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EXPLORATORY TIME-TREND ANALYSIS OF 'ELECTRICAL ENGINEERING' AND CHEMICAL TECHNOLOGICAL DOMAINS PATENTS IN BRAZIL: LESSONS FOR DEVELOPING COUTRIES

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Exploratory time-trend analysis of 'electrical engineering' and chemical technological domains patents in Brazil: lessons for developing countries.

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This paper presents data on the patenting practice in Brazil and contributes to the understanding of some characteristics of the Brazilian National System of Innovation that possibly other countries with the same level of industrial development share with it. In particular, the paper throws some light on the fact that in Brazil there is a dominant share of patents on the hands of non-residents, almost all non-residents are transnational companies (TNCs) and most of them are from the USA, Western Europe and Japan. Besides this, we show that indigenous companies' strategies are not straight forwardly translated into patents and those indigenous companies, which were acquired by TNCs, reduced their patenting activities. This article focuses on 'electrical engineering' technological domain – electrical components, audiovisual, telecommunications, information technology and semiconductors – and 'chemical' technological domain – organic fine chemicals, macromolecular chemistry, pharmaceuticals and cosmetics, and biotechnology – using data from PATSTAT.

Keywords: IPRs, TNCs, Development

CNR-IRPPS

Analisi esplorativa delle tendenze dei brevetti nei domini tecnologici di 'ingegneria elettrica' e di 'chimica' in Brasile: lezioni per i paesi in via di sviluppo.

Tulio Chiarini*, Marcia Siqueira Rapini, Thiago Caliari, Leonardo Costa Ribeiro

2017, p. 27 IRPPS Working paper 99/2017

Questo articolo presenta i dati sulla pratica di brevettazione in Brasile e contribuisce alla comprensione di alcune caratteristiche del sistema nazionale di innovazione brasiliana, che altri paesi con lo stesso livello di sviluppo industriale potrebbero condividere con esso. In particolare, l'articolo mette in luce come in Brasile vi sia una quota dominante di brevetti nelle mani di soggetti non residenti, essendo per la maggior parte imprese transnazionali, provenienti dagli Stati Uniti, dall'Europa occidentale e dal Giappone. L'articolo, inoltre, dimostra che le strategie delle aziende indigene non sono tradotte in brevetti e che le aziende indigene, acquistate da parte delle imprese transnazionali, hanno ridotto le loro attività di brevettazione. Questo articolo si concentra su due domini tecnologici: 'ingegneria elettrica' – componenti elettrici, audiovisivi, telecomunicazioni, tecnologia dell'informazione e semiconduttori – e 'chimica' – prodotti chimici organici sottili, chimica macromolecolare, prodotti farmaceutici e cosmetici, e biotecnologiche – utilizzando i dati di PATSTAT.

Parole chiave: Proprietà intellettuale, Imprese transnazionali, Brasile.

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SUMMARY

Introduction

Companies have different capabilities depending on to which industrial sector they belong. Some, for instance, are more knowledge-intensive (i.e., science-based) however, companies belonging to the same industrial sector are not homogeneous. Within a specific sector, there are companies with different capabilities: those, which are able to invest in creating new technologies to apply in the production processes and in product creation and others able to copy and imitate them.

The case of Brazil is interesting once it hosts a great deal of companies with heterogeneous capabilities. Brazil had a relative rapid industrialization process, under the command of companies based in developed countries. Transnational companies (TNCs, hereafter) invaded the country creating and reinforcing oligopolistic structures, benefiting from market higher concentration to ensure self-financing and plan their long-term activities, as they had economic conditions to manage prices. The main industrial activities linked to the internal market were (and still are) controlled by modern companies with their own international expansion agendas, of which little knowledge has the government in which they operate.

Despite following the development path based on 'welcoming policy' to TNCs, the openness of the Brazilian economy did not favor the development of new capabilities and indigenous industrial companies had to face the competition of more efficient TNCs that entered the country[1]. TNCs had the capabilities to create new technologies and has many strategies to maintain their market share and one of those is the use of legal protection through intellectual property rights (henceforth, IPR). In order to be part of the World Trade Organization (WTO) and to benefit from the advantages of free trade, not only Brazil but also other countries were 'requested' to have an IPR system conformed to the standards already operating in most developed countries. "We open up our markets to your merchandise, but you should guarantee our IPRs in your countries" (Filippetti and Archibugi 2015, p. 435).

Given the particularities of Brazilian industrial development, we throw some light on the fact that a specific group of entities – i.e., TNCs – deposits relatively more IPRs than other groups in the country. Our preoccupation is to identify that group of companies – which TNCs they are – and see their behavior throughout time (from 1980 to 2010) in relation to technologies considered 'strategic' and with high intensity of knowledge and high innovation propensity. In other words, we focus on the 'electrical engineering' technological domain – especially the following technologies: electrical components, audiovisual, telecommunications, information technology and semiconductors – and on the 'chemical' technological domain – especially the following technologies: organic fine chemicals, macromolecular chemistry, pharmaceuticals and cosmetics, and biotechnology. Both technological domains overlaps with almost all domains of modern technologies. Because of the technological domains selected, we use only patent information.

The framework we propose in this paper traces the evolution of patent application in Brazil over time (from 1980 to 2010) considering the ownership structure. This description is a

[1] Suzigan and Furtado (2006) and Mazzoleni and Póvoa (2010) present an overview of Brazil's economic development.

contribution to the understanding of some characteristics of the Brazilian National System of Innovation that possibly are shared with other countries with the same level of industrial development. The paper is expanded into a discussion of the role on IPR and we present arguments for the study of Brazilian domestic patents (section 1); however, the objective is not to cover all the discussion available on the topic. We then present the database and its exploratory analysis (sections 2 and 3). We conclude presenting the main points identified using PATSTAT database and use them to characterize the Brazilian National System of Innovation. We also present considerations of what the implications for economic development of a country such as Brazil are, where TNCs are the main entities when we talk about patent applications.

1. Intellectual property rights

Nordhaus (1969) and Scherer (1972) are important contributions in highlighting how relevant a patenting system is to improve technological appropriability and creating incentives for companies' innovative capacity. It is said that industrial property rights (IPR) strengthening is a decisive feature for a TNC[2] when deciding to invest in developing countries (Helpman 1992, Lai 1998, 2007).

Following the previous argument, IPRs supposedly could bring mutual benefits for both developing and developed countries, since there are improvements on goods production in developing countries[3] – which more than compensate the exclusion of imitative companies – and improvements on innovative capabilities of TNCs in its countries of origin.

Contrarily to those that advocate in favor of strong IPR system, IPRs create monopoly power, making it difficult for developing countries' companies to compete in more technological domains – those that are more likely to generate innovation, thus more profits. Critical analysts suggest that in its capacity to confer ownership and control over technological development, intellectual property has often served as an instrument of power and domination (Sell 2004). Moreover, countries at different levels of industrial and technological development face different economic costs and benefits from IPRs (Lall 2003). Kim et al. (2012), using a panel dataset of over 70 countries, find that patent protection is an important determinant of innovation and that patentable innovations contribute to economic growth in developed countries, but not in developing.

Some economists brought into the debate the evolutionary perspective that imitation is crucial for knowledge absorption, learning and capacity building. Therefore, for newly industrializing countries' companies in a catching-up processes, IPRs create real barriers for imitation[4] and can constrict copying and reverse engineering. Moreover, Archibugi and Filippetti (2010) and Niosi (2012) suggest that without imitating it is impossible to learn and

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[2] Ietto-Gillies (2012, 2015) discusses the role of technological and organizational innovation in the emergence and development of the TNC.

