Chapter 5

Patenting activity in Brazil and abroad

List of figures

List of tables

Detailed Tables

The Detailed Tables for this chapter are available on the internet at: <http://www.fapesp.br/enindicadores2010>.

1. Introduction

This chapter differs from the chapters on patenting in previous editions of *Indicators of Science, Technology & Innovation in São Paulo State* by presenting a long-term view. It analyzes statistics for the periods 1980-2005 (in the case of INPI, Brazil's patent office) and 1974-2006 (in that of USPTO). Opportunities for structural change in the production of technology in Brazil and São Paulo State are highlighted in accordance with the evidence available from patent statistics.

The use of patent statistics in this type of investigation requires care. Adequate understanding of the theoretical significance of patents, and hence of their statistical significance, is indispensable to avoid improper use of these data. Box 1 summarizes the most important points for an adequate interpretation of these statistics. In addition, the Methodological Annex contains a section on the methods, problems and limitations of the approach used in this chapter for the treatment of data from INPI and Instituto de Pesquisa Econômica Aplicada (IPEA).

Patent statistics can help identify what might be called tips of the iceberg, i.e. phenomena indicating innovation-related activities. The underlying structural changes in technology production cannot be captured by these statistics, but they can be indirectly perceived in this manner.

In the case of this publication, the possibility of analyzing patent statistics alongside statistics in other chapters on equally important aspects of innovation, such as investment in R&D, human resources employed in S&T activities, the technology balance of payments, and so on, enables information and statistics to be qualified via comparison and critical evaluation, while also representing an opportunity for the reader to explore more freely the full informational potential of patent statistics.

This chapter sets out to explore two of the main advantages of patent statistics: the availability of long data series and international comparability.

2. Brazil in the world context

This section establishes the guiding thread for the chapter, evaluating three phenomena and their possible articulation: (1) Brazil's relative position in the world from a technological standpoint; (2) the contrast between the persistence of the most important technological subdomains for Brazil in the period analyzed in this chapter (1980-2005) and the changes in the most important technological subdomains in global terms; and (3) the significance of patents held by non-residents in technological subdomains relating to current leading-edge fields and emerging technologies.

2.1 Brazil – relative technological stagnation in global terms?

The diagnosis of stagnation is suggested by Brazil's position in the global rank order of patent applications filed with the U.S. Patent and Trademark Office (USPTO) in five selected years, as shown in Table 5.1. Brazil ranked 28th in 1974, 25th in 1982, 27th in 1990, 29th in 1998, and again 29th in 2006. In other words, its position in the USPTO patent ranking remained basically unchanged over a period of 32 years.[1]

Brazil's position in the ranking deserves to be discussed because overcoming underdevelopment requires an improvement in the country's global technological standing, among other factors. This diagnosis is linked to Brazil's economic and social stagnation, as reflected by indicators such as per capita gross domestic product (GDP) and a comparison of per capita GDP for Brazil and the U.S., the leading country in the present economic and technological context. While Brazil's per capita GDP rose from 15.2% to 23.3% of U.S. per capita GDP between 1913 and 1973, the gap has not narrowed further, remaining in the range of 20% since 1973 (Maddison, 2002; UNDP, 2007).

The word "relative" is used in the title of this subsection in acknowledgement of the quantitative change in patent filings. As can be seen from Table 5.1, 44

1. Readers interested in the science and technology interaction matrix method will find a complete version in Ribeiro, L.C. et al. (2009).

Box 1 – The statistical significance of patents

The study of patents refers to appropriability conditions, one of the determinants of technological progress (Dosi, 1984; Klevorick et al., 1995). A patent is only one of the mechanisms for appropriating innovations. Other appropriation mechanisms include especially (1) first-mover advantages, (2) learning-curve advantages, (3) trade secrecy, and (4) sales and service efforts.*

The specificity of patents

The imperfect appropriability secured by patents varies according to sector, as does their importance as the main instrument of appropriation (Mansfield, Schwartz & Wagner, 1981, p. 917).

The *Yale Survey on Industrial Research & Development* (Levin et al., 1987) found that process patents were relatively unimportant compared with other forms of appropriation. Only the pharmaceutical and oil refining industries consider process patents as effective as other appropriation mechanisms (Levin, 1986, p. 200). As for product patents, their effectiveness is seen as more than "moderate" only for technologies relating to chemicals and in industries that produce simple mechanical equipment and devices (Levin, 1986, p. 200). Research by the Organization for Economic Co-operation & Development (OECD) reports more recent surveys in the U.S. confirming these findings in general terms (OECD, 1997, p. 23). In Brazil, almost 5% of innovative firms use invention patents and/or utility models to protect intellectual property, according to IBGE's 2005 Survey of Technological Innovation in Industry (Pintec) (see Figure 7.11 in Chapter 7 of this publication).

Limitations of patent statistics

The value and problems of patent statistics are extensively discussed in the literature (Pavitt, 1988; Griliches, 1990; Patel & Pavitt, 1995; Moed, Glänzel & Schmoch, 2004). Six issues have immediate implications for the statistical significance of patents:

(1) Not all economically useful knowledge is codifiable – tacit knowledge is an important dimension that is not always captured by patent statistics;

(2) Not all innovations are patentable because of minimum legal requirements;

(3) Other appropriation mechanisms may be considered more suitable by innovators, so that not all innovations are patented;

(4) Different industries have different "propensities to patent", i.e. patents are more important in some sectors than in others;

(5) Radical innovations and patented minor improvements become equivalent in the statistics but do not have the same economic value;

(6) Legislation differs significantly between countries, affecting the international comparability of patents – even within a single country, such as the U.S., patenting may be influenced by such factors as business relationships, investment flows etc.

Archibugi & Pianta (1996) stress the intertemporal comparability of patent statistics, given the fact that they have been collected for over a century, despite their limitations due to differing legislation across different countries and the large number of domestic filings.

These problems raised in the literature basically involve patent statistics in the advanced economies, which have mature national innovation systems. Additional problems arise when countries at different stages of technological and economic development are compared (Albuquerque, 2004).

* In the Brazilian case, patent protection is only the third most used mechanism, according to Pintec. Brands come first, trade secrecy second (see Figure 7.11 in Chapter 7).

Table 5.1
Top 32 countries filing for patents with USPTO – Brazil & leading countries, 1974-2006 (selected years)

Patent applications filed with USPTO by country														
Country	1974		Country	1982		Country	1990		Country	1998		Country	2006	
	Rank	No. of patents		Rank	No. of patents		Rank	No. of patents		Rank	No. of patents		Rank	No. of patents
United States	1	64,093	United States	1	63,316	United States	1	90,643	United States	1	135,483	United States	1	221,784
Japan	2	9,163	Japan	2	16,068	Japan	2	34,113	Japan	2	45,260	Japan	2	76,839
West Germany	3	8,897	West Germany	3	10,002	West Germany	3	11,261	Germany	3	13,885	Germany	3	22,369
UK	4	5,109	UK	4	4,351	UK	4	4,959	Taiwan	4	7,412	South Korea	4	21,685
France	5	3,157	France	5	3,336	France	5	4,771	UK	5	6,110	Taiwan	5	19,301
Canada	6	2,191	Canada	6	2,138	Canada	6	3,511	Canada	6	5,689	Canada	6	9,652
Switzerland	7	2,057	Switzerland	7	1,820	Italy	7	2,093	South Korea	7	5,452	UK	7	8,342
Sweden	8	1,357	Italy	8	1,500	Taiwan	8	2,035	France	8	5,249	France	8	7,176
Italy	9	1,192	Sweden	9	1,144	Switzerland	9	1,931	Sweden	9	2,359	Netherlands	9	3,823
Netherlands	10	985	Netherlands	10	1,077	Netherlands	10	1,588	Italy	10	2,313	China	10	3,768
USSR	11	728	Australia	11	630	Sweden	11	1,057	Switzerland	11	1,875	Israel	11	3,657
Australia	12	442	Taiwan	12	509	Australia	12	811	Netherlands	12	1,816	Italy	12	3,274
Austria	13	413	Austria	13	418	South Korea	13	775	Australia	13	1,420	Australia	13	2,928
Belgium	14	408	Belgium	14	356	Israel	14	624	Israel	14	1,198	Switzerland	14	2,773
Denmark	15	250	USSR	15	331	Finland	15	595	Belgium	15	1,059	Sweden	15	2,680

(CONTINUED ON NEXT PAGE)

Table 5.1 (continued)
Top 32 countries filing for patents with USPTO – Brazil & leading countries, 1974-2006 (selected years)

Patent applications filed with USPTO by country

Country	1974		Country	1982		Country	1990		Country	1998		Country	2006	
	Rank	No. of patents		Rank	No. of patents		Rank	No. of patents		Rank	No. of patents		Rank	No. of patents
Finland	16	178	Israel	16	316	Belgium	16	592	Finland	16	970	Finland	16	2,383
Spain	17	175	Denmark	17	277	Austria	17	560	Denmark	17	784	India	17	1,923
Norway	18	156	Finland	18	275	Denmark	18	370	Austria	18	710	Belgium	18	1,546
South Africa	19	156	Hungary	19	225	USSR	19	304	Spain	19	409	Austria	19	1,214
Israel	20	155	South Africa	20	199	Spain	20	289	Norway	20	337	Denmark	20	1,165
Hungary	21	108	Spain	21	159	South Africa	21	185	Singapore	21	336	Singapore	21	1,143
Mexico	22	108	Norway	22	152	Norway	22	164	Hong Kong	22	274	Hong Kong	22	889
Taiwan	23	102	East Germany	23	107	Hungary	23	138	Russia	23	273	Spain	23	844
New Zealand	24	66	New Zealand	24	87	Ireland	24	130	Ireland	24	228	Norway	24	562
Poland	25	61	**Brazil**	**25**	**70**	China	25	111	South Africa	25	211	Ireland	25	483
Dem. Rep. Congo	26	55	Mexico	26	70	New Zealand	26	105	New Zealand	26	187	New Zealand	26	415
Argentina	27	50	South Korea	27	68	**Brazil**	**27**	**88**	China	27	181	Russia	27	412
Brazil	**28**	**44**	Hong Kong	28	55	Hong Kong	28	86	India	28	180	Malaysia	28	379
India	29	43	Ireland	29	48	Mexico	29	76	**Brazil**	**29**	**165**	**Brazil**	**29**	**341**
Romania	30	42	Luxembourg	30	45	India	30	58	Mexico	30	141	South Africa	30	231

Source: USPTO (1974, 1982, 1990, 1998, 2006).

patent applications with the first-named inventor residing in Brazil were filed with USPTO in 1974 and 341 in 2006.[2] However, this almost eightfold growth in patent filings with USPTO was not sufficient to improve Brazil's position in the rank order, which as already noted has been close to 30th for decades. It should be borne in mind that the number of patent applications filed with USPTO increased fourfold in the period (USPTO, 2007). Although there is a positive aspect to these data, inasmuch as Brazilian patent production grew twice as fast as global patenting activity, this differential did not boost Brazil's international position and the data show the size of the effort needed if Brazil is to make consistent progress in the field of technology on an international scale.[3]

Table 5.1 suggests different movements and technological trajectories for different countries. Roughly speaking, four distinct trajectories can be discerned.

The first is the trajectory of the countries that consistently lead the field: the U.S., Japan and Germany. Since 1974 these three countries have filed the most patent applications with USPTO. Even the reunification of Germany in 1990 did not put it ahead of Japan. The relative weights of the three leaders have changed over time, however. In particular, the U.S. share of total USPTO filings has fallen. In 1974 it was 62.5%, and by 2006 it had fallen to 52.1% (USPTO, 2007). This decline in the weight of the U.S. on the international stage is also captured (possibly more appropriately) by the statistics on triadic patents. As noted in Box 2, the U.S. accounted for 31% of these patents in 2005.

Secondly, Table 5.1 shows that the USSR fell from 11th to 19th place between 1974 and 1990. While it is difficult to compare the Soviet Union in 1990 with Russia in 1998, given the problems deriving from the dismemberment of the USSR as well as far from trivial statistical problems (Wilson & Markusova, 2004), the important point in Table 5.1 is Russia's decline in the rank order between 1998 and 2006 (from 23rd to 27th place). This fall contrasts with Brazil's holding its place during the same period, clearly showing that despite the diagnosis of relative stagnation Brazil's performance could have been worse, given that the former USSR and Russia actually went backwards in technological terms.

Thirdly, there are countries with an upward trajectory, such as Taiwan, South Korea, China, India and Malaysia. With the exception of Taiwan, all these countries ranked below Brazil in 1974 and above it in 2006, according to Table 5.1. What differentiates them is the timing of their ascent. South Korea and Taiwan rose up the rank order in the 1970s and 1980s; China and India in the 1990s; Malaysia joined the top 30 in 2006.

The fourth type of trajectory is exemplified by South Africa and Mexico, which deserve attention because their characteristics resemble those of Brazil in terms of technology, level of development and income concentration. Both followed a more uneven path, although they ranked higher than Brazil in 1974 and lower in 2006. From this standpoint Brazil has performed better than comparable countries.

The Brazilian case can be called a fifth trajectory, since it is unique in that its place in the rank order did not change throughout the period. In light of the downward paths of countries such as the former USSR, Russia, Mexico and South Africa, an internal effort was required for Brazil to hold its position and this should be duly noted.

However costly, nevertheless, the mere maintenance of a position in the global ranking for patent activity should not be a public policy target for a country that has not yet overcome the historical barrier of underdevelopment.

2. USPTO statistics reports patents granted by the first-named inventor's country of residence (see FAPESP, 2005, pp. 6-32).

3. As discussed in Box 1, significant limitations are associated with patent statistics. One is the existence of other appropriation mechanisms. An interesting example is the case of plant breeder's rights or plant variety rights, which are particularly important for Brazil. Preliminary statistical treatment of data from the International Union for the Protection of New Varieties of Plants (UPOV, 2007) shows that Brazil ranked 13th in 2006 with 129 applications for plant variety protection, ahead of Canada, for example. Europe ranked first with 2,212 applications, followed by Japan with 918, China with 870, and the U.S. with 673. Other countries also ahead of Brazil included South Korea with 317 applications, Russia with 585, Ukraine with 403, and Argentina with 180. Systematic treatment of these data and the effort to make them compatible with patent statistics is part of a future research agenda.

Box 2 – Triadic patents

The USPTO data presented in Table 5.1 show an important aspect of the international state of play in the technology field, but with a significant limitation: the contribution of U.S. residents may well be overestimated because USPTO is a domestic patent office for American inventors.

An analysis of triadic patents is a useful way to offset this limitation. What are triadic patents? According to the OECD concept,[1] triadic patents are a series of corresponding patents filed for the same invention, by the same applicant or inventor, at today's three most important patent offices: the European Patent Office (EPO), the U.S. Patent and Trademark Office (USPTO) and the Japan Patent Office (JPO). Triadic patents form a special type of patent family.[2]

The importance of the U.S. on the world stage can be better contextualized via an analysis of triadic patents. As shown by Table 5.2, triadic patent filings by U.S. residents accounted for 34.03% of the total in 1990 and 31% in 2005. A share of this size may possibly be more realistic than the 50% share based on USPTO data alone.

Besides counterbalancing a possible bias, this approach highlights the most significant patents in each location, since triadic patents are filed on three major continents at the same time. Focusing on triadic patents also improves the international comparability of patent-based indicators.

