 5 in 2013. Other important uprising countries are India, Israel, Brazil, and Russia.

This chapter will focus on analyzing changing trends of foreign inventorship in the period 2000–2013. We will first analyze the major source of foreign R&D spenders by MNC and the increased importance of R&D labs in the Brazil, Russia, India, and China (BRIC) countries (Sections 2, 3). These data are differentiated by sectors and product groups. The share of foreign inventorship was going up strongly for companies from the USA, Germany, France, and the UK. More recently, companies from China also increased their share of inventors located in foreign R&D labs.

We then analyze the profiles of the major host-countries and their inventor characteristics. We will focus on China, India, Israel, Singapore, Brazil, Taiwan, Korea, and Russia. Information on strong increases of inventorship in specific technical fields and in specific sectors, together with additional information on collaborative patenting and patent citations, serve as an excellent data source for assessing country-specific development patterns.

2. Globalization of R&D and patenting trends in emerging countries

Since the 1990s, we can observe a persistent trend toward globalizing value chains including production, logistics, as well as research and development (R&D). Multinational corporations are the main drivers of this process that leads to the global dispersion of production and

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R&D-related activities. Between 1990 and 2005, however, foreign R&D investments within multinational firms were primarily concentrated within a rather small group of advanced countries. Major investor countries were the USA, Germany, Switzerland, France, Sweden, Britain, and Japan. MNCs from these countries increased their share of foreign R&D spending continuously, even though they invested primarily in other advanced countries. Still in 2003, the major target countries for R&D investment within MNCs were: (1) the USA, (2) Germany, (3) the UK, (4) France, (5) Japan, (6) Canada, and (7) Sweden followed by Belgium, Italy, and Spain [15]. Other emerging or less developed countries were considered as production location, but not as a destination for establishing R&D laboratories.[1]

This pattern has changed considerably during the period 2005–2015. While foreign R&D spending still followed on upward trends in general, selected emerging countries became an interesting target for MNCs, particularly those that followed a technology-oriented transformation process. The so-called BRIC countries as well as other emerging nations were pursuing strategies of innovation-driven development, with a strong emphasis on attracting R&D labs of foreign MNCs. The UNCTAD World Investment Report in 2005 highlighted the role of transnational corporations and the internationalization of R&D, and emphasized the new role of China and India as potential targets [18].[2] Increasing R&D investments and the shortening of product lifecycles, together with the need to locate R&D close to markets and production environments, serve as additional drivers for multinational firms to establish distributed R&D centers in an increasing number of new high-tech nations.

US-based MNCs in particular have increased their foreign R&D, spending from 28 billion in 2005 to 52 billion in 2014. While major US R&D investments are still concentrated in Europe, China, and India have attracted an annual level of 3 billion of R&D investments each, and rank at position numbers 5 and 6. Both countries have become a more important location for R&D labs within the US-based MNCs than France or Japan [2, 3].[3] Similar patterns can be observed for MNCs from other advanced countries. A survey of foreign R&D spending on German MNCs found that China and India together with Brazil and selected countries in Eastern Europe are seen as important new targets for establishing new R&D centers [7, 8] .[4]

The process of foreign direct investment from an advanced country into an emerging country represents an effective mechanism of inward technology transfer. The effectiveness of this process can be measured by indicators of host-country patenting and host-country inventorship. These indicators as well as the performance of selected target countries will be described in Sections 3 and 4. We assume that a sequential upgrading of technical capabilities as well as of human talent takes place as illustrated in **Table 1**. In an initial phase, foreign MNCs will increase sales revenues as well as production in the target country. Under certain conditions, foreign MNCs will then build-up development centers that support local production and

[1]There were some early exceptions, based on strategies in Singapore, Israel, and China to attract foreign R&D [4].
[2]See UNCTAD (2005), summarizing a survey on R&D investment targets among managers within MNC [18]. For newest version please see Ref. [19]
[3]See the studies of the U.S. Bureau of Economic Analysis in the Survey of Current Research [1, 2, 3]
[4]See EFI ([8], chapter A5) for a survey on outward R&D investment of German MNC as well as EFI ([7], chapter B2) for an in-depth analysis of the new role of global R&D in Germany, as well as [6]