[3] For a review of the relationship between knowledge and economic development, see Conceição et al. (2001).

[4] Mansfield et al. (1981), through empirical studies of imitation costs and imitation time, show that patents tend to increase imitation costs, particularly in the drug industry. For a theoretical discussion see Mazzoleni and Nelson (1998a, b).

innovate, once incremental innovations, imitation and reverse engineering are important processes for developing countries' companies to absorb knowledge (Kim et al. 2012). In this toke, the strengthening of IPR in countries with little (or no) local innovative capabilities does not stimulate domestic innovation (Lall 2003).

In a historical perspective, Chang (2003) suggests that a strong IPR regime was not a recognized prerequisite for economic development for many countries that today are considered industrialized and developed. Many of these countries have used, with strong State support, theft of skilled workers, smuggling and theft of capital goods and industrial espionage, without paying for the intellectual knowledge that was being stolen and appropriated. In addition, violation of trademarks and copyright laws were frequent practices, suggesting that many countries considered developed today (including England, the Netherlands, France and the USA) had an IPR system that was quite lenient. In short, historical evidence shows that the current developed countries did not provide a strong IPR (especially to non-residents) until they were capable of generating unique and internationally competitive inventions, brands and copyrights (Chang 2003, 2004, 2009).

Worldwide, patent applications have grown considerably: in 1990, there were 997,501 provisional applications (direct and PCT[5] national phases entries) for patents in the world according to the World Intellectual Property Organization (WIPO) and in 2014, there were 2,680,900 new applications, representing a 169% growth in a decade and a half (Figure 1). Not surprisingly we acknowledge that the rise of patent applications coincide with the growth of globalized production (Lall 2003), with the rise of distance-shrinking technologies, and with the shift in companies' strategies regarding the geographical scope of their innovations (Archibugi and Filippetti 2015).

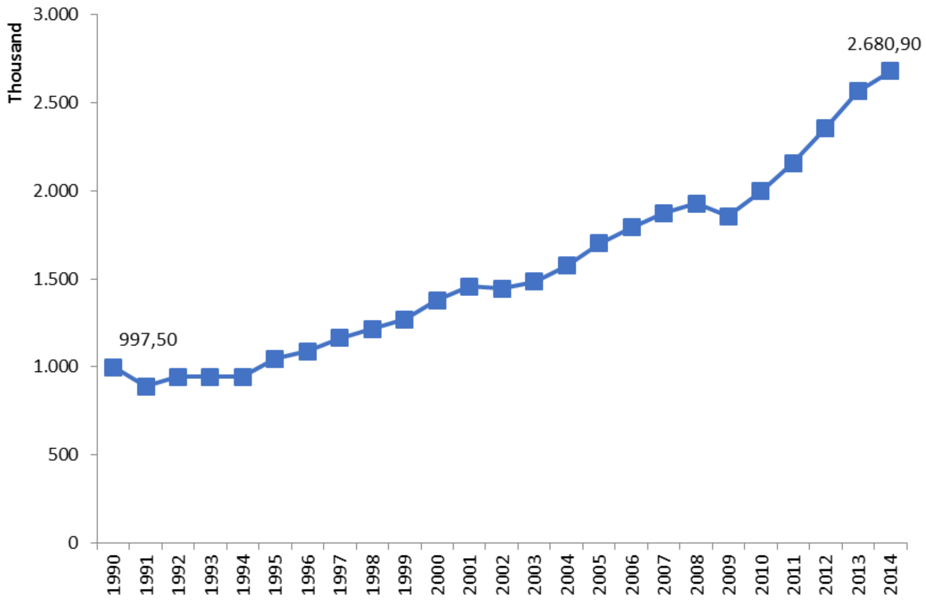
According to Filippetti and Archibugi (2015), in nowadays global economy, knowledge and intangibles are important as production factors and as consumption goods, however IPR holders are highly concentrated in number of giant TNCs (Patel and Pavitt 1997) located in developed countries[6] (Chesnais 2010, Archibugi and Pietrobelli 2003). Notwithstanding that, those companies also concentrate considering amounts of R&D expenditure, industrial design and investment in intangibles (Archibugi and Pietrobelli 2003).

Chesnais (2010) arguments that subsidiaries start to be more and more integrated to their parent-company and their R&D agendas are more subservient to the TNCs' global agenda. These TNCs assure that IPRs are protected both in their home country and in the areas where they concentrate the bulk of their sales (Filippetti and Archibugi 2015). As a result, net recipients of IPR royalties and fees are based in developed countries (mainly the US, Western Europe and Japan) and the net payers are based in developing countries (Filippetti and Archibugi 2015, Chiarini and Silva 2016, Chiarini, Rapini, and Silva 2016).

[5] PCT stands for Patent Cooperation Treaty, which presents the unified procedure for filling patent application and, according to WIPO, by filing one international patent application under the PCT, applicants can simultaneously seek protection for an invention in 148 different countries.

[6] According to Archibugi and Pietrobelli (2003, p. 872) "TNCs have a limited propensity to base their R&D and innovative activities in host countries. The quantitative evidence based on R&D and patents indicates that not more than 10% of TNCs' technological effort is carried out in host countries."

Figure 1. Total patent applications, World, 1990-2014.



Source: Author's own contribution. Data sourced from WIPO. Note: Direct and PCT national phase entries were considered.

For example, in 2014 while the high-income countries had a net receipt of US$ 12 billion, less developed countries (middle and low-income countries), according to World Bank data, had a negative net receipt of US$ 52 billion (Figure 2).

The battle between those that defend a strong IPR system and those that are against the strengthening of IPRs has been occupying a lot of debate in academics and in political forums. It is not our objective here to cover all the literature available on this rivalry due to space limitations and because too much has being done[7]. However, we do recognize that TNCs practice other strategical actions other than patenting. In fact, they develop complex strategies that include R&D activities, design, industrial secret etc. We also do recognize that imitators cannot catch-up just by getting knowledge unprotected by IPRs[8] (Filippetti and Archibugi 2015). Nonetheless, we cannot ignore the fact that some companies, especially those in pharmaceuticals and chemicals, heavily depend on IPRs, nor the fact that less developed countries spend increasingly huge amounts of resources for the use of intellectual property. Brazil[9], for instance, spent US$ 5.922 million in 2014 while received about US$ 375 million[10].

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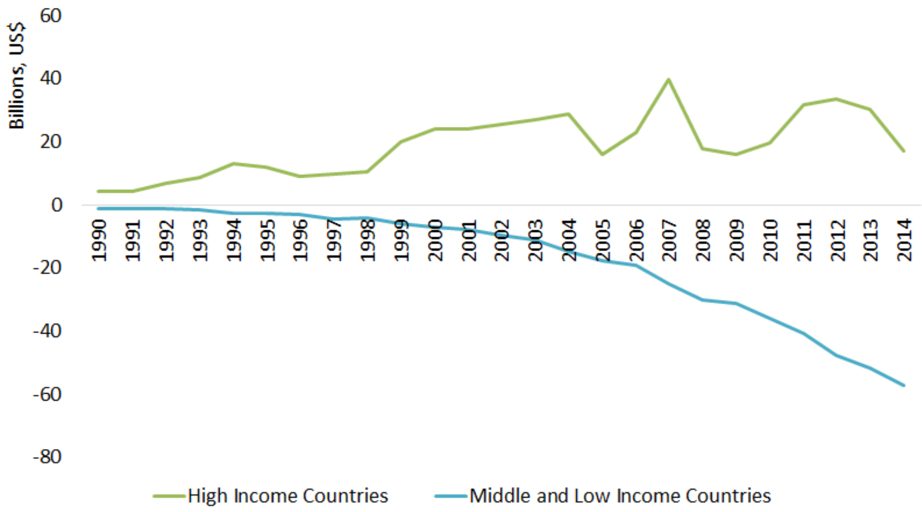
[7] Filippetti and Archibugi (2015) make a concise literature review on this.