Table 5.2 also permits an assessment of the relative positions of various countries and a comparison with Table 5.1. The top three countries remained the same throughout the period analyzed, with the U.S., Japan and Germany in first, second and third place here, as in Table 5.1.[3] Thus the U.S. is number one even when its share of the total is weighted on the basis of triadic patents.

Brazil's position also remains substantially unchanged. It ranked 27th in 1985 and 26th in 2005. The more general discussion presented in the course of the chapter with regard to Brazil's international position is therefore not refuted.

1. This concept is mentioned in reports of the National Science Foundation (NSB, 2006), based on OECD research. See: <www.oecd.org/sti/ipr-statistics/> and <http://europa.eu.int/estatref/info/sdds/en/pat/pat_triadic_base.htm>.
2. According to OECD (2004, p. 19), the families are based on patent applications filed with EPO and JPO, and patents granted by USPTO. Thus "USPTO patent grants data is used as a proxy for the USPTO applications".
3. It is important to note that 1998 is the last year for which most triadic patent family data are available. Thus the 2005 data are estimates based on more recent patent statistics.

2.2 Changes in the world's leading technology subdomains

Very significant technological changes occurred in many sectors throughout the world between 1974 and 2006, the period covered by the USPTO data used in this chapter. Some authors who advocate an evolutionary approach, such as Freeman & Louçã, see this period as marking a transition from the fourth to the fifth "long wave of capitalist development" (Freeman & Louçã, 2001). These changes had far from negligible implications for the dynamics of global capitalism, including the most important mechanisms of appropriation (as discussed in Box 1). For the specific purposes of this chapter it is sufficient to note that patents (and other intellectual property rights) became more important during the period because of the growing role played by information and knowledge in contemporary capitalist dynamics. The importance of IP rights in the Uruguay Round of multilateral trade negotiations in the framework of the General Agreement on Tar-

4. The Uruguay Round lasted from September 1986 to April 1994, and led to the establishment of the World Trade Organization (WTO).

Table 5.2
World shares of triadic patents (%) – top 20 countries & Brazil, 1985-2005

World shares of triadic patents							
1985		1990		1998		2005	
Country by rank	Share of total triadic patents (%)	Country by rank	Share of total triadic patents (%)	Country by rank	Share of total triadic patents (%)	Country by rank	Share of total triadic patents (%)
United States	34.01	United States	34.03	United States	33.54	United States	30.96
Japan	23.32	Japan	30.47	Japan	26.50	Japan	28.83
Germany	15.75	Germany	12.61	Germany	14.32	Germany	11.85
France	6.51	France	5.83	France	5.30	South Korea	5.97
UK	5.49	UK	4.44	UK	3.94	France	4.66
Switzerland	3.24	Switzerland	2.40	Netherlands	2.12	UK	3.00
Netherlands	2.40	Italy	1.98	Switzerland	1.80	Netherlands	2.24
Italy	2.23	Netherlands	1.79	Sweden	1.75	Canada	1.55
Sweden	1.82	Sweden	1.27	Italy	1.50	Switzerland	1.51
Canada	0.87	Canada	0.89	Canada	1.39	Italy	1.35
Belgium	0.71	Belgium	0.69	South Korea	1.15	Sweden	1.23
Austria	0.70	Australia	0.57	Finland	1.00	China	0.82
Australia	0.68	Austria	0.53	Belgium	0.91	Australia	0.78
Denmark	0.35	Finland	0.45	Israel	0.74	Israel	0.75
Finland	0.24	Denmark	0.38	Australia	0.73	Belgium	0.63
Israel	0.23	Israel	0.26	Denmark	0.63	Austria	0.57
Hungary	0.19	Spain	0.23	Austria	0.62	Finland	0.50
Norway	0.16	South Korea	0.21	Spain	0.28	Denmark	0.42
Spain	0.14	Norway	0.14	Norway	0.22	Spain	0.38
China	0.13	Hungary	0.08	Taiwan	0.22	Taiwan	0.26
(27th) Brazil	0.04	(28th) Brazil	0.03	(28th) Brazil	0.06	(26th) Brazil	0.11
Worldwide production	22,879		32,480		42,391		52,864

Source: OECD, Patent Database, June 2007.

iffs & Trade (GATT),[4] and the changes made to patent legislation to extend the scope of patents, demonstrate the growing significance of patents to the workings of the economic system.[5]

Table 5.3, extracted from Ribeiro et al. (2009), shows the distribution of USPTO patents granted to U.S. residents and non-residents by technology subdomain, using the classification adopted by France's Observatoire des Sciences et des Techniques (OST) (Fapesp, 2005).

Noteworthy changes occurred between 1974 and 2006. In 1974 there was a clear predominance of technologies associated with the fourth "long wave" of capitalist development. The leading technology subdomains include "Electrical components, "Handling and printing", "Consumer goods", and "Analysis, measurement and control".

The importance of subdomains linked to information and communications technology (ICT), which is key to the "fifth wave", increased during the period. In 2006 three of the leading five subdomains were related to ICT: "Information technology" in first place, "Telecommunications" in second, and "Semiconductors" in

5. Interested readers are advised to look up the special issue of the OUP journal *Industrial and Corporate Change* on this subject (see the introduction to Dosi et al., 2006).

Table 5.3
Total USPTO patents issued to assignees in all countries by OST technology subdomain, 1974-2006

OST technology subdomain (1)	USPTO patents issued to assignees in all countries									
	1974		1982		1990		1998		2006	
	Rank	No. of patents	Rank	No. of patents	Rank	No. of patents	Rank	No. of patents	Rank	No. of patents
Total	-	**220,731**	-	**257,843**	-	**387,251**	-	**610,094**	-	**649,319**
4. Information technology	23	3,458	26	3,214	21	8,896	2	37,829	1	75,843
3. Telecommunications	12	8,070	18	6,975	16	10,891	5	31,813	2	69,270
1. Electrical components	1	18,938	1	22,653	1	29,260	1	47,256	3	51,427
7. Analysis, measurement, control	4	14,127	6	12,736	6	21,610	3	34,487	4	45,588
5. Semiconductors	25	2,702	25	3,271	24	7,536	15	20,513	5	36,748
6. Optics	14	6,943	16	7,292	12	13,447	12	23,420	6	28,290
29. Consumer goods & equipment	3	15,088	7	12,666	3	23,447	6	31,562	7	26,424
2. Audiovisual technology	21	4,138	23	4,460	22	7,955	17	17,123	8	26,173
10. Organic fine chemicals	17	5,795	4	17,815	5	22,629	7	31,187	9	21,851
11. Macromolecular chemistry	15	6,577	2	18,532	4	22,908	8	30,190	10	20,271
20. Materials processing	5	13,840	3	18,518	2	24,627	4	33,172	11	19,893
27. Transport	8	10,665	14	7,681	14	12,523	18	16,636	12	18,654
19. Handling, printing	2	15,319	8	12,540	7	20,677	10	24,460	13	18,637
18. Technical procedures	9	10,265	9	11,791	10	15,853	13	21,539	14	18,625
12. Basic materials chemistry	20	4,605	10	10,439	9	16,011	11	23,945	15	17,238

(CONTINUED ON NEXT PAGE)

Table 5.3 (continued)
Total USPTO patents issued to assignees in all countries by OST technology subdomain, 1974-2006

OST technology subdomain (1)	USPTO patents issued to assignees in all countries									
	1974		1982		1990		1998		2006	
	Rank	No. of patents	Rank	No. of patents	Rank	No. of patents	Rank	No. of patents	Rank	No. of patents
13. Surface treatment	13	7,556	5	15,429	8	18,998	9	28,514	16	17,111
8. Medical engineering	22	3,603	24	4,079	18	9,751	14	21,199	17	15,813
24. Engines, pumps, turbines	11	9,283	13	7,937	19	9,256	24	10,040	18	15,799
23. Machine-tools	6	12,574	12	8,447	13	12,859	22	14,550	19	15,202
16. Pharmaceuticals, cosmetics	29	844	22	4,463	20	9,246	16	20,124	20	14,766
30. Civil engineering, building	10	9,990	15	7,665	15	12,194	21	14,982	21	14,293
26. Mechanical components	7	11,843	11	10,379	11	15,340	19	16,479	22	13,723
15. Biotechnology	30	442	28	1,494	28	3,474	20	15,315	23	12,613
14. Materials, metallurgy	16	5,822	17	7,079	17	9,912	23	10,876	24	7,174
17. Agricultural & food products	24	2,771	20	4,781	23	7,541	25	8,681	25	6,773
22. Agricultural & food processing apparatus	18	5,667	21	4,643	25	6,697	26	7,953	26	6,319
25. Thermal procedures	19	5,183	19	6,046	26	5,775	27	6,253	27	5,484
21. Environment, pollution	27	1,484	27	2,121	27	3,500	28	5,443	28	4,394
9. Nuclear techniques	28	1,333	30	1,244	30	1,995	30	2,001	29	2,996
28. Space technology, weapons	26	1,806	29	1,453	29	2,443	29	2,552	30	1,927

Source: USPTO (1974, 1982, 1990, 1998, 2006).

(1) Subdomains ranked by positions in 2006.

fifth. In 1974 these subdomains ranked far lower (23rd, 12th and 25th respectively).

In sum, Table 5.3 shows how the most important technology subdomains have changed over time.[6] These changes in the most important technologies, in turn, relate to another crucial change: the growing significance of science for the most important technologies (see 2.3 below).

A breakdown of the world data shown in Table 5.3 for selected countries (Detailed Tables 5.1-5.8) provides an indication of the different technological subdomains in which these countries specialize.

First, there are differences between the leading countries (the U.S., Japan and Germany). The most striking is that "Information technology" ranks highest for patentees resident in the U.S. and Japan (Detailed Tables 5.1 and 5.2), but only fifth for patentees resident in Germany (Detailed Table 5.3). The top-ranking technology subdomain for Germany is "Electrical components" (top worldwide in 1974).

Second, there is something in common among the non-leading countries: the "Information technology" subdomain does not rank highest (Detailed Tables 5.4-5.8, for Australia, South Korea, Taiwan, China and Brazil).

Third, there are differences in the subdomain rank order even for South Korea and Taiwan, which recently completed a successful catching-up process and have similar industrial characteristics: "Semiconductors" ranks first for South Korea, "Electrical components" for Taiwan.

Finally, Brazil is the only country in the group for which the top-ranking technology subdomain is "Consumer goods" (which matches the INPI data discussed in 2.4 below). This discrepancy between Brazil and the other countries mentioned underscores the distance between the typical fields in which Brazil obtains patents and the key scientific fields in which the patents obtained by more developed countries are concentrated.

2.3 S&T interaction matrices

One of the most important changes in the dynamics of global technological development is the increasing contribution of science to the production of technology. A useful method for capturing this change is the S&T interaction matrix approach discussed below, as developed by Ribeiro et al (2009) based on USPTO patents.[7]

2.3.1 Preparation of the matrices

Patents are classified during the application process in ways that link them to specific technological fields. These categories can be converted into OST technological subdomains (see RIBEIRO et al., 2009). Patent filings may also cite scientific articles (published by indexed or non-indexed journals) and make technical references to equipment manuals, the in-house magazines of large corporations etc., whereby they can be linked to science and engineering (S&E) fields used to produce the inventions being patented.

Keywords in patent texts are submitted to lexical analysis to construct a dictionary with headwords corresponding to ISI scientific fields and "entries" corresponding to unique keywords or descriptors for each field, enabling patent citations to be linked to one or more S&E field.

Thus by identifying the technology subdomains and S&E fields to which patents are linked, the procedure also identifies linkages between technology and S&E fields. These pairs constitute the cells of the matrices discussed below (Figures 5.1 and 5.2). The interactions are interpreted as follows: if technological subdomain α interacts with S&E field β, this means that scientific knowledge developed in β was required to develop technology α.

2.3.2 World matrices: growing interaction

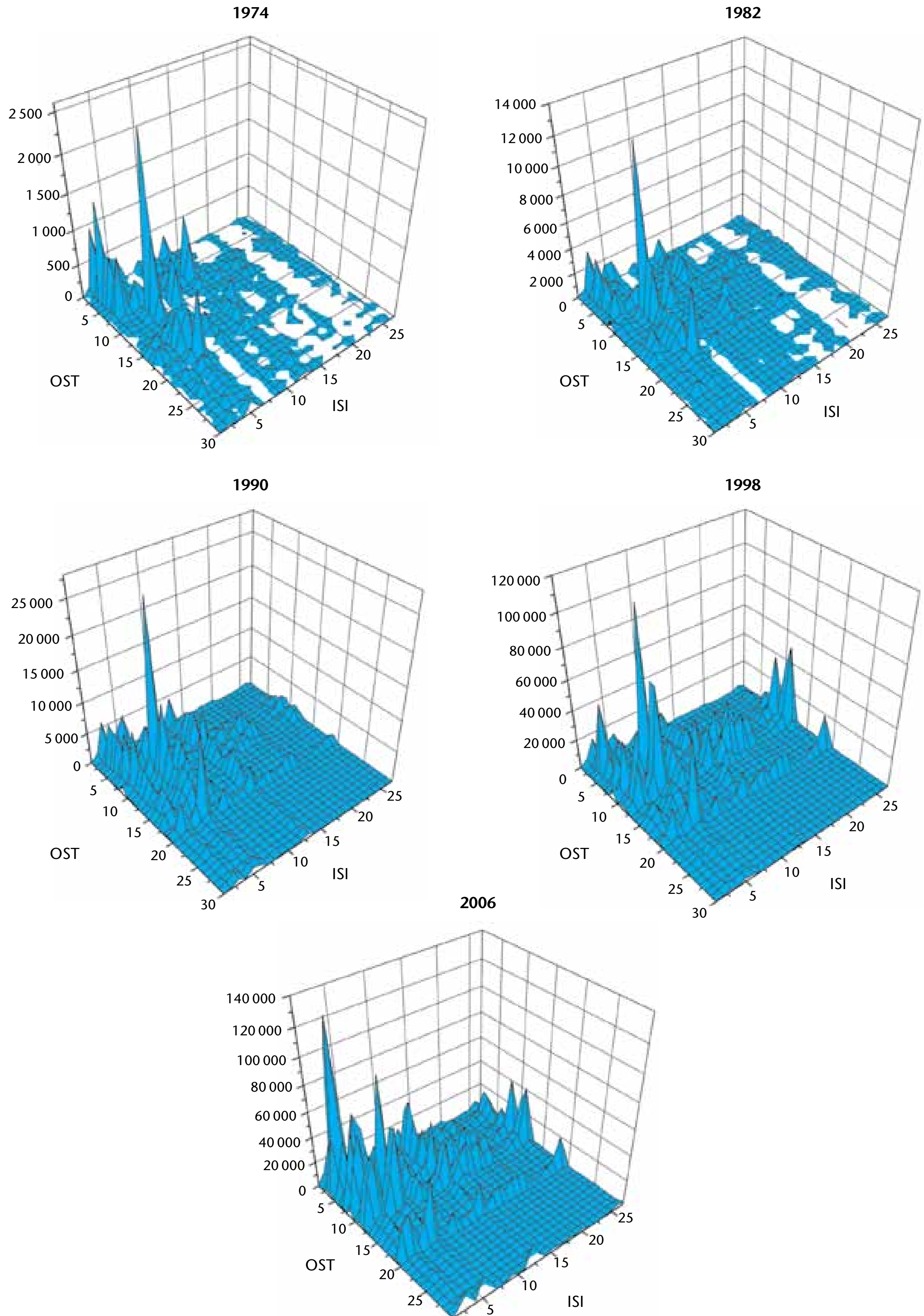
Based on information on USPTO patents granted in selected years between 1974 and 2006 (1974, 1982, 1990, 1998 and 2006), Ribeiro et al. (2009) identified all pairs of linked technological subdomains and S&E fields to construct S&T interaction matrices for these years, as shown in Figure 5.1.