Value-adding activity	As measured by
Increasing export sales	FTO-ratio revenues
Production in host-country	FTO-ratio production
Application-oriented development in host-country	FTO-ratio D
Country-specific research activities	FTO-ratio R
Increased patenting in host-country	Patent indicators at the patent office in host-country
Increasing share of inventors from host-country international patents	FTO-ratio host-country patenting

Table 1. Measuring the performance of R&D capabilities and inventorship in host-countries.

country-specific market requirements. The third phase does not involve much sophisticated R&D work or the formation of inventive activity in the host-country. In later years, however, the target country may provide improved conditions for doing sophisticated research, for example, through local research capabilities, universities, highly educated people, as well as demanding customers. Furthermore, governments may actively support or even require the formation of more advanced R&D labs, as has been observed in Singapore and China. In this case, the MNC builds up more advanced R&D centers of increased size and sophistication. More research-type activities are then organized in the respective country, and such an off-shore R&D center may even develop into a leading center-of-excellence for a certain technology or product group. Local inventors will become involved in discovery processes, and the resulting inventions eventually lead to stronger patent repositories.

The performance of inventors and patenting activities can then be measured using different indicators. In a first step, technology upgrading is measured by patents registered at the national patent office in the host-country. Past studies by the authors have revealed the following patterns for selected Asian countries. In a first phase, patent filing was dominated by foreign multinationals. Later, local firms and applicants increased their share in national patent filing. Additional measures of patent quality can then be used to assess the performance of host-country inventors [7].[5]

The movement from step 5 to step 6 in **Table 1** represents an additional performance improvement for which the quality of local inventorship can then be assessed through the participation of host-country inventors in international patent filing. If inventors from emerging countries appear as major contributors on patent documents filed at the European Patent Office (EPO), at the US Patent Office (USPTO), or under the PCT agreement, it may be concluded that this person's contribution represents inventive work relevant for the international pool of knowledge. In the following sections, we analyze **host-country patenting** as the number resp. the share of inventors

[5]In a case study on China, the author has developed this metric while working as a member of the EFI-Commission (see particularly in EFI ([7], chapter B5). This patent upgrading process was also observed for the early phases of inward technology transfer in Japan and South Korea (see Refs. [12] and [13]).

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located in a certain foreign country (like India), that appear on EPO patents filed by one or more MNC from an advanced country. Over time this share tends to go up for specific corporations and for certain industries. This performance indicator is then used as a proxy for the extent and quality of R&D of a particular location within a specific corporation. The share of host-country patenting tends to be somewhat smaller than the share of foreign R&D. As an example, German MNCs invests about 28–30% of R&D abroad, while the rate of foreign inventorship is only 18%. Still, host-country patenting is a useful proxy in cases where data for foreign R&D expenditures are not published. Furthermore, upward changes in host-country patenting are signaling developmental performance and capability-building within a specific country or region.

3. Patenting trends 2000–2013 and the new role of emerging countries

The Organization for Economic Co-operation and Development (OECD) publishes and processes patent data on a national level as supplied by the European Patent Office (EPO), the U.S. Patent and Trademark Office (USPTO), patent applications filed under the Patent Co-operation Treaty (PCT) that designate the EPO, as well as Triadic patent families [16].

The advantage of EPO and PCT is that applicants only have to apply at one institution for a transnational patent protection. We, as researchers, in turn, benefit from a relatively standardized and comprehensive data set and an overview of the worldwide patenting activities of MNCs in OECD and non-OECD countries, by combining the EPO and PCT data. Through the databases, we determine corresponding patents both filed under the PCT, as well as the EPO treaty, in order to avoid double counting in our analyses [10].

The patent filing process regularly takes at least 2 years, which has the following two implications. First, we have chosen to analyze the priority year, not the filing year, as the former implies a shorter time span to the actual invention, that is, the underlying research activity. Second, we want to contrast the most recent data on patent filing with data for the year 2000. As the most recent reference year, we have chosen the year 2013, since data for later years are still incoherent and incomplete due to the above-mentioned time-lag of 2 years. The data shown and discussed in the following were retrieved and last updated in December 2016.

A total of 202,051 patents were filed under the PCT-Treaty worldwide in 2013, compared to 172,174 in 2010 and 102,702 in 2000. From 2000 to 2013 the annual patent filings have almost doubled with an annual growth rate of 5.3%. This outlines the increasing importance of R&D as a determinant for business success through the proxy of increasing patent filings.