[8] This is so because technologies are not a simply set of techniques described by their blueprints and can be codified in IPRs. "Much of the knowledge on how to perform elementary processes and how to combine them efficiently is tacit, not easily embodied, nor codifiable or readily transferable" (Archibugi and Pietrobelli 2003, p. 863). Besides this, choosing and acquiring the best technique freely available does not imply operating it efficiently (Archibugi and Pietrobelli 2003).

[9] For a review of the key features of the history of Brazilian patent law, see Mazzoleni and Póvoa (2010).

[10] Data sourced from the World Bank.

Figure 2. Charges for the use of intellectual property, net receipts (BoP, current US$), 1990-2014.



Source: Author's own contribution. Data sourced from the World Bank.

2. The Database

To fulfill the objective of identifying the group of TNCs that produce new knowledge and use legal protection as a relevant strategy to maintain their market share and see their behavior throughout time in Brazil we use the database for statistical analysis available by PATSTAT[11]. We focus on technologies considered 'strategic' and with high intensity of knowledge and high innovation propensity, which is the reason why we use patent data (excluding other industrial property statistics such as copyrights, trademarks, utility models, industrial designs etc.). However, we acknowledge that some companies use a combination of IPR instruments to protect their activities (Filippetti and Archibugi 2015). We opt to use only patent figures as they are crucial for pharmaceuticals, chemicals and electronics manufacturing industries.

PATSTAT provides raw data regarding bibliographical and legal status of each patent extracted from the European Patent Office's databases (EPO). There are different statistics regarding patents available at EPO:

i. Patent application (or deposit): it is a request pending at national intellectual property offices for the grant of a patent for the invention described and claimed by that application/deposit;

[11] In addition to PATSTAT, the Statistical Database of Intellectual Property (*Base de Dados Estatísticos sobre Propriedade Intelectual* – BADEPI v1.1) provided by the Brazilian National Institute of Industrial Property (*Instituto Nacional de Propriedade Industrial* – INPI) was used to cover some data missing on PATSTAT in recent years.

ii. Patent publication: prior to publication (generally patents are published 18 months after the earliest priority date of the application) the application is confidential to the national intellectual property offices. After publication, depending on each office rules, certain parts of the application file may remain confidential. The publication of a patent application marks the date at which it becomes publicly available;

iii. Patent granted (or issued or registered): once the patent application complies with the requirements of each national intellectual property office, the patent will be granted/issued/registered.

We use patent application data available once the patenting granting process in Brazil is sluggish. In some cases, applicants have to wait 11 years for the filed patent to be examined and to be finally approved (if it is the case)[12]. The backlog of unexamined patents at the Brazilian National Institute of Industrial Property (*Instituto Nacional de Propriedade Industrial* – INPI) is massive.

Using patent application can be a limitation of the data we are going to present in this paper as an application/deposit consists of a description of the invention and it does not guarantee at all that the property right will be granted. This choice is justified once the focus of this article is the analysis of technology trends of patenting and the time delay caused by the examining process would preclude this kind of analysis[13].

It is possible to segregate patents accordingly to different technological domains: electrical engineering; instruments; chemistry; mechanical engineering; and other fields. Each domain is subdivided into what we can call 'technologies', as shown in Table 1.

Because of the immense database that we can construct using PATSTAT, it would be impossible to analyze the information of patenting in Brazil for all technological domains, as time and space limitations are pressing. The bulk of the paper selects particular technological domains, mainly those related to the current techno-economic paradigm as 'electrical engineering', especially the following technologies: electrical components, audiovisual, telecommunications, information technology and semiconductors. We also analyze patents in 'chemistry' technological domain, considered a science-based field, especially the following technologies: organic fine chemicals, macromolecular chemistry, pharmaceuticals and cosmetics, and biotechnology. The chemistry technologies emerged in the third technological revolution and patents for this sector are relevant means of appropriation. We can see a revival of chemistry technologies in the current paradigm embracing new technologies that probably will lead to another paradigm as biotechnology.

[12] Information available at <www.managingip.com/Article/3501851/Brazils-battle-against-the-patent-backlog.html>.

[13] For a discussion about the patent indicator calculation please see: Zheng *et al*. (2014) and Moed *et al*. (2004).

Table 1. Patent by technological domains and main technologies.

Technological Domains	**Main technologies**
Electrical Engineering	Electrical machinery, apparatus, energy; Audio-visual technology; Telecommunications; Digital communication; Basic communication processes; Computer technology; IT methods for management; Semiconductors.
Instruments	Optics; Measurement; Analysis of biological materials; Control; Medical technology.
Chemistry	Organic fine chemistry; Biotechnology; Pharmaceuticals; Macromolecular chemistry, polymers; Food chemistry; basic materials chemistry; materials, metallurgy; Surface technology, coating; Micro-structural and nanotechnology; Chemical engineering; Environmental technology.
Mechanical Engineering	Handling; Machine tools; Engines, pumps, turbines; Textile and paper machines; Other special machines; Thermal processes and apparatus; Mechanical elements; Transport.
Other fields	Furniture, games; Other consumer goods; Civil engineering.

Source: Author's own contribution based on WIPO.

With the database constructed, we can answer the following questions: who are the main patentees of 'electrical engineering' and 'chemistry' technologies in Brazil? How have the entities changed overtime? However, before proceeding, we make an important caveat: compared to more developed countries, in less developed countries like Brazil local learning may exist without local patenting, therefore, domestic patent statistics do not capture a big share of relevant local technological activities (Albuquerque 2000).

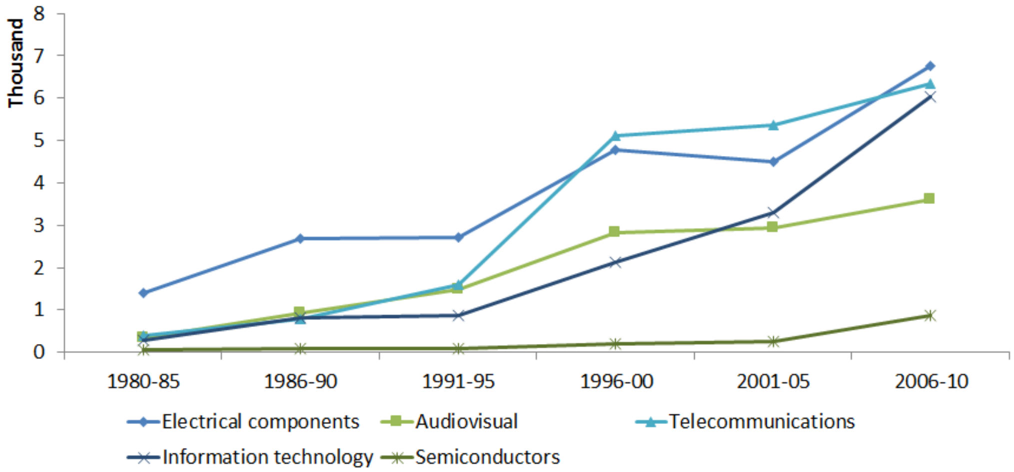
3. Exploratory analysis

The first important information is that all technologies selected had an increase in number of patent deposits over the period of analysis. Taking, for example, 'Information' technologies, it is possible to note that in 1980-85 there were 291 patent deposited at the Brazilian National Institute of Industrial Property (INPI) and in 2006-10, there were 6,027, that is, about 20 times more. 'Telecommunications' technologies on its turn had in 1980-85, 393 deposits and in 2006-10, 6,331 applications (that is, 16 times more) (Figure 3).