The empty portions of the 1974 matrix correspond to an absence of interaction between the pairs in question. The highest level of interaction for that year is between the OST technology subdomain "Organic fine chemicals" and the ISI S&E field "Inorganic chemistry & chemical engineering" (OST 9:ISI 6). The matrices for subsequent years show previously non-existent interactions developing, and the interaction peak shifting: in 2006 it is between the OST technology subdomain "Information technology" and the ISI S&E field "Electronic engineering" (OST 4:ISI 3). The shift character-

6. The importance attributed by the U.S. National Science Foundation to these technology subdomains can be seen in the latest edition of *Science and Engineering Indicators*, in the section on "Patents Granted for Information and Communications Technology and Biotechnology" (NSB, 2008, p. 6-43/6-44).

7. Readers interested in the S&T interaction matrix methodology will find a short version of the paper by Ribeiro et al. (in English) at http://www.cedeplar.ufmg.br/publicacoes/trabalhos/textos-para-discussao/3.php, and a longer version at http://repositorios.inmetro.gov.br/bitstream/123456789/442/1/2009_RibeiroRuizBernardes.pdf.

Figure 5.1
World S&T interaction matrices, 1974-2006



Source: USPTO; Ribeiro et al. (2009).

Note: The OST axis corresponds to technological subdomains. The ISI axis corresponds to S&E fields. The vertical axis shows the frequency with which linked pairs appear in articles for the corresponding year.

izes changes in the profile of world interaction between science and technology as development proceeds.

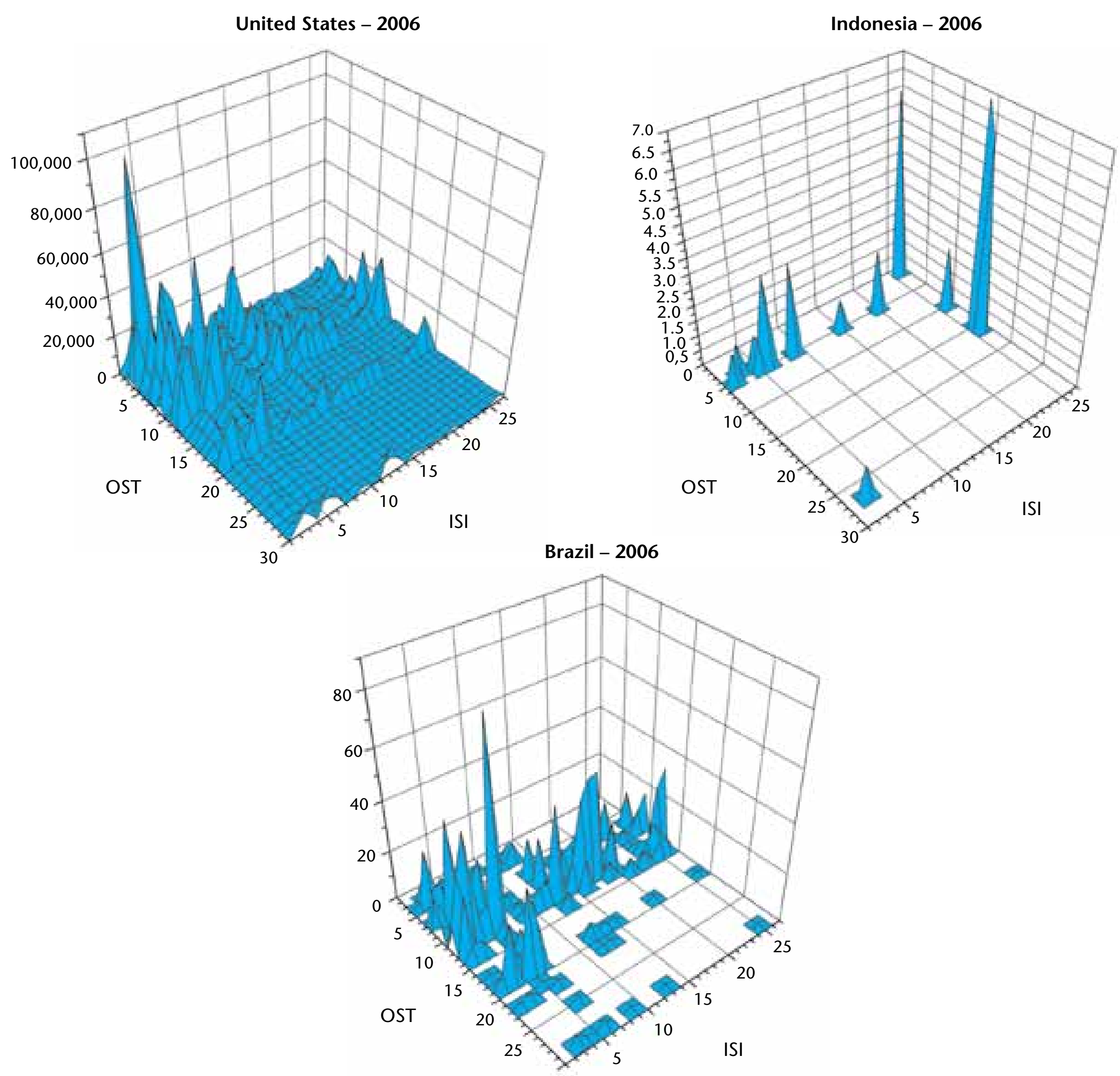
What is the theoretical significance of the data synthesized in Figure 5.1? It is that the scientific content of technology has increased over time and that technological development consequently depends more and more on its interaction with scientific development.

2.3.3 Brazil's intermediate position

S&T interaction matrices can be constructed for each country based on the USPTO patentee's country of residence. Figure 5.2 shows the matrices for USPTO patents granted to inventors resident in the U.S., Brazil and Indonesia in 2006.

From Figure 5.2 it can be seen that the U.S. matrix is almost completely full, with a high level of overall S&T interaction (on a scale of 0 to 100,000 for article citations), peaking for the interaction between the OST technology subdomain "Organic fine chemicals" and the ISI S&E field "Inorganic chemistry & chemical engineering" (OST 9:ISI 6), as in the world matrix. Brazil displays an intermediate level of interaction in terms of the overall balance between empty and full cells, but a distinctly different citation pattern from the U.S. While U.S. interaction is concentrated in OST subdomains 1-11 and ISI fields 1-5, Brazilian interaction is concentrated in OST subdomains 5-10 and the full array of ISI fields, peaking for OST 12, "Biotechnology", and ISI 6, "Inorganic chemistry & chemical engineering".

Figure 5.2
Country S&T interaction matrices – United States, Brazil & Indonesia, 2006



Source: USPTO; Ribeiro et al. (2009).

Indonesia's matrix is poor in diversity, with relatively few interactions. The difference in magnitudes on the vertical axis is also worth noting.

2.3.4 The Biotechnology subdomain as an example

This analytical tool can be used to focus on specific fields of technology in order to try to see what S&E fields support their development. Taking biotechnology (OST 12) as an example, what S&E fields have contributed to progress in this subdomain? To generalize, what S&E fields is it important for a given technology subdomain to interact with in order to develop?

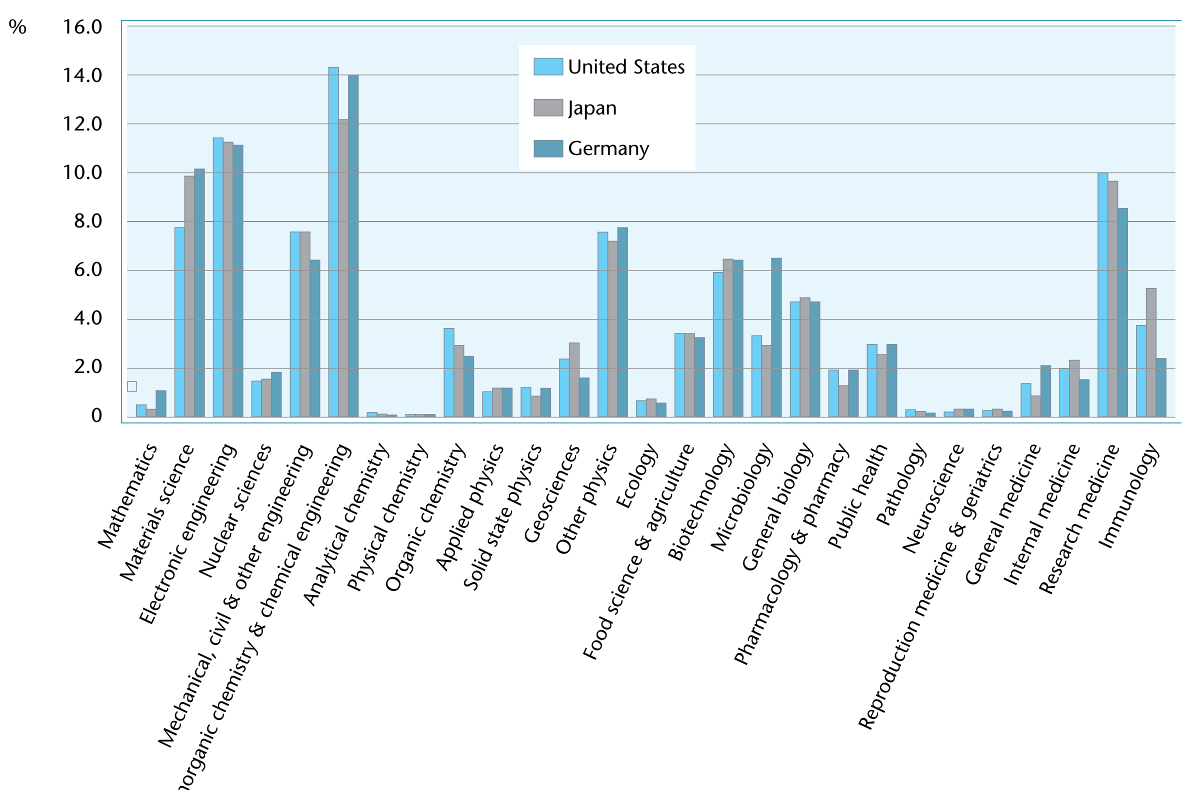
Figure 5.3 shows how the OST subdomain "Biotechnology" interacts with ISI S&E fields for USPTO patentees resident in the U.S., Japan and Germany in 2006.

From Figure 5.3 it can be seen that the development of a given technology depends closely on interactions with a large number of S&E fields. The similarity of the interaction patterns in all three countries suggests that this is a stable and structural phenomenon. The ineluctable conclusion is that it is impossible to promote technological development in any country without building a strong science base.

2.3.5 The role of the national science base

An important point stressed in the literature is the key role played by the national science base in the S&T interactions identified by patent research. In a comprehensive review of this literature, Tijssen (2004, p. 704) refers to Narin, Hamilton & Olivastro (1997) on the propensity for self-citation in all the most important countries, noting that a significant proportion of citations, between two and four times more than statistically expected, refer to articles produced in the same country. The magnitude of this "national bias" in patent citations indicates the localized nature of knowledge flows and suggests relatively strong interaction between science and technological progress, as well as cumulative effects in the creation and dis-

Figure 5.3
S&T interaction matrices for biotechnology-related patents granted to residents of U.S., Japan & Germany, 2006



Source: USPTO.

semination of knowledge in regional or national innovation and R&D systems. This tendency is also discussed in *Science and Engineering Indicators*: "Examining the share of cited literature [in patents] in the United States, Western Europe, and Asia adjusted for their respective shares of scientific literature reveals that inventors favour their own country or region" (NSB, 2002, p. 5-54). These findings have important implications for development processes by pointing clearly to the growing contribution of science to technological progress and the role of the national scientific base in S&T interaction.

2.4 Leading subdomains in Brazil

This section addresses two questions: how Brazil is positioned with regard to the changes in the front-ranking technology subdomains in the global context, and how these changes are reflected in Brazil.

The discussion of these questions is based on data from INPI, Brazil's patent office, given its potential to provide a more complete picture than USPTO statistics of technological activities in Brazil based on patenting (as explained in the Methodological Annex, the data refer to invention privileges, or PIs in the local acronym, and utility models, or MUs).[8] The numbers are presented below in two sets of four tables for three periods (1980-89, 1990-99 and 2000-05). The data for patent applications filed with INPI by Brazilian residents are presented in Tables 5.4A, 5.4B, 5.4C and 5.4D. The data for filings by non-residents are presented in Tables 5.5A, 5.5B, 5.5C and 5.5D. Both sets of tables refer to Brazil and São Paulo State.

Tables 5.4A, 5.4B, 5.4C and 5.4D show no change in the top four technology subdomains between 1980 and 2005 for Brazil. They are "Consumer goods", "Handling and printing", "Civil engineering and building", and "Transport". The most noteworthy feature of the data in Tables 5.4 is the persistence of these four subdomains in the top four ranks. The order is slightly different for São Paulo in the period 1980-1989, with "Electrical components" replacing "Transport".

In Detailed Table 5.10 (see separate volume), which presents INPI patent applications filed by Brazilian residents in the period 1980-2005, segregated by technological subdomain and by patent type (PI or MU), it is worth noting that MUs predominate in the top four subdomains. On the other hand, PIs predominate in the subdomains that are most characteristic of recent technological paradigms ("Telecommunications", "Pharmaceuticals and cosmetics", "Agricultural and food products", "Information technology", "Macromolecular chemistry", and "Biotechnology").

A comparison with Table 5.3 highlights two differences. First, the top-ranking subdomains vary more in the case of world patents, with only two of the leading subdomains in 1974 remaining so in 2006. Second, data for Brazil and the world coincide most in 1974, when the subdomains "Handling and printing" and "Consumer goods" were among the top four in both datasets (for Brazil and the world).

---

8. According to the legislation governing INPI, "To be patentable an invention [IP] must meet the requirements of novelty, inventive activity and industrial application"; and "An object of practical use, or part thereof, is patentable as a utility model [MU] when it is susceptible of industrial application, presents a new shape or arrangement, and involves an inventive act that results in a functional improvement in its use or manufacture" (Law 9279/96, http://www.inpi.gov.br/menu-esquerdo/desenho/pasta_legislacao/lei_9279_ingles_html).