As shown in **Table 2**, the decreasing distance of the number of patents between the USA as rank 1 and its followers suggests that the overall dominance of the USA in R&D activities has decreased, particularly through the new role of countries like China and Korea. China has significantly caught up in terms of patent filing, growing at an annual rate of 22.7% between 2000 and 2013. As a result of strong patenting in uprising countries, the former dominance of the Triadic countries has been reduced considerably [11].

Rank 2013	Country	No. of patents 2000	No. of patents 2013
1	USA	40,839	57,266
2	Japan	10,895	41,739
3	China	1628	23,220
4	Germany	13,313	17,206
5	Korea	1964	11,942
6	France	4695	7729
7	UK	5810	6194
8	Switzerland	2340	4070
9	Netherlands	3299	3951
10	Sweden	3274	3662
	World total	102,702	202,051

Table 2. Overview number of patents by country of applicant.

We now look at the international distribution of inventorship within multinational corporations. We study, where the inventors mentioned on patent documents are located. A "foreign inventor" is defined as a person located outside of the homebase country of an applicant organization, that is, in most cases the location of the company's headquarter. We conducted the

Rank 2013	Home base of applicant	2010		2013	
		Patents with foreign inventors	Share of foreign inv. (%)	Patents with foreign inventors	Share of foreign inv. (%)
1	USA	4345	27.0	6695	23.7
2	Germany	2016	12.5	3482	12.3
3	China	206	1.3	3201	11.3
4	UK	2096	13.0	2854	10.1
5	France	1362	8.5	2102	7.4
6	India	125	0.8	1317	4.7
7	Japan	943	5.9	1233	4.4
8	Switzerland	589	3.7	930	3.3
9	Russia	242	1.5	386	1.4
10	Korea	101	0.6	365	1.3
	World Total	16,083	15.7 (of world patents)	28,235	14.0 (of world patents)

Table 3. Major target countries for R&D as measured by foreign inventorship.

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method of "partial counting" [5] to determine how many patents have been filed by inventors with residence in the respective countries. **Table 3** shows the major target countries for R&D by foreign inventors in the years 2010 and 2013.

Data on patent filing and the share of foreign inventors serve as a proxy to determine the magnitude of research activity and inventiveness in the respective country. As an example, if a US-based automotive supplier files in a certain year 40% of its patents with Chinese inventors, one may safely deduce that China is an important R&D location for this company. However, based on partial counting we may assess the weight of the Chinese contribution. If the US company files one patent with nine US and one Chinese inventors, that patent would be counted as 0.9 for the number of home-based, that is, US patents and 0.1 for the number of patents with foreign inventorship.

While the biggest number of patents usually gets filed with inventors from the country of the respective headquarters, an increasing fraction and absolute number of patents is based on the work of inventors located in foreign countries. In **Table 3**, we analyze the share of foreign inventors for companies headquartered in 10 major home countries. The absolute number of foreign inventors has gone up for most of the countries, even though the relative share of foreign inventorship has slightly been reduced for the USA, UK, France, and Japan. During the same period, Chinese applicants have increased their share of foreign inventorship from 1.3 to 11.3%, while companies from India were increasing this share from 0.8 to 4.7%.

In the following **Table 4**, we will break down the target countries for US- and Germany-based corporations, the two countries with the highest number of foreign inventors. We analyze the international distribution of inventors for US-based corporations. Until 2000, most of the foreign

Rank 2013	Country	No. of patents 2000	No. of patents 2013
1	**China**	**118**	**1300**
2	Germany	788	1202
3	UK	1040	1169
4	Canada	614	830
5	**India**	**66**	**780**
6	Israel	338	580
7	Japan	568	560
8	France	431	505
9	Switzerland	153	294
10	Belgium	246	280
	Total number of patents with foreign inventors	5483	9356

Table 4. Target countries for US-based corporations.

inventors within US applicant were located in the UK, in Germany, Canada, Israel, and Japan. China and India still had a minor role. This changed considerably and in the year 2013, China became the most important location for foreign inventors with US corporations. India has also attained number 5, overtaking countries like Japan, Israel, and France. Other emerging countries in Eastern Europe, Asia, and Latin America are also becoming more important as locations for R&D activities within US corporations.