The same happens to 'chemical' technologies. 'Pharmaceuticals and Cosmetics' deposits have skyrocketed from only 204 in 1980-85 to 16,584 in 2006-10; and 'Biotechnology' deposits from 200 applications in 1980-85 to 5,328 in 2006-10 (Figure 4).

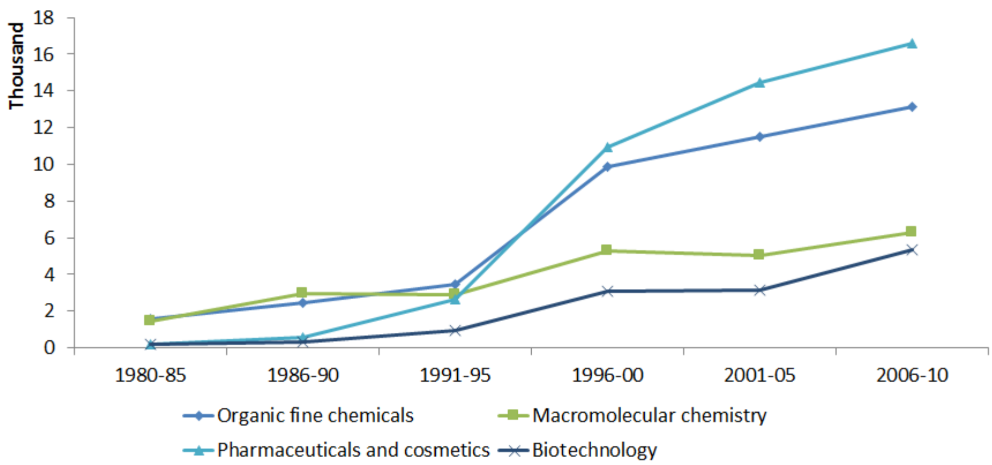
Non-residents deposited most of the patents registered at INPI. Considering the technologies presented above, in 1980-85, 84.88% of 'Information' technologies patents were deposited by non-residents; in 2006-10, the share had a little decline to 83.82%. Contrarily, 'Telecommunications' technologies patent deposits on the hands of non-residents which represented 70.74% in 1980-85 had an increase to 88.85% in 2006-10.

Figure 3. Evolution of patent deposit of selected 'electrical engineering' technologies.



Source: Author's own contribution. Data sourced from PATSTAT.

Figure 4. Evolution of patent deposit of selected 'chemistry' technologies.



Source: Author's own contribution. Data sourced from PATSTAT.

'Pharmaceuticals and Cosmetics' and 'Biotechnology' figures are even more critical: for the first, non-residents' share on the total patent application was 95.59% (1980-85) and then 93.08% (2006-10) and for the second, it was 81% and 92.27% for the two periods respectively (Table 2).

With PASTAT, we can identify who these non-residents are, that is exactly what we do next, but before proceeding, it important to make a caveat: the pattern of growth of patent depositing of non-residents is not exclusive to Brazil. Vaitsos (1972) once pointed out that most patents in less industrialized countries were owned mostly by foreign companies.

Table 2. Non-residents' share on total patent application, %, Brazil

Sector	Technology	1980-85	1986-90	1990-95	1996-00	2001-05	2006-10
Electrical Engineering	Electrical components	74.91	58.36	51.88	68.54	62.52	73.81
	Audiovisual	80.36	40.58	45.14	62.74	65.24	74.94
	Telecommunications	70.74	47.51	66.21	88.76	86.73	88.85
	Information technology	84.88	71.57	64.58	82.29	85.54	83.82
	Semiconductors	96.36	91.09	88.75	91.84	85.38	89.76
Chemistry	Organic fine chemicals	97.35	96.42	97.59	98.52	97.92	96.68
	Macromolecular chemistry	97.50	94.98	95.69	96.57	93.27	92.12
	Pharmaceuticals and cosmetics	95.59	90.19	94.77	95.63	93.78	93.08
	Biotechnology	82.00	85.04	91.70	96.16	93.45	92.27

Source: Author's own contribution. Data sourced from PATSTAT.

3.1. 'Electrical engineering' technological domain: the patentees

In the period 1980-85, 2,466 patents of 'electrical engineering' technological domain were applied at INPI, of which 76.64% corresponded to non-residents' applications, that is, 1,890 applications.

Ten of those non-residents concentrated 33.2% of all non-residents'. Non-residents' applications were deposited by TNCs and the main patentee in 1980-85 was General Electric (GE) which contributed to 5.8%. GE was followed by International Business Machines Corporation (IBM) with 4.7% and by Siemens with 4.4%. Other TNCs were also significant patentees such as AMP, Westinghouse Electric Corp, Sony, Fujitsu and Minnesota Mining and Manufacturing (3M). (Table 3).

Throughout the periods, some TNCs lost their relative relevance in protecting their knowledge of 'electrical engineering' technological domain through patents. This can be either a reflection of their relative inefficient inventive capability vis-à-vis other companies or their less preoccupation in gaining income through royalties or barring their knowledge spillover.

Motorola, for instance, in 1980-85 deposited 10 patents, in 1986-90 it deposited 50, and in 1991-95 it deposited 297 patents (being the TNCs that had most applied for a patent recognition in the period). After 1991-95, Motorola patent applications at INPI started to decline: in 1996-00, Motorola deposited 294; in 2001-05, it deposited 225; and finally in 2006-10 it had 96 patents applied in Brazil. The time-trend of Motorola's patent application can possibly reflect the failure of Motorola to anticipate great demand of digital mobiles.

GE, on its turn, was the most important player in terms of patent deposits in 1980-85 suddenly lost momentum and by 1991-95, it simply had only 23 deposits and from that period on it did not even occupied the first 20 positions of TNCs ranked by their capability to patent inventions of the 'electrical engineering' technological domain in Brazil.

Table 3. Non-residents' patent application, electrical engineering technological domain, Brazil.