Table 5.4A
Applications filed with INPI by residents for invention patents (PIs) and utility models (MUs) by OST technology subdomain – Brazil & São Paulo State, 1980-2005

INPI invention patent & utility model filings by residents of:					
Brazil			São Paulo State		
OST technology subdomain	No.	Share of total (%)	OST technology subdomain	No.	Share of total (%)
Total	**106,770**	**100.0**	**Total**	**31,679**	**100.0**
29. Consumer goods & equipment	23,889	22.4	29. Consumer goods & equipment	6,508	20.5
19. Handling, printing	10,426	9.8	19. Handling, printing	3,644	11.5
30. Civil engineering, building	9,459	8.9	30. Civil engineering, building	2,608	8.2
27. Transport	8,818	8.3	27. Transport	2,340	7.4
22. Agricultural & food processing apparatus	5,662	5.3	8. Medical engineering	1,726	5.4
8. Medical engineering	5,449	5.1	22. Agricultural & food processing apparatus	1,584	5.0
7. Analysis, measurement, control	5,441	5.1	26. Mechanical components	1,487	4.7
1. Electrical components	4,702	4.4	1. Electrical components	1,483	4.7
26. Mechanical components	4,238	4.0	7. Analysis, measurement, control	1,465	4.6
2. Audiovisual technology	2,810	2.6	20. Materials processing	962	3.0
20. Materials processing	2,733	2.6	18. Technical procedures	800	2.5
23. Machine-tools	2,692	2.5	25. Thermal procedures	771	2.4
18. Technical procedures	2,635	2.5	2. Audiovisual technology	733	2.3
25. Thermal procedures	2,378	2.2	23. Machine-tools	733	2.3
24. Engines, pumps, turbines	2,315	2.2	24. Engines, pumps, turbines	629	2.0
3. Telecommunications	1,942	1.8	16. Pharmaceuticals, cosmetics	600	1.9
14. Materials, metallurgy	1,457	1.4	3. Telecommunications	542	1.7
16. Pharmaceuticals, cosmetics	1,404	1.3	17. Agricultural & food products	410	1.3
12. Basic materials chemistry	1,344	1.3	12. Basic materials chemistry	407	1.3
17. Agricultural & food products	1,344	1.3	14. Materials, metallurgy	407	1.3
4. Information technology	1,232	1.2	4. Information technology	372	1.2
21. Environment, pollution	809	0.8	13. Surface treatment	301	1.0
13. Surface treatment	786	0.7	21. Environment, pollution	267	0.8
6. Surface treatment	681	0.6	11. Macromolecular chemistry	237	0.7
11. Macromolecular chemistry	599	0.6	6. Surface treatment	183	0.6
28. Space technology, weapons	435	0.4	15. Biotechnology	95	0.3
15. Biotechnology	264	0.2	28. Space technology, weapons	79	0.2
10. Organic fine chemicals	73	0.1	10. Organic fine chemicals	39	0.1
9. Nuclear techniques	72	0.1	9. Nuclear techniques	24	0.1
5. Semiconductors	54	0.1	5. Semiconductors	19	0.1
Unclassified	627	0.6	Unclassified	224	0.7

Source: INPI.

Table 5.4B
Applications filed with INPI by residents for invention patents (PIs) and utility models (MUs) by OST technology subdomain – Brazil & São Paulo State, 1980-1989

INPI invention patent & utility model filings by residents of					
Brazil			São Paulo State		
OST technology subdomain	No.	Share of total (%)	OST technology subdomain	No.	Share of total (%)
Total	**14,763**	**100.0**	**Total**	**2,555**	**100.0**
29. Consumer goods & equipment	3,516	23.8	29. Consumer goods & equipment	391	15.3
19. Handling, printing	1,319	8.9	19. Handling, printing	263	10.3
30. Civil engineering, building	1,142	7.7	1. Electrical components	203	7.9
27. Transport	1,112	7.5	30. Civil engineering, building	167	6.5
1. Electrical components	817	5.5	27. Transport	164	6.4
7. Analysis, measurement, control	704	4.8	26. Mechanical components	160	6.3
22. Agricultural & food processing apparatus	683	4.6	22. Agricultural & food processing apparatus	143	5.6
26. Mechanical components	667	4.5	7. Analysis, measurement, control	127	5.0
8. Medical engineering	652	4.4	20. Materials processing	117	4.6
23. Machine-tools	518	3.5	23. Machine-tools	101	4.0
20. Materials processing	440	3.0	18. Technical procedures	97	3.8
18. Technical procedures	415	2.8	8. Medical engineering	96	3.8
24. Engines, pumps, turbines	329	2.2	12. Basic materials chemistry	71	2.8
2. Audiovisual technology	312	2.1	14. Materials, metallurgy	59	2.3
3. Telecommunications	308	2.1	3. Telecommunications	58	2.3
25. Thermal procedures	301	2.0	25. Thermal procedures	49	1.9
14. Materials, metallurgy	259	1.8	24. Engines, pumps, turbines	45	1.8
12. Basic materials chemistry	255	1.7	11. Macromolecular chemistry	35	1.4
4. Information technology	172	1.2	2. Audiovisual technology	28	1.1
6. Surface treatment	120	0.8	13. Surface treatment	27	1.1
17. Agricultural & food products	101	0.7	4. Information technology	23	0.9
13. Surface treatment	99	0.7	21. Environment, pollution	14	0.5
11. Macromolecular chemistry	90	0.6	6. Surface treatment	14	0.5
21. Environment, pollution	84	0.6	17. Agricultural & food products	12	0.5
28. Space technology, weapons	75	0.5	10. Organic fine chemicals	9	0.4
16. Pharmaceuticals, cosmetics	44	0.3	15. Biotechnology	8	0.3
15. Biotechnology	35	0.2	16. Pharmaceuticals, cosmetics	7	0.3
9. Nuclear techniques	18	0.1	9. Nuclear techniques	6	0.2
10. Organic fine chemicals	12	0.1	28. Space technology, weapons	5	0.2
5. Semiconductors	4	0.0	5. Semiconductors	2	0.1
Unclassified	160	1.1	Unclassified	54	2.1

Source: INPI.

Table 5.4C
Applications filed with INPI by residents for invention patents (PIs) and utility models (MUs) by OST technology subdomain – Brazil & São Paulo State, 1990-1999

INPI invention patent & utility model filings by residents of					
Brazil			São Paulo State		
OST technology subdomain	No.	Share of total (%)	OST technology subdomain	No.	Share of total (%)
Total	**51,780**	**100.0**	**Total**	**10,657**	**100.0**
29.Consumer goods & equipment	12,196	23.6	29. Consumer goods & equipment	2,175	20.4
19. Handling, printing	5,246	10.1	19. Handling, printing	1,341	12.6
30. Civil engineering, building	4,769	9.2	30. Civil engineering, building	891	8.4
27. Transport	4,572	8.8	27. Transport	869	8.2
7. Analysis, measurement, control	2,685	5.2	26. Mechanical components	555	5.2
8. Medical engineering	2,550	4.9	1. Electrical components	536	5.0
22. Agricultural & food processing apparatus	2,458	4.7	8. Medical engineering	521	4.9
1. Electrical components	2,374	4.6	22. Agricultural & food processing apparatus	481	4.5
26. Mechanical components	2,073	4.0	7. Analysis, measurement, control	477	4.5
2. Audiovisual technology	1,547	3.0	20. Materials processing	293	2.7
23. Machine-tools	1,336	2.6	23. Machine-tools	288	2.7
20. Materials processing	1,190	2.3	25. Thermal procedures	276	2.6
18. Technical procedures	1,139	2.2	2. Audiovisual technology	268	2.5
25. Thermal procedures	1,102	2.1	18. Technical procedures	241	2.3
24. Engines, pumps, turbines	1,005	1.9	24. Engines, pumps, turbines	203	1.9
3. Telecommunications	960	1.9	3. Telecommunications	183	1.7
14. Materials, metallurgy	636	1.2	14. Materials, metallurgy	138	1.3
4. Information technology	569	1.1	16. Pharmaceuticals, cosmetics	130	1.2
17. Agricultural & food products	510	1.0	12. Basic materials chemistry	122	1.1
12. Basic materials chemistry	502	1.0	4. Information technology	109	1.0
16. Pharmaceuticals, cosmetics	457	0.9	13. Surface treatment	109	1.0
13. Surface treatment	373	0.7	17. Agricultural & food products	97	0.9
6. Surface treatment	339	0.7	21. Environment, pollution	68	0.6
21. Environment, pollution	299	0.6	11. Macromolecular chemistry	64	0.6
11. Macromolecular chemistry	232	0.4	6. Surface treatment	56	0.5
28. Space technology, weapons	218	0.4	28. Space technology, weapons	24	0.2
15. Biotechnology	85	0.2	10. Organic fine chemicals	19	0.2
10. Organic fine chemicals	33	0.1	15. Biotechnology	17	0.2
9. Nuclear techniques	28	0.1	9. Nuclear techniques	11	0.1
5. Semiconductors	15	0.0	5. Semiconductors	4	0.0
Unclassified	282	0.5	Unclassified	91	0.9

Source: INPI.

Table 5.4D
Applications filed with INPI by residents for invention patents (PIs) and utility models (MUs) by OST technology subdomain – Brazil & São Paulo State, 2000-2005

INPI invention patent & utility model filings by residents of					
Brazil			São Paulo State		
OST technology subdomain	No.	Share of total (%)	OST technology subdomain	No.	Share of total (%)
Total	**40,228**	**100.0**	**Total**	**18,506**	**100.0**
29. Consumer goods & equipment	8,177	20.3	29. Consumer goods & equipment	3,936	21.3
19. Handling, printing	3,862	9.6	19. Handling, printing	2,041	11.0
30. Civil engineering, building	3,548	8.8	30. Civil engineering, building	1,556	8.4
27. Transport	3,134	7.8	27. Transport	1,308	7.1
22. Agricultural & food processing apparatus	2,521	6.3	8. Medical engineering	1,117	6.0
8. Medical engineering	2,247	5.6	22. Agricultural & food processing apparatus	963	5.2
7. Analysis, measurement, control	2,052	5.1	7. Analysis, measurement, control	859	4.6
1. Electrical components	1,569	3.9	26. Mechanical components	773	4.2
26. Mechanical components	1,498	3.7	1. Electrical components	771	4.2
20. Materials processing	1,141	2.8	20. Materials processing	564	3.0
18. Technical procedures	1,081	2.7	18. Technical procedures	462	2.5
24. Engines, pumps, turbines	981	2.4	16. Pharmaceuticals, cosmetics	457	2.5
25. Thermal procedures	975	2.4	25. Thermal procedures	449	2.4
2. Audiovisual technology	951	2.4	2. Audiovisual technology	441	2.4
16. Pharmaceuticals, cosmetics	882	2.2	24. Engines, pumps, turbines	385	2.1
23. Machine-tools	838	2.1	23. Machine-tools	345	1.9
17. Agricultural & food products	733	1.8	17. Agricultural & food products	302	1.6
3. Telecommunications	674	1.7	3. Telecommunications	302	1.6
12. Basic materials chemistry	587	1.5	4. Information technology	240	1.3
14. Materials, metallurgy	553	1.4	12. Basic materials chemistry	214	1.2
4. Information technology	491	1.2	14. Materials, metallurgy	207	1.1
21. Environment, pollution	426	1.1	21. Environment, pollution	186	1.0
13. Surface treatment	314	0.8	13. Surface treatment	167	0.9
11. Macromolecular chemistry	277	0.7	11. Macromolecular chemistry	139	0.8
6. Surface treatment	222	0.6	6. Surface treatment	113	0.6
28. Space technology, weapons	142	0.4	15. Biotechnology	62	0.3
15. Biotechnology	120	0.3	28. Space technology, weapons	51	0.3
10. Organic fine chemicals	93	0.2	10. Organic fine chemicals	37	0.2
5. Semiconductors	35	0.1	5. Semiconductors	14	0.1
9. Nuclear techniques	26	0.1	9. Nuclear techniques	7	0.0
Unclassified	78	0.2	Unclassified	38	0.4

Source: INPI.

The data for INPI patent applications filed by non-residents, presented in Table 5.5A, differ in important ways from both INPI filings by residents (Tables 5.4) and world patenting activity (Table 5.3).

With regard to the latter, it worth noting the difference between the leading subdomains for U.S. patents (USPTO) and for filings by non-residents in Brazil (INPI). The top OST technology subdomain in the world ("Electrical components" in 1974-98, and "Information technology" in 2006) at no time coincided with the top subdomain for non-residents in Brazil. Conversely, the leading subdomains for non-residents

Table 5.5A
Applications filed with INPI by non-residents for invention patents (PIs) and utility models (MUs) by OST technology subdomain – Brazil, 1980-2005

OST technology subdomain	INPI invention patent & utility model filings by non-residents	
	No.	Share of total (%)
Total	**191,560**	**100.0**
16. Pharmaceuticals, cosmetics	23,236	12.1
12. Basic materials chemistry	12,879	6.7
11. Macromolecular chemistry	10,898	5.7
20. Materials processing	10,176	5.3
19. Handling, printing	9,421	4.9
3. Telecommunications	9,231	4.8
8. Medical engineering	8,977	4.7
27. Transport	8,956	4.7
18. Technical procedures	8,736	4.6
26. Mechanical components	7,367	3.8
29. Consumer goods & equipment	7,255	3.8
14. Materials, metallurgy	7,238	3.8
1. Electrical components	6,992	3.7
7. Analysis, measurement, control	6,008	3.1
30. Civil engineering, building	5,005	2.6
4. Information technology	4,954	2.6
23. Machine-tools	4,680	2.4
24. Engines, pumps, turbines	4,568	2.4
10. Organic fine chemicals	4,482	2.3
17. Agricultural & food products	4,348	2.3
13. Surface treatment	4,278	2.2
2. Audiovisual technology	3,568	1.9
15. Biotechnology	3,278	1.7
22. Agricultural & food processing apparatus	2,526	1.3
6. Surface treatment	2,429	1.3
25. Thermal procedures	2,208	1.2
21. Environment, pollution	1,262	0.7
28. Space technology, weapons	601	0.3
5. Semiconductors	418	0.2
9. Nuclear techniques	174	0.1
Unclassified	5,411	2.8

Source: INPI.

Table 5.5B
Applications filed with INPI by non-residents for invention patents (PIs) and utility models (MUs) by OST technology subdomain – Brazil, 1980-1989

OST technology subdomain	INPI invention patent & utility model filings by non-residents	
	No.	Share of total (%)
Total	**25,239**	**100.0**
12. Basic materials chemistry	2,699	10.7
11. Macromolecular chemistry	1,969	7.8
20. Materials processing	1,799	7.1
14. Materials, metallurgy	1,699	6.7
1. Electrical components	1,370	5.4
18. Technical procedures	1,355	5.4
26. Mechanical components	1,312	5.2
19. Handling, printing	1,263	5.0
27. Transport	1,249	4.9
29. Consumer goods & equipment	1,044	4.1
13. Surface treatment	862	3.4
7. Analysis, measurement, control	837	3.3
8. Medical engineering	787	3.1
30. Civil engineering, building	756	3.0
23. Machine-tools	747	3.0
24. Engines, pumps, turbines	664	2.6
4. Information technology	567	2.2
10. Organic fine chemicals	504	2.0
25. Thermal procedures	398	1.6
6. Surface treatment	351	1.4
3. Telecommunications	341	1.4
16. Pharmaceuticals, cosmetics	332	1.3
2. Audiovisual technology	332	1.3
22. Agricultural & food processing apparatus	268	1.1
17. Agricultural & food products	190	0.8
15. Biotechnology	173	0.7
21. Environment, pollution	167	0.7
28. Space technology, weapons	166	0.7
9. Nuclear techniques	75	0.3
5. Semiconductors	61	0.2
Unclassified	902	3.6

Source: INPI.