For German corporations, the ranking of foreign inventors is analyzed in **Table 5**. Four of the most important inventor locations, like the US, France, the UK, and the Netherlands, remain at the top throughout the whole period. China has increased in importance and has even overtaken the role of the neighboring states (like Austria, Switzerland, and Belgium). India, Brazil, and some Eastern European countries have increased their share of foreign patenting within German corporations.

China and India have not only significantly increased their number of patents and the share of foreign inventors; they have also grown in significance as a location for foreign R&D, as shown exemplarily with the case of the US and Germany. This suggests that the flow of innovation is not a one-way street anymore, but rather goes in both directions.

Rank 2013	Country	No. of patents 2000	No. of patents 2013
1	USA	793	984
2	France	228	313
3	UK	132	254
4	Netherlands	111	222
5	**China**	**22**	**214**
6	Austria	255	211
7	Switzerland	186	204
8	Belgium	109	110
9	Italy	67	106
10	Japan	102	98
11	**India**	**17**	**75**
12	Brazil	5	60
13	Sweden	60	58
14	Singapore	17	54
15	Spain	61	47
	Total number of patents with foreign inventors	2263	3207

Table 5. Target countries for German corporations.

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4. The evolution of host-country patenting in BRIC countries

British economist Jim O'Neill first coined the term "BRIC" in 2001 as an acronym for the countries Brazil, Russia, India, and China. These countries, unified by their two-digit GDP growth rates, were assumed to eventually surpass the established Western economies [14]. This group of countries held their first official summit in 2009.

Over the years, the BRIC countries have diverged: while China's economy has consistently grown at a high rate over the last years, other countries have struggled to keep the once high expectations: a plummeting oil price and sanctions in connection to the Ukraine crisis have devitalized the Russian economy, while an unstable political situation, dropping commodity prices, and an increasing indebtedness of the private sector have halted Brazil's economic growth. The concept of BRIC and their importance still prevail, as these countries encompassed 41% of the world's population in 2015 [20].

As shown above, particularly China and India are countries of interest, which shall be examined further. In this section, we will analyze the information and communication technology (ICT) sector, as it is one of the most relevant sectors of R&D in emerging markets [17] and show the innovation development of the biggest companies, by looking at the patent data.

The European Commission publishes in its "Investment Scoreboard" company data annually, including the respective R&D spending of companies worldwide [9]. This in-depth data allow to identify the innovation development of companies and track their development. Through analyses we have identified the Top 100 companies in the ICT sector.

Subsequently, the raw patent data for each company are analyzed, as described above, and aggregated by country of inventor for the 6-year periods 2000–2005 as well as 2006–2011.

We show the most relevant companies of the ICT sector in **Table 6**, sorted decreasingly by their overall number of patents in the period 2006–2011. The displayed nine companies are all the ICT companies with at least two-digit number of patents in either China or India in the period 2006–2011.

The data reveal first that both China and India are highly relevant countries for innovation in the ICT industry, with China having the edge. It also is revealed that several companies exceed the country average, as shown above, by far, meaning that R&D investment is highly diverse.

Depending on the respective business strategy some companies have heavily ramped up R&D investments over the last years in the emerging countries, with Alcatel Lucent, for example, generating almost 20% of their worldwide patents in 2006–2011 with Chinese inventors alone.

In our forthcoming publications, we will put these developments in host-country patenting under scrutiny and explain the reasoning of some companies that are heavily investing in emerging countries.

Company	Country	China		India	
		2000–2005	2006–2011	2000–2005	2006–2011
Samsung	KR	25.5	42.2	12.6	86.3
Alcatel Lucent	FR	43.6	263.5	0.8	75.5
Hewlett-Packard	US	4.1	14.9	32.0	40.1
Intel	US	35.9	88.0	15.5	9.4
Cisco Systems	US	0.0	0.2	8.3	10.3
Google	US	0.0	11.1	0.2	7.0
Fujitsu	JP	3.5	85.6	1.0	1.0
MediaTek	TW	12.0	213.3	0.0	0.3
Hon Hai Precision Industry	TW	7.0	90.3	0.0	0.0

Table 6. Development of patent filings by country of inventor in the ICT industry.

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