1980-85	**N.**	**%**	**1986-90**	**N.**	**%**
General Electric Company	109	5.8	International Business Machines Corporation	452	15.1
International Business Machines Corporation	88	4.7	Siemens Aktiengesellschaft	126	4.2
Siemens Aktiengesellschaft	83	4.4	Westinghouse Electric Corporation	85	2.8
Amp Incorporated	69	3.7	General Electric Company	81	2.7
Westinghouse Electric Corporation	66	3.5	N.v. Philips'gloeilampenfabrieken	72	2.4
Sony Corporation	56	3.0	Amp Incorporated	54	1.8
Fujitsu Limited	50	2.6	E.i. Du Pont De Nemours And Company	51	1.7
Minnesota Mining and Manufacturing Company	38	2.0	Motorola. Inc.	50	1.7
N.v. Philips'gloeilampenfabrieken	37	2.0	Minnesota Mining and Manufacturing Company	47	1.6
La Telemecanique Electrique	31	1.6	Telefonaktiebolaget l.m. Ericsson	36	1.2
1991-95	**N.**	**%**	**1996-00**	**N.**	**%**
Motorola. Inc.	297	7.9	Qualcomm Incorporated	334	2.9
International Business Machines Corporation	294	7.8	Telefonaktiebolaget lm Ericsson (publ)	333	2.9
Telefonaktiebolaget l.m. Ericsson	146	3.9	Motorola. Inc.	294	2.6
Qualcomm Incorporated	73	1.9	Siemens Aktiengesellschaft	291	2.5
Siemens Aktiengesellschaft	67	1.8	Ericsson inc.	246	2.1
The Whitaker Corporation	62	1.6	Lucent Technologies inc.	230	2.0
Sony Corporation	60	1.6	Robert Bosch Gmbh	156	1.4
Xerox Corporation	57	1.5	Nec Corporation	149	1.3
Philips Electronics n.v.	42	1.1	Samsung Electronics co.. Ltd.	145	1.3
Minnesota Mining and Manufacturing Company	42	1.1	Xerox Corporation	143	1.2
2001-05	**N.**	**%**	**2006-10**	**N.**	**%**
Qualcomm Incorporated	1,002	8.1	Qualcomm Incorporated	1,118	5.8
Microsoft Corporation	611	4.9	Microsoft Corporation	830	4.3
Nokia Corporation	281	2.3	Thomson Licensing	516	2.7
Siemens Aktiengesellschaft	255	2.1	Sharp Kabushiki Kaisha	481	2.5
Motorola. Inc.	225	1.8	Sony Corporation	299	1.6
Thomson Licensing s.a.	193	1.6	Zte Corporation	224	1.2
Koninklijke Philips Electronics n.v.	192	1.5	Koninklijke Philips Electronics n.v.	223	1.2
LG Electronics Inc.	174	1.4	Panasonic Corporation	214	1.1
Samsung Electronics co. Ltd.	162	1.3	Nokia Corporation	208	1.1
Rowenta France	154	1.2	Ntt Docomo. Inc.	201	1.0

Source: Author's own contribution. Data sourced from PATSTAT.

Another interesting example is the surge of Nokia Corporation in 1996-00 with 142 patents deposited. In the next period, Nokia started to play a preeminent role reaching the third position in patent application in 2001-05 with its 281 deposits. Then in 2006-10, it had 208 deposits.

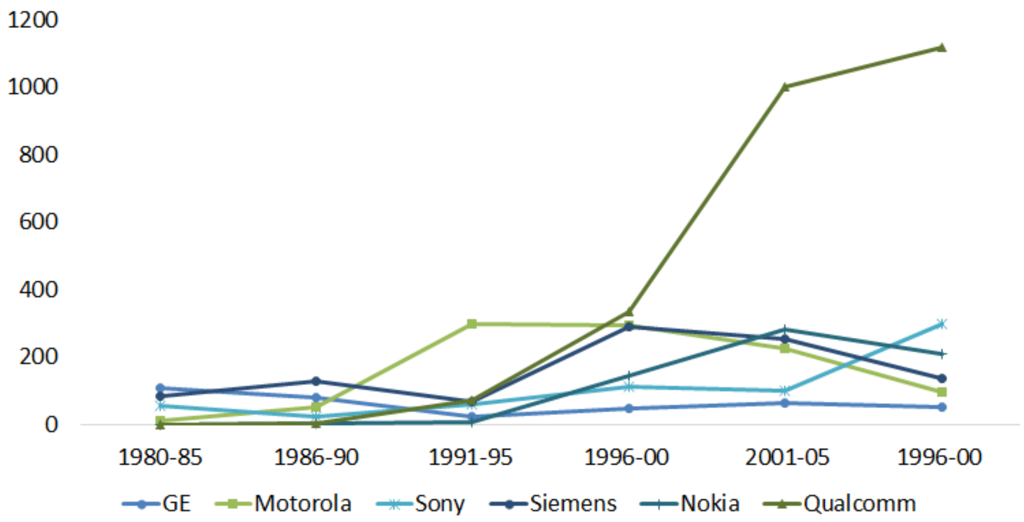
Differently than Motorola, GE and Nokia, other TNCs had opposite paths. Sony, for instance, had 56 patents deposited in 1980-85 and it reaches 299 in 1996-00. Sony became a conglomerate, with a number of disparate businesses operating under the Sony umbrella: from semiconductor technologies and imaging to smart phones and games.

Qualcomm Inc. – an American semiconductor company – gained importance in terms of patenting in 1991-95 with its 73 patent deposits (representing the fourth position in the period). In the next periods 1996-00, 2001-05 and 2006-10, Qualcomm Inc. occupied the first position in terms of patent deposits with 334, 1,002 and 1,118 deposits respectively. Qualcomm Inc. showed agility and an active behavior to compete in developing countries such as Brazil, protecting new inventions from competitors. (Figure 5).

What is also interesting to note is that in 1980-85 the ten biggest patent appliers concentrated 33.2% of non-residents' deposits and in 2006-10 the ten biggest represented 22.5% of deposits. If we consider the biggest twenty appliers for the same periods, they represented 41.8% and then 29.0%. These figures show in relative terms the intensification of competition in terms of patenting probably reflecting the market competition growth in Brazil with new entrant players in domestic market especially after economic liberalization in the 1990s.

The observation of residents' patent application (Table 4) in 'electrical engineering' technological domain points out to a distinct dynamic when comparing with non-residents' patent application. If exists a stable relevance for private companies in patenting application of non-residents, the same behavior is not seem for residents patentees.

Figure 5. Evolution of patent deposit of selected non-resident companies, electrical engineering technological domain.



Source: Author's own contribution. Data sourced from PATSTAT.

In 1980-85, residents applied for 576 patents while non-residents applied for 1,890. Of the biggest ten resident patentees the first two were public national companies: Usinas Siderúrgicas de Minas Gerais (USIMINAS) and Telecomunicações Brasileiras (TELEBRÁS). While USIMINAS had 19 applications (which gave the company the first position in the rank of residents), GE (the leader of non-residents) had 109, i.e. almost six times more applications.

While in 1980-85 the main non-resident patentees were TNCs, resident main patentees were individual inventors or researchers, public national companies and branches of TNCs operating in Brazil (Philips, Siemens and Pirelli, for example) (Table 4). A few indigenous companies were also important patentees such as Lorenzetti, Arno and Produtos Elétricos Corona, which corroborates the fact the indigenous companies in the first half of the 1980s, were producing new knowledge in 'electrical engineering' technological domain. However, they do not maintain such behavior throughout time.

Table 4. Residents' patent application, electrical engineering technological domain, Brazil.