Table 5.5C
Applications filed with INPI by non-residents for invention patents (PIs) and utility models (MUs) by OST technology subdomain – Brazil, 1990-1999

OST technology subdomain	INPI invention patent & utility model filings by non-residents	
	No.	Share of total (%)
Total	**87,844**	**100.0**
16. Pharmaceuticals, cosmetics	9,650	11.0
12. Basic materials chemistry	6,123	7.0
11. Macromolecular chemistry	5,476	6.2
20. Materials processing	5,034	5.7
19. Handling, printing	4,677	5.3
3. Telecommunications	4,374	5.0
27. Transport	4,176	4.8
18. Technical procedures	3,997	4.6
8. Medical engineering	3,906	4.4
1. Electrical components	3,421	3.9
26. Mechanical components	3,418	3.9
29. Consumer goods & equipment	3,365	3.8
14. Materials, metallurgy	3,328	3.8
7. Analysis, measurement, control	2,772	3.2
30. Civil engineering, building	2,185	2.5
10. Organic fine chemicals	2,158	2.5
23. Machine-tools	2,155	2.5
17. Agricultural & food products	1,998	2.3
24. Engines, pumps, turbines	1,928	2.2
13. Surface treatment	1,746	2.0
2. Audiovisual technology	1,707	1.9
4. Information technology	1,703	1.9
15. Biotechnology	1,367	1.6
6. Surface treatment	1,299	1.5
22. Agricultural & food processing apparatus	1,088	1.2
25. Thermal procedures	1,079	1.2
21.Environment, pollution	637	0.7
28. Space technology, weapons	254	0.3
5. Semiconductors	151	0.2
9. Nuclear techniques	70	0.1
Unclassified	2,602	3.0

Source: INPI.

Table 5.5D
Applications filed with INPI by non-residents for invention patents (PIs) and utility models (MUs) by OST technology subdomain – Brazil, 2000-2005

OST technology subdomain	INPI invention patent & utility model filings by non-residents	
	No.	Share of total (%)
Total	**78,477**	**100.0**
16. Pharmaceuticals, cosmetics	13,254	16.9
3. Telecommunications	4,516	5.8
8. Medical engineering	4,284	5.5
12. Basic materials chemistry	4,057	5.2
27. Transport	3,531	4.5
19. Handling, printing	3,481	4.4
11. Macromolecular chemistry	3,453	4.4
18. Technical procedures	3,384	4.3
20. Materials processing	3,343	4.3
29. Consumer goods & equipment	2,846	3.6
4. Information technology	2,684	3.4
26. Mechanical components	2,637	3.4
7. Analysis, measurement, control	2,399	3.1
14. Materials, metallurgy	2,211	2.8
1. Electrical components	2,201	2.8
17. Agricultural & food products	2,160	2.8
30. Civil engineering, building	2,064	2.6
24. Engines, pumps, turbines	1,976	2.5
10. Organic fine chemicals	1,820	2.3
23. Machine-tools	1,778	2.3
15. Biotechnology	1,738	2.2
13. Surface treatment	1,670	2.1
2. Audiovisual technology	1,529	1.9
22. Agricultural & food processing apparatus	1,170	1.5
6. Surface treatment	779	1.0
25. Thermal procedures	731	0.9
21. Environment, pollution	458	0.6
5.Semiconductors	192	0.2
28. Space technology, weapons	181	0.2
9. Nuclear techniques	43	0.1
Unclassified	1,907	2.4

Source: INPI.

in Brazil ("Basic materials chemistry" in 1980-89, and "Pharmaceuticals and cosmetics" in 1990-99 and 2000-05) consistently ranked far lower among world patents.[9] This points to a dual logic for patenting activity in Brazil, with filings by residents differing significantly from filings by non-residents.

The rank order of the top subdomains for patent filings by non-residents changes over time, in contrast with those for residents, with only the subdomain "Basic materials chemistry" remaining among the top four throughout the period 1980-2005. The changes in non-resident patent filings have followed the major changes in the world's leading fields of technology over time, while resident patent filings reflect the persistence of relatively independent subdomains remote from the new scientific fields that have driven intense patenting activity in both the advanced developed countries and less developed countries that have achieved catch-up growth.

This conclusion leads to another question: is there a link between the "relative stagnation" noted in the previous subsection (which is basically quantitative) and the persistence of leading technology subdomains in Brazil, none of which match the subdomains that have led the global rank order in recent decades? The corollary to this question and the related factual elements is that for Brazil to improve its position in the global rank order in quantitative terms there must be changes in the "quality" of Brazilian patents, which in turn requires major structural changes in Brazilian industry. These structural changes relate to the challenge of seizing the "windows of opportunity" offered by emerging technologies such as biotechnology, nanotechnology and new energy sources.

2.5 Contrast between resident and non-resident patent filings: weaknesses and technological hurdles

This subsection presents and discusses Table 5.6, which juxtaposes INPI resident and non-resident patent filings by OST technology subdomain for the period 2000-05. The purpose of Table 5.6 is to help understand both domestic technological capabilities and those strongly dominated and protected by non-residents.

Table 5.6 is organized so as to highlight the subdomains in which non-resident patent filings predominate and those in which resident patent filings are significant or actually in the majority. The rank order is based on the former's share in percentage terms (rather than absolute numbers, as in Tables 5.4 and 5.5).

The technology subdomains in which residents predominate over non-residents correlate closely with the leading subdomains identified in Tables 5.4. In "Consumer goods", residents account for 74.2% of the total, followed by "Agricultural and food processing apparatus" with 68.3%, "Civil engineering and building" with 63.2%, "Thermal procedures" with 57.1%, and "Handling and printing" with 52.6%. In all other subdomains, non-residents account for over 50%.

There are nine subdomains in which non-residents have a significant advantage, with more than 80% of the total. Only two of these ("Basic materials chemistry" and "Surface treatment") are not directly related to emerging technologies (ICT and healthcare). Four of the other seven relate to healthcare ("Organic fine chemicals", "Pharmaceuticals and cosmetics", "Macromolecular chemistry" and "Biotechnology), and three to ICT ("Telecommunications", "Semiconductors" and "Information technology").

This contrast has another important implication, because legally a patent represents a monopoly, albeit temporary, over a specific innovation. As noted earlier, the international context is one in which intellectual property protection is being strengthened. Thus the predominance of non-resident patents in fields directly associated with today's leading-edge technologies (ICT) and emerging technologies (biotech, new medical drugs, macromolecular chemistry) could turn out to be a hurdle preventing Brazil from penetrating such important markets, or at the very least impose very high entry costs.

This combination of domestic technological weaknesses and important obstacles in leading and emerging fields of technology may contribute to Brazil's remaining in the areas where it currently operates and hence persistence of the "relative stagnation" identified in this section.

This diagnosis should be read as a stimulus to the formulation of S&T policies capable of overcoming this situation of relative stagnation. São Paulo State's contri-

9. The logic of non-resident patenting involves several factors, such as companies' concern to occupy or protect markets. The debility of Brazil's IT and semiconductor industry may explain the weak presence of these subdomains in Tables 5.5. In the period 2000-05, the IT subdomain ranked eleventh for Brazilian non-resident patentees and ranked first for world patents in 2006 (Table 5.3), while the subdomain "Semiconductors" ranked 28th for non-residents and fifth for world patents. The position of the subdomain "Pharmaceuticals and cosmetics" in the latter two periods may be due to the fact that these patents did not exist before 1996.

Table 5.6
Applications filed with INPI by residents and non-residents for invention patents (PIs) and utility models (MUs) by OST technology subdomain – Brazil, 2000-2005

OST technology subdomain		No.	Share of total (%)		
			Total	Non-residents	Residents
Total		**118,705**	**100.0**	**66.1**	**33.9**
Strong advantage of non-residents	10. Organic fine chemicals	14,157	100.0	97.7	2.3
	16. Pharmaceuticals, cosmetics	3,730	100.0	93.7	6.3
	11. Macromolecular chemistry	1,882	100.0	92.6	7.4
	15. Biotechnology	4,644	100.0	91.1	8.9
	12. Basic materials chemistry	5,190	100.0	87.4	12.6
	3. Telecommunications	218	100.0	87.0	13.0
	5. Semiconductors	3,175	100.0	84.6	15.4
	4. Information technology	1,984	100.0	84.5	15.5
	13. Surface treatment	2,773	100.0	84.2	15.8
	14. Materials, metallurgy	814	100.0	79.8	20.2
	6. Surface treatment	4,465	100.0	78.1	21.9
	18. Technical procedures	4,446	100.0	75.9	24.1
	20. Materials processing	2,893	100.0	75.6	24.5
	17. Agricultural & food products	2,092	100.0	74.7	25.3
	No OST subdomain technology	2,616	100.0	74.4	25.6
	23. Machine-tools	2,957	100.0	68.0	32.0
	24. Engines, pumps, turbines	6,336	100.0	66.9	33.1
	8. Medical engineering	4,135	100.0	65.7	34.4
	26. Mechanical components	2,290	100.0	63.8	36.2
	9. Nuclear techniques	14,157	100.0	62.3	37.7
	2. Audiovisual technology	3,730	100.0	61.7	38.3
	1. Electrical components	1,882	100.0	59.4	40.6
	28. Space technology, weapons	4,644	100.0	56.0	44.0
	7. Analysis, measurement, control	5,190	100.0	53.9	46.1
	27. Transport	218	100.0	53.0	47.0
	21. Environment, pollution	3,175	100.0	51.8	48.2
Advantage of residents	19. Handling, printing	1,984	100.0	47.4	52.6
	25. Thermal procedures	2,773	100.0	42.9	57.1
	30. Civil engineering, building	814	100.0	36.8	63.2
	22. Agricultural & food processing apparatus	4,465	100.0	31.7	68.3
	29. Consumer goods & equipment	4,446	100.0	25.8	74.2

Source: INPI.

bution to such policies is decisive, given its importance to technological production in Brazil, its presence in the technologically most advanced fields and the strength of its science infrastructure.

3. Long-term assessment of INPI resident patent filings

Thanks to the possibility of constructing a database for INPI patent applications filed between 1980 and 2005, as well as a database for USPTO patents issued between 1980 and 2006, the analysis presented in this chapter can be more comprehensive than in the previous two editions of this series (FAPESP, 2002; 2005).

This section focuses on the most important changes signaled by the patent statistics just mentioned. Thus the discussion begun in the previous section continues to supplement the above analysis of technology subdomains by including other dimensions.

To organize this analysis, the period was divided into three subperiods: 1980-89, 1990-99 and 2000-05. Between 1980 and 2005 the total number of resident patent applications filed with INPI increased, according to the database prepared for this chapter. The average number of such filings rose from 1,476 per year between 1980 and 1989 to 5,178 between 1990 and 1999, and again to 6,705 between 2000 and 2005.

Based on this periodization, the chapter investigates changes in three dimensions of INPI patenting activity: geographic distribution, leading companies and institutions, and economic sectors and industries.

3.1 Geographic distribution

São Paulo is the leading state in INPI patenting activity, as can be seen from Table 5.7. Its share for the entire period (1980-2005) is 49.5% of applications identifying the assignee's state of residence.[10]

São Paulo State's share of the total with identified assignee states falls during the three subperiods, from 60.3% in 1980-89 to 46.5% in 2000-05. This is consistent with the relevant USPTO statistics, which show São Paulo with 53.3% in 1980-89 and 50.6% in 2000-06, for a share of 52.5% in 1980-2006 overall (Detailed Table 5.11).

It should be noted that São Paulo's significant share of Brazilian patenting activity in quantitative terms has important qualitative repercussions, in so far as the leading technology subdomains in São Paulo and Brazil are closely correlated, as already seen in Tables 5.4. In other words, São Paulo's technological characteristics determine Brazil's to a large extent.

The top six states in patenting activity remain unchanged in all three subperiods. They are: São Paulo, Rio Grande do Sul, Rio de Janeiro, Minas Gerais, Paraná and Santa Catarina. Patenting activity is strongly concentrated in these six states, which account for 90.4% of the total with identified assignee states between 1980 and 2005. Moderate deconcentration occurs during this period, however: the share of the top six states accounts for 94.9% in 1980-89 and for 89.1% in 2000-06.[11]

Another way to measure geographic deconcentration is by looking at the number of municipalities that file for patents throughout Brazil. The database furnished by INPI shows significant growth: seven municipalities are identified in 1980, 75 in 1985, 181 in 1990, 268 in 1995, 669 in 2000, 705 in 2004 and 694 in 2005.[12]

The top six states vary from one subperiod to another, as shown in Table 5.7. Rio de Janeiro ranks second in 1980-89 and fifth in 2000-05. Rio Grande do Sul moves in the opposite direction, rising from fifth place in 1980-89 to second in 2000-05. Paraná rises from fifth to third, while Minas Gerais falls from third to fourth between 1980-89 and 2000-05. In short, the most important change in terms of the state ranking is an improvement on the part of southern states, at the expense of Rio de Janeiro and Minas Gerais.

Lastly, Table 5.7 presents a state-by-state breakdown of INPI patent applications by individuals and companies.[13] Applications by individuals are more nu-

10. See the Methodological Annex for details of patent filings with identified assignee states.

11. In percentage terms, this level of concentration is high compared to the U.S. In 2005, for example, the top seven states in patenting activity (California, Texas, New York, Michigan, Massachusetts, New Jersey and Illinois) accounted for 53.2% of all U.S. patents (NSB, 2008, p. 6-40).

12. These numbers are derived from the patent database prepared for this chapter, as explained in the Methodological Annex. The information on patent distribution by municipality extends that presented in the previous edition of this series (FAPESP, 2004, p. 6-28), which stated only the total number of municipalities with patents: 886 between 1999 and 2001. It is also worth noting that these findings certainly reflect limitations in the database, again as explained in the Methodological Annex. Statistical growth in patenting by municipalities should combine real numerical growth in identified municipalities with an improvement in the quality of the statistical information compiled over the years. In any event, it is interesting to observe that the total increases during the 2000s, when the database is more reliable as far as this information is concerned.

13. For the first period (1980-89) a large proportion of the database received does not identify whether the applicant is an individual or company (see Methodological Annex): 5,560 out of 14,763 filings in the period are classified as "NA". This may explain why most of the filings with this identification are attributed to companies in the period in question, which is not the case for other periods.

merous than by companies for all states in the period 2000-05. This predominance is an indicator of underdevelopment, according to the classic analysis by Penrose (1973).[14]

3.2 Resident patents: leading companies and institutions

This subsection discusses INPI patent applications filed by corporate entities resident in Brazil. Only 26.5% of all the resident applications identifying whether the first-named inventor was an individual or corporate entity (Table 5.7) were filed with INPI by corporate entities in the period 1980-2005. In the case of the U.S., U.S. corporations owned 86% of patents issued to U.S. inventors in 2005, with individuals owning 14% (NSB, 2008, p. 6-40).[15] It is also worth noting that São Paulo is the state of origin for just over half the leading companies and institutions in INPI patenting activity during the same period.

A preliminary analysis shows that the number of corporate entities filing for INPI patents totalled 9,552 between 1980 and 2005. In the first subperiod, 1980-89, corporate entities averaged 79.6 per year. The average jumped to 302.2 in the second subperiod, 1990-99, and to 670.2 in the third subperiod, 2000-05[16] (amounts obtained by processing the database supplied).[17]

The next four tables (Tables 5.8, 5.9, 5.10 and 5.11) present the top 20 resident corporate patentees in the same three subperiods for Brazil and São Paulo State.

Table 5.8 shows Petrobras in the number one position for the overall period 1980-2005. As can be seen from the next three tables (Tables 5.9, 5.10 and 5.11), Petrobras leads the rank order in all three subperiods. Its leadership is reaffirmed by USPTO statistics (Detailed Table 5.14). Table 5.8 also shows the importance of companies and institutions in São Paulo State, where ten of the top 20 corporate patentees are located.

Lastly in relation to this table, it is worth noting the presence of several universities and research institutions among the top patentees: six among the leaders for Brazil, and five among the top patentees for São Paulo. Unicamp, the State University of Campinas located in São Paulo State, ranks second in Brazil in the third subperiod and overall, but unlike Petrobras it does not hold the same position in all three subperiods.

In the period 1980-89, Petrobras is the leader for Brazil and Rhodia Brazil for São Paulo State, as shown in Table 5.9.

Only two research institutions feature among the leaders for Brazil in this subperiod: Instituto de Pesquisas Tecnológicas (IPT), in seventh place, and Empresa Brazileira de Pesquisa Agropecuária (Embrapa), in eleventh. It is worth noting that three steel companies (Usiminas, CSN and Cosipa) feature among the top five leaders for Brazil.

The top 20 include six state-owned enterprises, five subsidiaries of multinationals, seven Brazilian-owned companies, and the two research institutions already mentioned (IPT and Embrapa).

Two subsidiaries of multinationals feature among the top three companies in São Paulo State (Rhodia Brazil as number one, and Philips Brazil in third place). Also in São Paulo, alongside IPT (which ranks fourth in the state) are two universities, USP in twelfth place, and Unicamp in seventeenth.

Petrobras remains leader in the period 1990-99, as shown in Table 5.10, which also highlights the rise of mining and metallurgical companies (six of the top 20, including Vale, formerly CVRD), and Vale's jump from fourteenth to second place in the rank order for Brazil.

Unicamp rises to the very top of corporate patentees in São Paulo in this period. It is interesting to note the presence of IPT only among the leaders in São Paulo, where it ranks nineteenth.

---

14. For a discussion of individual and corporate patents, see FAPESP (2005, p. 6-11/6-12).

15. Detailed Table 5.9 shows a complete breakdown of INPI patent filings into individual and corporate patents, and into inventions (PIs) and utility models (MUs), for residents as well as non-residents. Corporate entities account for more PIs (56.8%, compared with 43.2% of MUs in the entire period), while the reverse is true for individuals (46.1% vs. 53.9% respectively).

16. It is worth noting that 37,985 individuals filed patent applications with INPI between 1980 and 2005. Six of these accounted for more than 50 applications each, including C. Lorenzetti, with 103, and Nelson Bardini, with 93.

17. Data from the patent database prepared for this chapter, as explained in the Methodological Annex.

Table 5.7
Applications filed with INPI for invention patents (PIs) and utility models (MUs) by state and resident first-named inventor's status as individual or corporate entity – Brazil, 1980-2005

State (1)	INPI invention patent & utility model filings by resident first-named inventor's status as individual or corporate entity																
	1980-1989					1990-1999					2000-2005					1980-2005	
	Rank	Corporate entity	Individual	NA (2)	Total	Rank	Corporate entity	Individual	NA (2)	Total	Rank	Corporate entity	Individual	NA (2)	Total	Rank	Total
Total		**4,822**	**4,359**	**5,582**	**14,763**	-	**12,778**	**34,477**	**4,524**	**51,779**	-	**10,642**	**25,074**	**4,512**	**40,228**	-	**106,770**
SP	1	2,657	233	19	2,909	1	6,487	4,494	286	11,267	1	5,624	11,457	1,425	18,506	1	32,682
RS	4	305	36	1	342	2	1,201	677	38	1,916	2	1,170	2,248	493	3,911	2	6,169
RJ	2	571	10	-	581	3	1,234	620	59	1,913	5	866	1,801	504	3,171	3	5,665
MG	3	358	25	-	383	4	1,018	837	28	1,883	4	762	2,008	454	3,224	4	5,490
PR	5	150	32	1	183	5	656	744	32	1,432	3	669	2,490	483	3,642	5	5,257
SC	6	166	11	1	178	6	686	542	29	1,257	6	860	1,743	399	3,002	6	4,437
BA	10	29	3	-	32	7	79	194	9	282	9	78	371	94	543	7	857
DF	7	47	-	-	47	11	127	67	2	196	7	153	375	71	599	8	842
ES	8	40	1	-	41	8	112	125	9	246	10	57	347	104	508	9	795
GO	14	2	8	-	10	12	23	99	8	130	8	70	439	81	590	10	730
PE	13	8	7	-	15	10	35	159	8	202	11	87	301	50	438	11	655
CE	11	31	-	-	31	9	107	96	6	209	12	54	284	54	392	12	632
PB	15	6	2	-	8	19	20	34	-	54	13	17	127	30	174	13	236
MT		-	-	-	-	15	6	50	3	59	14	11	114	47	172	14	231

(CONTINUED ON NEXT PAGE)

Table 5.7 (continued)
Applications filed with INPI for invention patents (PIs) and utility models (MUs) by state and resident first-named inventor's status as individual or corporate entity – Brazil, 1980-2005

UF (1)	INPI invention patent & utility model filings by resident first-named inventor's status as individual or corporate entity																
	1980-1989					1990-1999					2000-2005					1980-2005	
	Rank	Corporate entity	Individual	NA (2)	Total	Rank	Corporate entity	Individual	NA (2)	Total	Rank	Corporate entity	Individual	NA (2)	Total	Rank	Total
AM	12	17	-	-	17	14	45	17	1	63	15	89	34	17	140	15	220
PA	16	3	1	-	4	16	9	47	2	58	16	23	92	25	140	16	202
MS	19	-	1	-	1	17	20	36	2	58	17	9	112	16	137	17	196
RN	24	-	-	-	-	18	13	43	2	58	18	-	102	35	137	18	195
SE	9	33	2	-	35	13	64	12	-	76	20	13	54	6	73	19	184
AL	17	1	-	-	1	21	3	16	2	21	19	6	69	5	80	20	102
MA	18	1	-	-	1	20	5	21	-	26	21	4	50	11	65	21	92
PI	20	-	1	-	1	22	5	9	1	15	24	14	23	4	41	22	57
TO	27	-	-	-	-	24	-	4	-	4	22	-	36	10	46	23	50
RO	25	-	-	-	-	23	1	4	-	5	23	2	35	8	45	24	50
RR	26	-	-	-	-	25	1	1	-	2	25	-	13	-	13	25	15
AP	22	-	-	-	-	26	1	-	-	1	26	1	6	2	9	26	10
AC	21	-	-	-	-	27	-	-	-	-	27	1	8	-	9	27	9
NA (3)	-	397	3,986	5,560	9,943	-	820	25,529	3,997	30,346	-	2	335	84	421	-	40,710

Source: INPI (2008).

Note: Brazil currently has 27 federal units including the Federal District (DF), with Brasília at its center. The names and abbreviations of the 26 states are as follows: Acre (AC), Alagoas (AL), Amapá (AP), Amazonas (AM), Bahia (BA), Ceará (CE), Espírito Santo (ES), Goiás (GO), Maranhão (MA), Mato Grosso (MT), Mato Grosso do Sul (MS), Minas Gerais (MG), Pará (PA), Paraíba (PB), Paraná (PA), Pernambuco (PE), Piauí (PI), Rio de Janeiro (RJ), Rio Grande do Norte (RN), Rio Grande do Sul (RS), Rondônia (RO), Roraima (RR), Santa Catarina (SC), Sao Paulo (SP), Sergipe (SE), Tocantins (TO).

(1) Federal units/states ranked by position in period 1980-2005.

(2) No identification of resident first-named inventor.

(3) No identification of federal unit/state.

Table 5.8
Top 20 resident corporate applicants for invention patents (PIs) and utility models (MUs) from INPI – Brazil & São Paulo State, 1980-2005

Rank	Brazil				São Paulo State		
	Patent applicant	State	No.	Share of total (%)	Patent applicant	No.	Share of total (%)
1	Petrobras	RJ	804	1	Unicamp	408	2.0
2	Unicamp	SP	408	0.5	Arno S.A.	261	1.3
3	Vale	MG	302	0.4	Multibrás S. A.	242	1.2
4	Arno S.A.	SP	261	0.3	USP	136	0.7
5	Usiminas	MG	249	0.3	Máquinas Agrícolas Jacto S.A.	131	0.6
6	Multibrás S.A.	SP	242	0.3	FAPESP	128	0.6
7	Embraco	SC	213	0.3	Rhodia Brazil Ltda.	115	0.6
8	CSN	RJ	202	0.2	Cosipa	106	0.5
9	Semeato S.A. Indústria e Comércio	RS	193	0.2	IPT	98	0.5
10	Embrapa	DF	165	0.2	Produtos Elétricos Corona Ltda.	94	0.5
11	USP	SP	137	0.2	Cibié do Brazil Ltda.	85	0.4
12	Máquinas Agrícolas Jacto S.A.	SP	131	0.2	Rhodia Agro Ltda.	84	0.4
13	FAPESP	SP	128	0.2	Duratex S.A.	80	0.4
14	UFMG	MG	117	0.1	Dana Industrial Ltda.	67	0.3
15	Rhodia Brazil Ltda.	SP	115	0.1	Marchesan Implementos e Máquinas Agrícolas Tatu S.A.	61	0.3
16	Souza Cruz S.A.	RJ	109	0.1	Metagal Indústria e Comercio Ltda.	61	0.3
17	Cosipa	SP	106	0.1	Philips do Brazil Ltda.	60	0.3
18	Produtos Elétricos Corona Ltda.	SP	103	0.1	Johnson & Johnson Industria e Comercio Ltda.	56	0.3
19	IPT	SP	98	0.1	Dixie Toga S.A.	53	0.3
20	Electrolux do Brazil S.A.	PR	93	0.1	UNESP	51	0.3
Subtotal	Subtotal		4,176	5.1	Subtotal	2,345	11.6
Other	Other		77,493	94.9	Other	17,896	88.4
Total:	**Total:**		**81,669**	**100**	**Total:**	**20,241**	**100**

Source: INPI.

Table 5.9
Top 20 resident corporate applicants for invention patents (PIs) and utility models (MUs) from INPI – Brazil & São Paulo State, 1980-1989

Rank	Brazil				São Paulo State		
	Patent applicant	State	No.	Share of total (%)	Patent applicant	No.	Share of total (%)
1	Petrobras	RJ	134	0.9	Rhodia Brazil Ltda.	75	2.9
2	Usiminas	MG	114	0.8	Cosipa	56	2.2
3	Rhodia Brazil Ltda.	SP	75	0.5	Philips do Brazil Ltda.	50	2
4	CSN	RJ	57	0.4	IPT	48	1.9
5	Cosipa	SP	56	0.4	Produtos Elétricos Corona Ltda.	28	1.1
6	Philips do Brazil Ltda.	SP	50	0.3	Rhodia Agro Ltda.	25	1
7	IPT	SP	48	0.3	Pirelli Energia Cabos e Sistemas do Brazil S.A.	24	0.9
8	Embraco	SC	47	0.3	Industrias Villares S.A.	22	0.9
9	Souza Cruz S.A.	RJ	41	0.3	Metagal Industria e Comércio Ltda.	20	0.8
10	Tubos e Conexões Tigre Ltda.	SC	32	0.2	Duratex S.A.	19	0.7
11	Embrapa	DF	30	0.2	F. L. Smidth Comércio e Industria Ltda.	17	0.7
12	Telebrás	DF	30	0.2	USP	17	0.7
13	Produtos Elétricos Corona Ltda.	SP	28	0.2	Cerâmica e Velas de Ignição NGK do Brazil Ltda.	17	0.7
14	Vale	MG	25	0.2	Udinese Indústria e Comércio Ltda.	15	0.6
15	Rhodia Agro Ltda.	SP	25	0.2	Mahle Metal Leve S.A.	15	0.6
16	Pirelli Energia Cabos e Sistemas do Brazil S.A.	SP	24	0.2	Lorenzetti S.A.	15	0.6
17	Ichtus Eletronica S.A.	RJ	22	0.1	Unicamp	15	0.6
18	Industrias Villares S.A.	SP	22	0.1	FAME S.A.	14	0.6
19	Unitec Ltda.	NA	21	0.1	Air Liquide Brazil S.A.	14	0.6
20	Metagal Industria e Comércio Ltda.	SP	20	0.1	M. Dedini S/A Metalúrgica	13	0.5
	Subtotal		901	6.1	Subtotal	519	20.5
	Other		13,862	93.9	Outros	2,020	79.9
Total	**Total**		**14,763**	**100**	**Total**	**2,526**	**100**

Source: INPI.

Changes occur during the third and last subperiod (2000-05), as shown in Table 5.11. Only five of the top 20 corporate patentees for Brazil in 1980-89 remain among the top 20 in 2000-05 (Petrobras, Vale, Embraco, Embrapa and Usiminas), and only three in São Paulo (Unicamp, USP and Duratex). Thus the companies and institutions that rank among the top 20 change considerably from one subperiod to the next.[18]

18. The explanation for this high churn rate could be that patenting activity is not continuous for most companies and institutions. This is a phenomenon that merits more investigation, but can easily be seen from an analysis of the frequency with which the same corporate entities filed for INPI patents, showing that 6,259 companies did so in only one of the years of the overall period, whereas only one corporate entity (Petrobras) did so in every single one of the 25 years concerned, and only 127 did so in more than ten of those years. This relative lack of continuity may be related to the high mortality rate for companies in Brazil, due to macroeconomic stability and scant systematic involvement with innovative activities, among other factors.

Table 5.10
Top 20 resident corporate applicants for invention patents (PIs) and utility models (MUs) from INPI – Brazil & São Paulo State, 1990-1999

Rank	INPI invention patent & utility model filings by resident corporate entities						
	Brazil				São Paulo State		
	Patent applicant	State	No.	Share of total (%)	Patent applicant	No.	Share of total (%)
1	Petrobras	RJ	353	2.8	Unicamp	117	1.9
2	Vale	MG	170	1.3	Arno S.A.	104	1.7
3	CSN	RJ	139	1.1	Multibrás S.A.	100	1.6
4	Usiminas	MG	126	1.0	USP	62	1.0
5	Unicamp	SP	117	0.9	Duchacorona Ltda.	62	1.0
6	Arno S.A.	SP	104	0.8	Rhodia Agro Ltda.	59	0.9
7	Multibrás S.A.	SP	100	0.8	Máquinas Agrícolas Jacto S.A.	50	0.8
8	Embraco	SC	83	0.6	Cosipa	47	0.8
9	Mendes Júnior Siderúrgica S.A.	MG	68	0.5	Cibié do Brazil Ltda.	45	0.7
10	USP	SP	62	0.5	Johnson & Johnson Indústria e Comércio Ltda.	41	0.7
11	Duchacorona Ltda.	SP	62	0.5	Metagal Indústria e Comércio Ltda.	41	0.7
12	Rhodia Agro Ltda.	SP	59	0.5	Duratex S.A.	40	0.6
13	Springer Carrier do Nordeste S.A.	RS	52	0.4	Rhodia Brazil Ltda.	39	0.6
14	Electrolux do Brazil S.A.	PR	51	0.4	Sabó Indústria e Comércio Ltda.	36	0.6
15	Máquinas Agrícolas Jacto S.A.	SP	50	0.4	K. Takaoka Indústria e Comércio Ltda.	36	0.6
16	Cosipa	SP	47	0.4	Mercedes-Benz do Brazil S.A.	34	0.5
17	Cibié do Brazil Ltda.	SP	45	0.4	Bs Continental S.A. Utilidades Domésticas	33	0.5
18	Soprano Eletrometalúrgica e Hidráulica Ltda.	RS	45	0.4	GE - Dako S.A.	32	0.5
19	Souza Cruz S.A.	RJ	45	0.4	IPT	31	0.5
20	Companhia Siderúrgica de Tubarão	ES	43	0.3	VDO Kienzle Instrumentos Ltda.	30	0.5
	Subtotal		1,821	14.3	Subtotal	1,039	16.6
	Other		10,957	85.7	Other	5,207	83.4
	Total		**12,778**	**100.0**	**Total**	**6,246**	**100.0**

Source: INPI.