1980-85	N.	%	1986-90	N.	%
Usinas Siderúrgicas de Minas Gerais s/a	19	3.3	Pirelli Cabos s/a	18	0.8
Telecomunicações Brasileiras s/a	18	3.1	Ichtus Eletrônica s/a	18	0.8
Lorenzetti s/a	18	3.1	Lorenzetti s/a	13	0.6
Hans Boris Belck	12	2.1	Hans Boris Belck	12	0.5
Pial Indústria e Comércio Ltda	11	1.9	Telecomunicações Brasileiras s/a	12	0.5
Siemens s/a	7	1.2	Empresa Brasileira de Compressores s/a	11	0.5
Pirelli Cabos s/a	7	1.2	Walma Indústria e Comércio Ltda	11	0.5
Philips do Brasil Ltda	7	1.2	Philips do Brasil Ltda	10	0.4
Arno s/a	6	1.0	Nec do Brasil s/a	10	0.4
Produtos Elétricos Corona Ltda.	5	0.9	Pextron Controles Eletrônicos Ltda.	9	0.4
1991-95	**N.**	**%**	**1996-00**	**N.**	**%**
Cláudio Lourenço Lorenzetti	27	0.9	Claudio Lourenço Lorenzetti	35	1.0
Nelson Guilherme Bardini	26	0.9	Alvaro Coelho da Silva	23	0.7
Amp Brasil Conectores Elétricos e Eletrônicos	21	0.7	Nelson Guilherme Bardini	22	0.6
Alvaro Coelho da Silva	21	0.7	Francisco José Duarte vieira	18	0.5
Telecomunicações Brasileiras s/a	20	0.7	João Queiroz do Nascimento	14	0.4
Júlio Guido Signoretti	15	0.5	Itautec Philco s/a	13	0.4
Ayres Antonio Paes de Oliveira	12	0.4	Produtos Elétricos Corona Ltda	13	0.4
José Carlos Cella	11	0.4	Empresa Brasileira de Compressores s/a	12	0.3
Nélio José Nicolai	11	0.4	Companhia Vale do Rio Doce	11	0.3
Daruma Telecomunicações e Informática s/a	10	0.3	Arno s/a	10	0.3
2001-05	**N.**	**%**	**2006-10**	**N.**	**%**
Universidade Estadual de Campinas	27	0.7	Whirlpool s/a	36	0.8
Nelson Guilherme Bardini	18	0.5	Universidade Estadual de Campinas	32	0.7
Lorinel Groppo	15	0.4	Fundação CPQD	22	0.5
Benito Benatti	14	0.4	Universidade de São Paulo	20	0.4
José Coelho da Silva	12	0.3	Roque Tarcisio Kloeckner	17	0.4
Inst. de Tec. para o Desenvolvimento	12	0.3	Delmar José Tarrasconi	16	0.4
Companhia Energética de Minas Gerais	12	0.3	Giuseppe Jeffrey Arippol	15	0.3
Universidade de São Paulo	12	0.3	Universidade Federal de Santa Catarina	13	0.3
Eliseu Kopp	10	0.3	Nivaldo da Silva	13	0.3
Ezequiel Sales Dias	10	0.3	Samsung Eletrônica da Amazônia Ltda	12	0.3

Source: Author's own contribution. Data sourced from PATSTAT.

For instance, Lorenzetti – manufacture of electrical appliances for residences and industries – applied for 18 patents in 1981-85, occupying the third position in the rank in that period

(Table 4) and applied for 13 in 1986-90. The French group Legrand, the largest globally for switches and sockets, acquired the ownership and control of Lorenzetti. Since 1977, Legrand has controlled Pial (so the patents applied in the name of Pial actually belong to Legrand: in 1981-85, Pial applied for 11 patents, in 1986-90 for eight, and in 1991-95 for seven). More recently, Legrand also acquired other companies in the sector: a public company called Compania Elétrica do Maranhão (CEMAR) – the Brazilian leader for consumer units and industrial enclosures also holds strong positions in cable management – and SMS Tecnologia Eletrônica – number one for uninterruptible power supply in Brazil and a frontrunner across Latin America in this field.

The acquisitions done by Legrand consolidates its positions on the high-potential Brazilian market where the group is already the leader in wiring devices and modular circuit breakers. The curious fact is that indigenous companies applied for patents but after their acquisition, the group to whom they belong do not apply for patents in the local market.

Another curious fact is the increase of individual inventors that applied to patents at INPI. Many of them belong to universities and due to government incentives to foster entrepreneurial universities, researchers started to patent their discoveries and findings.

3.2. 'Chemistry' technological domain: the patentees

In 1980-85 there were 3,428 patents of the 'chemistry' technological domain applied at INPI of which 3,305 (that is 96.41%) belonged to non-residents. Since then, the increase on patenting was about 1,200% (41,360 patents in 2006-2010) with no relevant changes of patentees. In 2006-10, non-residents concentrate 93.97% of the patents' application.

The most important patentees in the period 1980-1985 were Hoechst (225 patents), Bayer (153), Union Carbide Corporation (135), Shell (120), Ciba-Geigy (106), The Dow Chemical Company (98), Basf (88), Imperial Chemical Industries (87), Monsanto (72) and GE (65). These ten TNCs represented 34.77% of all non-residents' patent applications (Table 5).

With time, some of these companies lost momentum and started to have their position in terms of patent application jeopardized. Union Carbide Corp. which occupied the third position in 1980-85, fell to the 11th in 1986-90 (with 91 patent applications) and from that moment on it simply did not appear in the top 20 and in 2001, Union Carbide Corp. was incorporated to the Dow Chemical Company of whom it became a wholly owned subsidiary.

The Dow Chemical Company has been depositing patents in Brazil in all periods of analysis. In 1986-90 it had deposited 321 patents (corresponding to 5.36% of non-residents' applications in the period), in 1991-95 it had deposited 144 (that is, 1.51% of non-residents' applications), in 1996-00 it had deposited 225 (representing 0.8% of non-residents' applications) and in 2001-05 it has deposited 150 patents (representing about 0.46% of non-residents' applications). In 2006-10, two subsidiaries of the Dow Chemical Company deposited patents in Brazil: Dow Global Technologies Inc. (198 patents) and Dow Global Technologies LLC (125 patents).

Table 5. Non-residents' patent application, chemistry technological domain, Brazil.

1980-85	N.	%	1986-90	N.	%
Hoechst Aktiengesellschaft	225	6.81	The Dow Chemical Company	321	5.36
Bayer Aktiengesellschaft	153	4.63	Bayer Aktiengesellschaft	308	5.15
Union Carbide Corporation	135	4.08	Ciba-Geigy Ag	277	4.63
Shell intern. Research Maatschappij B.v	120	3.63	Shell Intern. Research Maatschappij b.v	258	4.31
Ciba-Geigy Ag	106	3.21	Hoechst Aktiengesellschaft	184	3.07
The Dow Chemical Company	98	2.97	Imperial Chemical Industries plc.	127	2.12
Basf Aktiengesellschaft	88	2.66	Rhone-Poulenc Chimie	119	1.99
Imperial Chemical industries Plc.	87	2.63	E.i. Du Pont de Nemours and company	115	1.92
Monsanto Company	72	2.18	Henkel Kommanditgesellschaft auf Aktien	99	1.65
General Electric Company	65	1.97	American Cyanamid Company	99	1.65
1991-95	**N.**	**%**	**1996-00**	**N.**	**%**
Bayer Aktiengesellschaft	305	3.20	Bayer Aktiengesellschaft	563	2.0
Hoechst Aktiengesellschaft	271	2.85	Basf Aktiengesellschaft	541	1.9
Ciba-Geigy Ag	227	2.38	The Procter & Gamble Company	437	1.5
Rohm And Haas Company	193	2.03	L'Oreal	402	1.4
The Procter & Gamble Company	182	1.91	The Dow Chemical Company	225	0.8
Eli Lilly AND Company	172	1.81	F. Hoffmann-la Roche ag	210	0.7
Unilever N.v.	158	1.66	Eli Lilly and Company	208	0.7
Basf Aktiengesellschaft	147	1.54	Pfizer Products Inc.	198	0.7
The Dow Chemical Company	144	1.51	E.i. Du Pont de Nemours and Company	197	0.7
Pfizer. Inc.	125	1.31	The Goodyear tire & rubber company	184	0.7
2001-05	**N.**	**%**	**2006-10**	**N.**	**%**
Basf Aktiengesellschaft	556	1.72	Novartis Ag	731	1.88
Novartis Ag	503	1.55	Basf se	664	1.71
Astrazeneca Ab	464	1.43	F. Hoffmann-la roche Ag	386	0.99
Wyeth	430	1.33	Astrazeneca Ab	327	0.84
Pfizer Products Inc.	373	1.15	Sanofi-Aventis	297	0.76
F. Hoffmann-la roche ag	370	1.14	Wyeth	277	0.71
L'Oreal	323	1.00	L'Oreal	274	0.70
The Procter & Gamble Company	230	0.71	The Procter & Gamble Company	225	0.58
Bayer Aktiengesellschaft	216	0.67	Bayer Cropscience Ag	223	0.57
E.i. Du Pont de Nemours and Company	211	0.65	Bayer Materialscience Ag	203	0.52

Source: Author's own contribution. Data sourced from PATSTAT.