Only one state-owned enterprise features among the top 20 in 2000-05, as a result of the privatization process that took place in the previous subperiod. Vale and Usiminas are the only privatized SOEs that remain in the top 20.

Steel companies descend in the rank order, in contrast with the ascent of farm implement manufacturers (Semeato S.A Indústria e Comércio, Máquinas Agrícolas Jacto S.A, Marchesan Implementos and Máquinas Agrícolas Tatu S.A).

Table 5.11
Top 20 resident corporate applicants for invention patents (PIs) and utility models (MUs) from INPI – Brazil & São Paulo State, 2000-2005

Rank	INPI invention patent & utility model filings by resident corporate entities						
	Brazil				São Paulo State		
	Patent applicant	State	No.	Share of total (%)	Patent applicant	No.	Share of total (%)
1	Petrobras	RJ	317	2.1	Unicamp	276	3.9
2	Unicamp	SP	276	1.8	Arno S.A.	151	2.1
3	Semeato S.A. Indústria e Comércio	RS	158	1.0	Multibrás S.A.	138	2.0
4	Arno S.A.	SP	151	1.0	FAPESP	121	1.7
5	Multibrás S.A.	SP	138	0.9	Máquinas Agrícolas Jacto S.A.	73	1.0
6	FAPESP	SP	121	0.8	Dana Industrial Ltda.	67	1.0
7	Vale	MG	107	0.7	USP	55	0.8
8	UFMG	MG	95	0.6	Marchesan Implementos e Máquinas Agricolas Tatu S.A.	44	0.6
9	Embraco	SC	83	0.5	Unesp	38	0.5
10	Máquinas Agrícolas Jacto S.A.	SP	73	0.5	Valeo Sistemas Automotivos Ltda.	37	0.5
11	Dana Industrial Ltda.	RS	67	0.4	Dixie Toga S.A.	36	0.5
12	UFRJ	RJ	65	0.4	Arvin Exhaust do Brazil Ltda.	26	0.4
13	CNPq	DF	61	0.4	Indústria e Comércio de Cosméticos Natura S.A.	26	0.4
14	Embrapa	DF	57	0.4	SSZK Empreendimentos Participações Ltda.	24	0.3
15	USP	SP	55	0.4	Alcoa Aluminio S.A.	23	0.3
16	Centro de Desenvolvimento da Tecnologia Nuclear	MG	49	0.3	Johnson & Johnson	23	0.3
17	Usiminas	MG	48	0.3	TRW Automotive Ltda.	23	0.3
18	Marchesan Implementos e Máquinas Agricolas Tatu S.A.	SP	44	0.3	Brudden Equipamentos Ltda.	21	0.3
19	Electrolux do Brazil S.A.	PR	42	0.3	Duratex S.A.	21	0.3
20	Unesp	SP	38	0.3	Brazilata S.A. Embalagens Metálicas	21	0.3
	Subtotal		2,045	13.5	Subtotal	1,244	17.7
	Other		13,081	86.5	Other	5,785	82.3
	Total		**15,126**	**100.0**	**Total**	**7,029**	**100.0**

Source: INPI.

3.3 Patenting by residents: economic sectors and branches of industry

The statistics presented in Tables 5.12-5.15 also refer to corporate entities. As explained in the Methodological Annex, the patent information supplied by INPI was grouped by industry using the National Economic Activity Classification (CNAE)* adopted by IBGE, Brazil's national bureau of statistics and population census. CNAE categories were identified from the Annual Employee Register (RAIS) produced by the Ministry of Labor & Employment (MTE). The tables in this subsection show the top 30 CNAE categories in INPI patenting between 1980 and 2005 (there are 646 CNAE categories all told).

* The National Classification of Economic Activities (CNAE 2.0), developed by the Brasilian Institute of Geography and Statistics (IBGE) and used in this chapter, corresponds to the International Standard Industrial Classification (ISIC), in its fourth revision, which is adopted by the United Nations (UN).

The specific contribution made by the approach used in this subsection, as opposed to the approach used in the previous subsection, is the possibility of analyzing not individual corporate entities but entire sets of entities by sector or branch of industry. This difference can be seen from the fact that CNAE category "Manufacture of refined petroleum products", of which Petrobras is part, ranks fourth in Brazil during the period 1980-2005 (Table 5.12). The top CNAE category in the period is "Manufacturing of plastic articles" in both Brazil and São Paulo. The significance of São Paulo State is clearer and more pronounced when this approach is used.

In São Paulo State, this methodology leads to a relevant change in the rank order (Table 5.12). First place is occupied not by Unicamp's sector, "Higher education", but by "Manufacturing of plastic articles", as already noted. A salient feature of this industry is the number of companies with patents: 258 corporate patentees are classified in this CNAE category, three of them with more than 20 patents (the leader, Indústria e Comércio Pizzoli, owns 36). Twenty institutions are classified in "Higher education" (Tables 5.11 and 5.19), with Unicamp and USP owning more than 100 patents. Another important difference between these two sectors is the distribution of invention patents (PIs) and utility models (MUs): the latter account for 73% of patents in the case of "Manufacturing of plastic articles" but only 7% in "Higher education".

However, if the patent applications in CNAE category "Higher education" in Table 5.12 were added to those in "Public administration", which includes Fundação Instituto Oswaldo Cruz (Fiocruz) and the National Council for Scientific & Technological Development (CNPq), and to those in "Research and development", which includes Embrapa and FAPESP, they would rank top in both Brazil (with 1,855 patents – see Table 5.19) and São Paulo (with 1,055 patents – CNAE category "Public administration" has 110 patents but is not listed in Table 5.12). This rank order differs from the one seen in the U.S.

Among the important CNAE categories associated with current or emerging technological paradigms, the highlights are "Manufacturing of medical instruments and devices" (ranked 21st for Brazil) and "Manufacturing of pharmaceutical preparations for human use" (ranked 25th – not shown in Table 5.12). The presence of these categories is discreet, but their importance points to an opportunity for Brazil to penetrate leading-edge sectors for the current technological paradigm more systematically. The appearance of the category covering medical drugs certainly reflects Brazil's new legislation on intellectual property passed in 1996 pursuant to the WTO agreement.

Table 5.13 presents statistics for the first subperiod (1980-89), with "Manufacturing of plastic articles" in the lead for both Brazil and São Paulo State.

The main difference between Brazil and São Paulo (which is repeated in all the other tables in this subsection) is the rank of CNAE category "Manufacturing of refined petroleum products" – third for Brazil and not among the top 20 for São Paulo State. It is also important to note the rank of CNAE category "Manufacturing of machinery and equipment for agriculture and poultry farming" - fourth for Brazil and second for São Paulo.

Table 5.14, which refers to the subperiod 1990-99, shows "Manufacturing of plastic articles" still in the lead for both Brazil and São Paulo State.

It also shows a strong presence for the mining and metallurgy sector (which is consistent with Table 5.10). Adding together the categories "Manufacturing of other fabricated metal products", "Manufacturing of flat rolled steel" and "Mining of iron ores" gives a total of 693 patents for Brazil, which would rank second ahead of "Manufacturing of refined petroleum products" (354 patents).

Table 5.15, which refers to the subperiod 2000-05, presents two important changes. The first is in the rank order of industries, with patents in the category "Manufacturing of machinery and equipment for agriculture and poultry farming" overtaking patents in the category "Manufacturing of plastic articles" for both Brazil and São Paulo State.

The second change is the new position of the CNAE categories relating to education and research, as noted above in the discussion of Table 5.12. This new position is consolidated during the subperiod in question. Given that education and research institutions are classified in different categories, it is reasonable to aggregate "Higher education" (universities), "Public administration" (universities as well as research institutions such as CNEN and CTA) and "Research and development in social, human, physical and natural sciences" (Embrapa and FAPESP), for a total of 1,070 patents for Brazil and 577 for São Paulo.[19] These numbers correspond to about 10% of total corporate patent filings in the subperiod.

Another important change is the appearance of the CNAE category "Manufacturing of pharmaceutical preparations for human use" among the leaders

19. Physical and natural sciences are not listed in Table 5.15 for São Paulo (34 patents).

Table 5.12
Top 20 industries with resident corporate applications for invention patents (PIs) and utility model (MUs) from INPI – Brazil & São Paulo State, 1980-2005

Rank	INPI invention patent & utility model filings by CNAE category					
	Brazil			São Paulo State		
	CNAE category	No.	Share of total (%)	CNAE category	No.	Share of total (%)
1	Manufacturing of plastic articles	1,367	4.8	Manufacturing of plastic articles	767	5.4
2	Manufacturing of machinery & equipment for agriculture & poultry farming	945	3.3	Higher education	605	4.2
3	Higher education	825	2.9	Manufacturing of machinery & equipment for agriculture & poultry farming	515	3.6
4	Manufacturing of refined petroleum products	805	2.9	Manufacturing of other home appliances	440	3.1
5	Manufacturing of other fabricated metal products	542	1.9	Manufacturing of other fabricated metal products	312	2.2
6	Manufacturing of other home appliances	480	1.7	Manufacturing of cookers, refrigerators & washing machines	297	2.1
7	Manufacturing of plastic packaging	461	1.6	Manufacturing of parts & accessories for automotive vehicles	289	2.0
8	Public administration in general	460	1.6	Manufacturing of plastic packaging	285	2.0
9	Other service provision, especially corporate	423	1.5	Manufacturing of other machinery & equipment for general use	234	1.6
10	Manufacturing of other machinery & equipment for general use	393	1.4	Manufacturing of other electrical equipment	221	1.6
11	Manufacturing of other electrical equipment	390	1.4	Manufacturing of other machinery & equipment for specific use	218	1.5
12	Manufacturing of cookers, refrigerators & washing machines	361	1.3	Corporate head offices & local administrative units	213	1.5
13	Manufacturing of parts & accessories for automotive vehicles	352	1.2	Manufacturing of metal packaging	178	1.3
14	Mining of iron ores	339	1.2	Manufacturing of medical instruments & devices	170	1.2
15	Research & development in physical & natural sciences	297	1.1	Manufacturing of metal auto parts & accessories	159	1.1
16	Manufacturing of other machinery & equipment for specific use	296	1.0	Other service provision, especially corporate	145	1.0
17	Manufacturing of flat rolled steel	295	1.0	Manufacturing of rubber articles	144	1.0
18	Corporate head offices & local administrative units	268	0.9	Manufacturing of electrical material for vehicles, except batteries	136	1.0
19	Manufacturing of compressors	243	0.9	Research & development in social & human sciences	128	0.9
20	Manufacturing of metal auto parts & accessories	221	0.8	Manufacturing of other chemicals not elsewhere specified or classified	128	0.9
21	Manufacturing of medical instruments & devices	208	0.7	Manufacturing of parts & accessories for automotive engines	127	0.9
	Subtotal	9,867	35.0	Subtotal	5,705	40.1
	Other CNAE categories	18,351	65.0	Other CNAE categories	8,512	59.9
	Total	**28,218**	**100.0**	**Total**	**14,217**	**100.0**

Source: INPI.

Table 5.13
Top 20 industries with resident corporate applications for invention patents (PIs) and utility model (MUs) from INPI – Brazil & São Paulo State, 1980-1989

Rank	INPI invention patent & utility model filings by CNAE category					
	Brazil			São Paulo State		
	CNAE category	No.	Share of total (%)	CNAE category	No.	Share of total (%)
1	Manufacturing of plastic articles	264	5.5	Manufacturing of plastic articles	143	6.1
2	Other service provision, especially corporate, non-specified	179	3.7	Manufacturing of machinery & equipment for agriculture & poultry farming	88	3.7
3	Manufacturing of refined petroleum products	134	2.8	Manufacturing of metal auto parts & accessories	88	3.7
4	Manufacturing of machinery & equipment for agriculture & poultry farming	116	2.4	Manufacturing of other machinery & equipment for specific use	82	3.5
5	Manufacturing of metal auto parts & accessories	108	2.2	Manufacturing of other home appliances	75	3.2
6	Manufacturing of other machinery & equipment for specific use	100	2.1	Manufacturing of glass articles	69	2.9
7	Manufacturing of glass articles	87	1.8	Manufacturing of other home appliances	68	2.9
8	Manufacturing of other electrical equipment	85	1.8	Other service provision, especially corporate, non-specified	61	2.6
9	Manufacturing of flat rolled steel	84	1.7	Manufacturing of other fabricated metal products	55	2.3
10	Manufacturing of other fabricated metal products	80	1.7	Manufacturing of other organic chemical products	51	2.2
11	Manufacturing of other home appliances	78	1.6	Corporate head offices & local administrative units	48	2.0
12	Manufacturing of other home appliances	75	1.6	Manufacturing of other machinery & equipment for general use	46	2.0
13	Manufacturing of other organic chemical products	63	1.3	Manufacturing of other electrical equipment	45	1.9
14	Research & development in physical & natural sciences	60	1.2	Manufacturing of electrical material for vehicles, except batteries	44	1.9
15	Corporate head offices & local administrative units	58	1.2	Manufacturing of machinery, equipment & apparatus for handling & lifting materials, goods or people other than over-the-road vehicles	42	1.8
16	Manufacturing of other machinery & equipment for general use	54	1.1	Higher education	40	1.7
17	Manufacturing of compressors	47	1.0	Manufacturing of other chemicals not elsewhere specified or classified	34	1.4
18	Manufacturing of machinery, equipment & apparatus for handling & lifting materials, goods or people other than over-the-road vehicles	44	0.9	Manufacturing of rubber articles	32	1.4
19	Manufacturing of electrical material for vehicles, except batteries	44	0.9	Manufacturing of insulated wire & cable	32	1.4
20	Higher education	43	0.9	Manufacturing of machinery & equipment for food processing	28	1.2
	Subtotal	1,803	37.4	Subtotal	1,171	49.7
	Other	3,019	62.6	Other	1,187	50.3
	Total	**4,822**	**100.0**	**Total**	**2,358**	**100.0**

Source: INPI.