Other TNCs gained importance throughout time as Rohm and Hass Company, which had 33 patent applications in 1980-85 and in 1986-90 had 94; in 1991-95, it had 193 (occupying the third position in the rank of non-residents); in 1996-00, it had 158 patents and finally in 2001-05 it had 186 patents. In 2008, the Dow Chemical Company bought Rohm and Hass Company and it is now its subsidiary. The Procter & Gamble Company and L'Oreal also started to protect their technologies in Brazilian market: the first had 182 patent applications in 1991-95; 437 in 1996-00; 230 patent applications in 2001-05; and 225 patent applications in 2006-10. For the same periods, L'Oreal had respectively 94, 402, 323 and 274 patent applications.

Some companies are frequently at the rank since the beginning of the analysis, as the case of Bayer (considering all of its subsidiaries), Basf and Hoechst, while others are coming up with competitive competence in the last decade, as Novartis, Astra Zeneca and Sanofi Aventis. These different movements show, at one hand, the path-dependency importance in some technological domains and the exploitation of window of opportunities in other ones.

To a better explanation, it would be necessary a more detailed observation of the evolution by technology (i.e., organic fine chemicals, macromolecular chemistry, pharmaceuticals and cosmetics and biotechnology). Unfortunately, we may not provide an entire table and detailed analysis for that, given the space constraints. However, we may highlight the large movements, patterns and similarities that can be extracted in a closer look at the available data.

First, the technological complementarity is remarkable mainly in organic fine chemicals and macromolecular chemistry domains. Companies establish patents in both technological domains often. In these domains we can find also the most influent impact of path-dependency, mainly because we are dealing with well-established industrial sectors in which technological patterns has been developed since nineteenth century, which ensures greater relevance to incumbent companies. Bayer, Basf, Novartis, Astrazeneca, Roche and The Dow Chemical should be highlighted.

We can find some of these firms also in Pharmaceutical and cosmetics technological domain, but now a new group of competitors arise, pointing to different niches of expertise in chemistry sector. L'Oreal, Colgate, Unilever and Procter & Gamble lead cosmetics. Novartis, Astrazeneca, Roche and Sanofiaventis appear as the leaders in pharmaceutical patenting.

A more entrepreneurial regime would be seen in biotechnological domain, since in the beginning of the database (1981-1985) a great number of small firms (new biotechnology firms) appears as important patentees, as CPC International (8.5% of total) and Genentech (7.3%). Large movements on the leadership positions were seen in this technological domain mainly until 1996-2000's with the emergence of new relevant firms and the increased participation of incumbent firms from other technological domains (which internalized capacity mainly through acquisition strategies). From there a more stable movement on top 10 is noted; now the path-dependency seems to be more important and the window of opportunities seems to be more closed.

The observation of residents' patent application (Table 6) in technological domain brings to us the same dynamic observed in 'Electrical engineering' technological domain, but now with relevance also for public universities/research institutes besides public researchers. This dynamic in the patent property does not boosted national agents in the total quantum of patents application in the INPI, since there is no important changing on share in favor of residents' patent application since 1981-1985. This change in ownership seems to be more a decrease in participation of national technological agents at the expense of participation of scientific agents.

Table 6. Residents' patent application, chemistry technological domain, Brazil.

1981 - 1985	N.	%	1986 - 1990	N.	%
Rhodia Group S/A	15	12.2	Rhodia Group S/A	74	30.6
Petróleo Brasileiro S/A	11	8.9	Universidade de São Paulo	12	5.0
Usinas Siderúrgicas de Minas Gerais S/A	5	4.1	Fundação Oswaldo Cruz	8	3.3
Petroflex Industria e Comercio S/A	4	3.3	Edir José Bernardi	6	2.5
Companhia Brasileira de Estireno	3	2.4	Petróleo Brasileiro S/A	6	2.5
Union Carbide do Brasil Ltda.	2	1.6	EDN - Estireno do Nordeste S/A	5	2.1
Fundação Universitária José Bonifácio - UFRJ	2	1.6	Trikem S/A	4	1.7
Acrilex Tintas Especiais S/A	2	1.6	Konstantin Makedonsky	4	1.7
Financiadora de Estudos e Projetos	2	1.6	Bernardo Daniel Kullok	3	1.2
Versa Consultoria Técnica Ltda.	2	1.6	Oxiteno S/A Indústria e Comércio	3	1.2
1991 - 1995	**N.**	**%**	**1996 - 2000**	**N.**	**%**
Rhodia Group S/A	37	8.8	Universidade Estadual de Campinas	34	3.7
Universidade Estadual de Campinas	9	2.1	Universidade Federal de Minas Gerais	25	2.7
Maria Inês de Castro Del Castillo	8	1.9	Cristiano Alberto Ribeiro Santana	10	1.1
Petróleo Brasileiro S/A	4	0.9	Rhodia Group S/A	9	1.0
Silvério Rodeiro Amado	4	0.9	CNPQ	7	0.8
Julio de Oliveira Maciel	4	0.9	Universidade de São Paulo	7	0.8
Universidade Federal do Rio de Janeiro	3	0.7	Fundação Oswaldo Cruz	7	0.8
Bryoline Ind e Com de Produtos Químicos Ltda	3	0.7	Andrzej Josef Malik	7	0.8
Química Nacional Quiminasa S/A	3	0.7	Fundação Butantan	7	0.8
Laboratórios Bruch Ltda	3	0.7	Opp Petroquímica S/A	7	0.8
2001 - 2005	**N.**	**%**	**2006 - 2010**	**N.**	**%**
Universidade Estadual de Campinas	87	5.2	Universidade Federal de Minas Gerais	103	4.1
Universidade Federal do Rio de Janeiro	38	2.3	Universidade de São Paulo	92	3.7
Universidade Federal de Minas Gerais	35	2.1	Universidade Estadual de Campinas	68	2.7
Henry Okigami	20	1.2	Universidade Federal do Rio de Janeiro	52	2.1
Fundação Oswaldo Cruz	19	1.1	Universidade Federal do Paraná	24	1.0
FAPESP	19	1.1	Petróleo Brasileiro S/A	23	0.9
Universidade de São Paulo	19	1.1	Braskem S/A	20	0.8
Universidade Federal do Rio Grande do Sul	15	0.9	Consuelo Dutra Cabral Velho	19	0.8
Botica Comercial Farmacêutica S/A	13	0.8	Fundação Oswaldo Cruz	18	0.7
José Carlos Barbosa Vosgerau	12	0.7	Universidade Federal de Viçosa	15	0.6

Source: Author's own contribution. Data sourced from PATSTAT. Note: Rhodia Group consider all different names for Rhodia Company (Rhodia S/A, Rhodia Agro S/A, Rhodia Agro Ltda.) in Patstat list.

Nevertheless, some papers that work on sectoral analysis of Brazilian pharmaceutical industry (Caliari and Ruiz 2013, Tigre, Nascimento, and Costa 2016, Caliari, Mazzoleni, and Póvoa 2013) point out, in the last years, the increase of relevance in market share and innovative strategies in favor of indigenous companies. Some national companies doubled investments on R&D, and some appears as market leaders. These movements are largely due to capacitation on generic drugs (Brazilian Law for generic drugs dates from 1999).

These works also highlight the window of opportunity on biotechnological domains as a way to catch-up. Our database does not capture this recent movement, since it goes until 2010, but considering all information and the amount of non-residents patents, it is not a trivial task. This possibility may be more easily pursued in interactions with public university/research institutes, since they are establishing competitive capabilities in knowledge generation.

An emblematic example is Petroleo Brasileiro S/A (Petrobras). One important factor that made Petrobras acquire important technological capabilities was the internal R&D center (*Centro de Pesquisa da Petrobras*, CENPES) and its many connections with other Brazilian research institutions especially the *Instituto Nacional de Tecnologia* (INT), *Universidade Estadual de Campinas* (UNICAMP), *Universidade Federal do Rio de Janeiro* (UFRJ) etc.. (Gielfi, Furtado, and Tijssen 2016, Turchi and Porto 2013).This is a feature that makes the company stand out in the national innovation system.

Final Comments

According to Albuquerque (2000), Brazil has the following characteristics that possibly are shared with other countries with the same level of industrial development:

i. High share of individual patents;
ii. Foreign-owned firms with important patent activities;
iii. Low firm involvement in R&D activities.

In this paper, taking into consideration two technological domains ('electrical engineering' and 'chemistry') we corroborated the first two findings presented by Albuquerque (2000). In other words, for both technological domains studied, we found high shares of individual (applications of) patents and high shares of (applications of) patents of foreign-owned firms. We also found that:

iv. (Public) universities have increased their patenting activities.

This may reflect federal policies that provided legal support and set incentives for the commercialization of the results of scientific and technological research. The Innovation Law (*Lei da Inovação*), which was approved in 2003, was a change in the intellectual property management and technology transfer systems in Brazilian university system. It incentivized the creation of technology and transfer offices (*Núcleos de Inovação Tecnológica*, NITs) in public universities. Additionally, the Innovation Law set guidelines for technology licensing and royalties distribution in universities.

We also found other important characteristics about the Brazilian National Innovation System dynamics. When considering all the patentees (both residents and non-residents) that made deposit requests at INPI, we have the following conclusions:

v. Dominant share of patents on the hands of non-residents;
vi. Almost all non-residents are TNCs;
vii. Most of the TNCs are from the USA, western Europe and Japan;

TNCs were responsible for 86.7% of the total of Brazil's patent application in 1980-1985 period and they slightly increased their share to 87.3% in 2006-2010 period. This findings are congruent to Vaitsos (1972) and Penrose (1973) who pointed out, back in the 1970s, that most patents in less industrialized countries were owned mostly by foreign companies. This has implications as suggested Chiarini e Silva (2016): non-resident patents do not reflect national inventive activity and obviously have no (positive) direct influence on the inventiveness of the country. We can then conclude that:

viii. Indigenous companies' strategies are not straight forwardly translated into patents.

This previous finding may be related to the third finding presented by Albuquerque (2000). However, in this paper we did not have the intention to verify the involvement of indigenous companies in domestic R&D activities, but using data from Brazilian Innovation Survey (PINTEC) we find that only 15% of Brazilian innovative industrial companies considered internal R&D activities important and only 5% considered external R&D important in 2014. Instead, the majority of innovative industrial companies innovate through the acquisition of machinery developed mainly abroad (72% of Brazilian innovative companies declared that the acquisition of machinery was the most important means of innovating)[14,15].

The eight conclusions presented above help characterize the Brazilian Innovation System and we can with them corroborate the characterization done by Albuquerque (1999) when he classified Brazil as an Immature Innovation System.

Besides contributing to the understanding of some characteristics of the Brazilian National System of Innovation, the data from PATSTAT presented in this paper, is remarkable to understand TNCs' strategies. Following the capitalism dynamics of fusion and acquisitions, TNCs acquired indigenous companies, which were relatively very dynamic and once they took control over them, we do not see patent requests at INPI. This was the case of Lorenzetti, which Legrand acquired in 2000. We can then conclude:

ix. Indigenous companies which were acquired by TNCs reduced their patenting activities;

For Brazilian indigenous companies it is important to foster their competitive advantage through national efforts towards technology and knowledge generation. Many policies have been designed but they do not seem to be effective.

TNCs, which operate in Brazil with their subsidiaries, are largely older, with scale and innovative capacity long established and they have achieved their position through a well-established strategy and certain internal flexibility in creating inventions. Besides that, they detain tacit knowledge that is very difficult to be imitated.

Moreover, the current phase of capitalism – marked by the fragmentation of the production

[14] Data sourced from PINTEC/IBGE 2014. Available at < http://www.pintec.ibge.gov.br/>.

[15] Furtado and Quadros (2005) demonstrated that Brazilian industries display levels of efforts in technology that differ from those encountered in developed countries. They define these levels adopting indicators of technological intensity (expenditure in R&D/added value), of the structure of spending in R&D and of the human resources allocated to each industry.

process and the development of complex supply networks – allows TNCs to have more control and flexibility to designate where (when and how) to invest, and their productive assets (i.e., know-how, design and technology) can be safeguarded within companies in a more secure manner (Akyuz 2005). Therefore, even if TNCs are patenting a lot in Brazil and in other developing countries, it does not mean they do not use other strategies to protect their knowledge.

Indigenous companies need to gain dynamic competitive advantages in order to compete against TNCs or to join them in their complex supply networks, being part of a global value chain. In this sense, there is a strong responsibility of government to stimulate the development of national capabilities to generate indigenous technologies through the development of an active national industrial policy.

That policy should go from investing in science and technology researches to augmenting the volume of qualified individuals for the innovation process in domestic companies, order to ameliorate the national absorptive capacity. Recent studies carried out by Rapini et al. (2016) show that Brazilian industrial companies, for instance, lack qualified individuals for two key activities: the promotion of innovation and the establishment of a dialogue between universities and firms. Therefore, government should nurturer national learning[16] through massive investment in education (especially in engineering and hard sciences) and incentives for indigenous companies' investment in raising their dynamic capabilities.

Another important policy should consider the evaluation of multilateral agreements on IPRs and licenses, obtaining IPRs at better (fair) conditions for indigenous companies. In addition, the presence of so many TNCs should be used as a way to enhance national technological capabilities (Archibugi and Pietrobelli 2003).

Last but not least, it is important to mention that although patent documents show what have been invented and who invented them, that is, allowing documented knowledge to be public, Brazilian indigenous companies do not appear to have used this as a way of generating innovations. This suggests a lack of their interest in accessing a patent base and monitoring the state-of-the-art trends of a certain technological domain, in search of new technological developments. This may be so due to the relatively high cost to access such documents (spent with qualified individuals able to track patent advances, with the costs of licensing, and with absorptive efforts to learn the tacit elements of the patented technology).

[16] Despite acknowledging investing in learning is important, it does not ensure success. This is so once learning processes have a stochastic nature. Both external environment and companies' actions affect the learning processes. (Archibugi and Pietrobelli 2003).

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