Table 5.14
Top 20 industries with resident corporate applications for invention patents (PIs) and utility model (MUs) from INPI – Brazil & São Paulo State, 1990-1999

Rank	INPI invention patent & utility model filings by CNAE category					
	Brazil			São Paulo State		
	CNAE category	No.	Share of total (%)	CNAE category	No.	Share of total (%)
1	Manufacturing of plastic articles	708	5.5	Manufacturing of plastic articles	431	6.9
2	Manufacturing of refined petroleum products	354	2.8	Manufacturing of machinery & equipment for agriculture & poultry farming	209	3.3
3	Manufacturing of machinery & equipment for agriculture & poultry farming	322	2.5	Higher education	209	3.3
4	Manufacturing of other fabricated metal products	302	2.4	Manufacturing of metal auto parts & accessories	201	3.2
5	Higher education	260	2.0	Manufacturing of other home appliances	189	3.0
6	Manufacturing of metal auto parts & accessories	244	1.9	Manufacturing of other fabricated metal products	175	2.8
7	Other service provision, especially corporate, non-specified	244	1.9	Manufacturing of other machinery & equipment for specific use	136	2.2
8	Manufacturing of flat rolled steel	211	1.7	Corporate head offices & local administrative units	124	2.0
9	Manufacturing of plastic packaging	209	1.6	Manufacturing of plastic packaging	123	2.0
10	Manufacturing of other home appliances	208	1.6	Manufacturing of other organic chemical products	119	1.9
11	Manufacturing of other machinery & equipment for specific use	196	1.5	Manufacturing of other electrical equipment	116	1.9
12	Mining of iron ores	180	1.4	Manufacturing of metal packaging	101	1.6
13	Manufacturing of other electrical equipment	175	1.4	Manufacturing of cookers, refrigerators & washing machines	100	1.6
14	Manufacturing of other machinery & equipment for general use	165	1.3	Manufacturing of other chemicals not elsewhere specified or classified	94	1.5
15	Corporate head offices & local administrative units	153	1.2	Manufacturing of perfumes & cosmetics	93	1.5
16	Manufacturing of other organic chemical products	145	1.1	Manufacturing of rubber articles	92	1.5
17	Manufacturing of cookers, refrigerators & washing machines	133	1.0	Manufacturing of electrical material for vehicles, except batteries	92	1.5
18	Retail trade in other products not elsewhere specified	126	1.0	Retail trade in other products not elsewhere specified	90	1.4
19	Public administration in general	117	0.9	Other service provision, especially corporate, non-specified	84	1.3
20	Manufacturing of other chemicals not elsewhere specified or classified	116	0.9	Manufacturing of other machinery & equipment for general use	78	1.2
	Subtotal	4,568	35.7	Subtotal	2,856	45.8
	Other	8,210	64.3	Other	3,385	54.2
	Total	**12,778**	**100.0**	**Total**	**6,241**	**100.0**

Source: INPI.

Table 5.15
Top 20 industries with resident corporate applications for invention patents (PIs) and utility model (MUs) from INPI – Brazil & São Paulo State, 2000-2005

Rank	INPI invention patent & utility model filings by CNAE category					
	Brazil			São Paulo State		
	CNAE category	No.	Share of total (%)	CNAE category	No.	Share of total (%)
1	Higher education	522	4.9	Higher education	356	6.2
2	Manufacturing of machinery & equipment for agriculture & poultry farming	507	4.8	Manufacturing of machinery & equipment for agriculture & poultry farming	218	3.9
3	Manufacturing of plastic articles	395	3.7	Manufacturing of plastic articles	193	3.4
4	Manufacturing of refined petroleum products	317	3.0	Manufacturing of cookers, refrigerators & washing machines	193	3.4
5	Public administration in general	301	2.8	Manufacturing of other home appliances	183	3.3
6	Manufacturing of cookers, refrigerators & washing machines	257	2.4	Manufacturing of metal auto parts & accessories	159	2.8
7	Manufacturing of plastic packaging	222	2.1	Manufacturing of plastic packaging	142	2.5
8	Manufacturing of metal auto parts & accessories	221	2.1	Research & development in social & human sciences	121	2.2
9	Manufacturing of other home appliances	194	1.8	Manufacturing of other machinery & equipment for general use	110	2.0
10	Manufacturing of other machinery & equipment for general use	174	1.6	Retail trade in other products not elsewhere specified	98	1.7
11	Manufacturing of other fabricated metal products	160	1.5	Manufacturing of other organic chemical products	83	1.5
12	Retail trade in other products not elsewhere specified	158	1.5	Manufacturing of pharmaceutical preparations for human use	82	1.5
13	Manufacturing of other machinery & equipment for specific use	149	1.4	Manufacturing of other fabricated metal products	82	1.5
14	Mining of iron ores	132	1.2	Manufacturing of other machinery & equipment for specific use	77	1.4
15	Manufacturing of other electrical equipment	130	1.2	Manufacturing of games & toys	76	1.4
16	Research & development in physical & natural sciences	125	1.2	Manufacturing of other chemicals not elsewhere specified or classified	73	1.3
17	Research & development in social & human sciences	122	1.1	Public administration in general	66	1.2
18	Other service provision, especially corporate	110	1.0	Other service provision, especially corporate	63	1.1
19	Manufacturing of pharmaceutical preparations for human use	107	1.0	Manufacturing of parts & accessories for automotive engines	62	1.1
20	Manufacturing of other organic chemical products	105	1.0	Manufacturing of metal packaging	61	1.1
	Subtotal	4,405	41.5	Subtotal	2,492	44.4
	Other	6,210	58.5	Other	3,124	55.6
	Total	**10,615**	**100.0**	**Total**	**5,616**	**100.0**

Source: INPI.

for the first time, both for Brazil (19th place) and for São Paulo State (12th place). As noted above, the 1996 patent law extended protection to new sectors including medical drugs.

In sum, the assessment presented in this section identifies changes in the geographic and corporate or institutional dimensions, and in economic sectors. The most important changes are: (1) southern states rising up the rank order, although a southeastern state, São Paulo, remains the leader; (2) changes in 17 leading corporate entities between 1980-89 and 2000-05, alongside the persistent leadership of Petrobras for Brazil; (3) minor changes among the top five industrial CNAE categories, with "Manufacturing of machinery and equipment for agriculture and poultry farming" reaching first place in 2000-05; and (4) a strong presence of education and research institutions among the leading corporate entities and CNAE categories.

These changes are compatible with the overall picture described in section 2 of this chapter. They mainly involve traditional economic sectors, while CNAE categories and sectors associated with emerging technologies remain relatively low in the rank order (as discussed earlier, sectors such as medical devices and drugs have not yet even reached tenth place).

4. Non-resident patents

Non-resident patent filings indicate the interest a given country represents for companies in other countries. The country with the most non-resident patents is the United States. In 2005, non-resident patent applications accounted for 182,866 out of a total of 390,733 patent applications filed with USPTO, or 46.8% (USPTO, 2007). USPTO defines the country of origin of an application based on the residence of the first-named inventor.

The ratio of resident patents to non-resident patents expresses the balance between the country's technological capabilities (patent applications filed by residents) and the attractiveness of its domestic market (patent applications filed by non-residents). The U.S. is world leader in numbers of non-resident patents but even so the number of resident patents is larger. Japan also has more resident than non-resident patents.

In Brazil, non-resident patent applications accounted for 64.2% of total patent applications filed with INPI in the period 1980-2005 (Table 5.16).

The proportion of non-resident patents remains relatively stable in all three subperiods. In the first two subperiods (1980-89 and 1990-99), the proportion of non-resident patents remains stable at around 63% of the total, while in the last subperiod (2000-05) it increases moderately, reaching 66% of the total.

The quality of non-resident patents can be gauged by comparing the number of invention patents (PIs), which are complex, to that of utility models (MUs), which are simpler. In the overall period 1980-2005, non-residents filed 78.5% of PIs and only 2.2% of MUs.

Table 5.17 presents a breakdown of non-resident INPI filings by country.

The data in this table show the U.S. as the leading country of origin for non-resident patent applications in Brazil, with 41.8% of the total in the period 1980-2005.

Table 5.18A presents a breakdown of non-resident INPI filings by company. A comparison with the statistics for patent applications filed by Brazilian residents (Table 5.8) shows that Petrobras would rank 19th in Table 5.18A, with 804 patents.

Twenty of the top 30 companies for the period 1980-2005 are headquartered in the U.S. In line with the changes in the most important technology subdomains discussed in connection with Table 5.5A, the leading non-resident corporate patentees in Brazil are different in each subperiod: IBM (information technology) for 1980-89, Procter & Gamble (food, hygiene, personal care and pharmaceuticals) for 1990-99, and Qualcomm (electronics and software) for 2000-05.

Ten of the top 30 companies in the first subperiod remain there in 2000-05. IBM falls from first place in 1980-89 to 16th in 1990-99, and below 30th in 2000-05, while Microsoft, not among the top 30 in 1980-89 or 1990-99, ranks fifth in 2000-05. It is also worth noting the appearance of Nokia among the top 30 in 2000-05 (15th place) and of a South Korean company (LG Electronics, ranked 28th). These changes reflect the emergence of new technological paradigms, as noted in section 2 of this chapter. The presence of a South Korean company, moreover, also reflects the changes in country ranks shown in Table 5.1.

Table 5.16
Applications filed with INPI by Brazilian residents and non-residents for invention patents (PIs) and utility models (MUs) – Brazil, 1980-2005

First-name inventor	Type of INPI application					
	Invention patents (PI)		Utility models (MU)		Total	
	No.	Share of total (%)	No.	Share of total (%)	No.	Share of total (%)
1980-2005						
Total	**242,454**	**100.0**	**55,876**	**100.0**	**298,330**	**100.0**
Residents	52,106	21.5	54,664	97.8	**106,770**	**35.8**
Non-residents	190,348	78.5	1,212	2.2	**191,560**	**64.2**
1980-1989						
Total	**31,940**	**100.0**	**8,062**	**100.0**	**40,002**	**100.0**
Residents	6,980	21.9	7,783	96.5	**14,763**	**36.9**
Non-residents	24,960	78.1	279	3.5	**25,239**	**63.1**
1990-1999						
Total	**111,508**	**100.0**	**28,115**	**100.0**	**139,623**	**100.0**
Residents	24,208	21.7	27,571	98.1	**51,779**	**37.1**
Non-residents	87,300	78.3	544	1.9	**87,844**	**62.9**
2000-2005						
Total	**99,006**	**100.0**	**19,699**	**100.0**	**118,705**	**100.0**
Residents	20,918	21.1	19,310	98.0	**40,228**	**33.9**
Non-residents	78,088	78.9	389	2.0	**78,477**	**66.1**

Source: INPI.

Table 5.17
Non-resident applications filed with INPI for invention patents (PIs) and utility models (MUs) by first-named inventor's country of origin – Brazil ,1980-2005

First-named inventor's country of origin	INPI invention patent & utility model filings by non-residents	
	No.	Share of total (%)
United States	80,149	41.8
Germany	27,747	14.5
France	13,170	6.9
Japan	10,190	5.3
Switzerland	9,426	4.9
Netherlands	7,613	4.0
UK	7,333	3.8
Italy	6,507	3.4
Sweden	5,358	2.8
Canada	2,738	1.4
South Korea	2,244	1.2
Australia	2,058	1.1
Finland	2,034	1.1
Belgium	1,752	0.9
Spain	1,664	0.9
Denmark	1,323	0.7
Austria	1,143	0.6
Norway	1,113	0.6
Argentina	905	0.5
Israel	880	0.5
South Africa	482	0.3
China	447	0.2
Taiwan	435	0.2
India	433	0.2
Luxembourg	401	0.2
Ireland	290	0.2
New Zealand	284	0.1
Mexico	272	0.1
USSR	230	0.1
Virgin Islands (England)	217	0.1
Subtotal	188,838	98.6
Other	2,722	1.4
Total	**191,560**	**100.0**

Source: INPI.

Table 5.18A
Top 30 companies filing non-resident applications with INPI for invention patents (PIs) and utility models (MUs) – Brazil, 1980-2005

Rank	Company	Country	INPI invention patent & utility model filings by non-residents	
			No.	Share of total (%)
1	The Procter & Gamble Company	United States	2,914	1.5
2	Bayer Aktiengesellschaft	Germany	1,723	0.9
3	Basf Aktiengesellschaft	Germany	1,668	0.9
4	Unilever N.V.	Netherlands	1,596	0.8
5	Johnson & Johnson	United States	1,458	0.8
6	Qualcomm Incorporated	United States	1,332	0.7
7	The Goodyear Tire & Rubber Company	United States	1,252	0.7
8	E.I. Du Pont de Nemours and Company	United States	1,219	0.6
9	Xerox Corporation	United States	1,211	0.6
10	Minnesota Mining and Manufacturing Company	United States	1,198	0.6
11	Siemens Aktiengesellschaft	Germany	1,191	0.6
12	Robert Bosch GmbH	Germany	1,183	0.6
13	Hoechst Aktiengesellschaft	Germany	1,013	0.5
14	L'Oreal	France	988	0.5
15	International Business Machines Corporation	United States	986	0.5
16	The Dow Chemical Company	United States	968	0.5
17	Rohm And Haas Company	United States	903	0.5
18	Motorola, Inc.	United States	887	0.5
19	3M Innovative Properties Company	United States	761	0.4
20	General Electric Company	United States	741	0.4
21	Eaton Corporation	United States	733	0.4
22	Kimberly-Clark Worldwide, Inc.	United States	680	0.4
23	Shell Internationale Research Maatschappij B.V	Netherlands	665	0.3
24	Ciba-Geigy AG	Switzerland	647	0.3
25	Colgate-Palmolive Company	United States	623	0.3
26	Astrazeneca AB	Sweden	622	0.3
27	Microsoft Corporation	United States	602	0.3
28	Deere & Company	United States	550	0.3
29	Pfizer Products Inc.	United States	539	0.3
30	Praxair Technology, Inc.	United States	528	0.3
	Subtotal		31,381	16.4
	Other		160,179	83.6
	Total		**191,560**	**100.0**

Source: INPI.

Table 5.18B
Top 30 companies filing non-resident applications with INPI for invention patents (PIs) and utility models (MUs) – Brazil, 1980-1989

Rank	Company	Country	INPI invention patent & utility model filings by non-residents	
			No.	Share of total (%)
1	International Business Machines Corporation	United States	475	1.9
2	The Dow Chemical Company	United States	413	1.6
3	Minnesota Mining and Manufacturing Company	United States	379	1.5
4	Shell Internationale Research Maatschappij B.V	Netherlands	378	1.5
5	Siemens Aktiengesellschaft	Germany	358	1.4
6	Ciba-Geigy AG	Switzerland	341	1.4
7	Unilever N.V.	Netherlands	335	1.3
8	Bayer Aktiengesellschaft	Germany	322	1.3
9	Hoechst Aktiengesellschaft	Germany	310	1.2
10	E.I. Du Pont de Nemours and Company	United States	274	1.1
11	Johnson & Johnson	United States	254	1.0
12	Union Carbide Corporation	United States	195	0.8
13	Imperial Chemical Industries Plc.	UK	174	0.7
14	The Goodyear Tire & Rubber Company	United States	169	0.7
15	Henkel Kommanditgesellschaft Auf Aktien	Germany	168	0.7
16	Colgate-Palmolive Company	United States	165	0.7
17	Rhone-Poulenc Chimie	France	162	0.6
18	General Electric Company	United States	152	0.6
19	American Cyanamid Company	United States	141	0.6
20	Eaton Corporation	United States	116	0.5
21	YKK Corporation	Japan	116	0.5
22	Fiat Auto S.p.A.	Italy	110	0.4
23	Westinghouse Electric Corporation	United States	108	0.4
24	Alcan International Limited	Canada	108	0.4
25	Robert Bosch GmbH	Germany	104	0.4
26	Rohm And Haas Company	United States	101	0.4
27	AMP Incorporated	United States	96	0.4
28	Degussa Aktiengesellschaft	Germany	92	0.4
29	Rhone-Poulenc Specialites Chimiques	France	91	0.4
30	Saint-Gobain Vitrage	France	90	0.4
	Subtotal		6,297	24.9
	Other		18,942	75.1
	Total		**25,239**	**100.0**

Source: INPI.

Table 5.18C
Top 30 companies filing non-resident applications with INPI for invention patents (PIs) and utility models (MUs) – Brazil, 1990-1999

Rank	Company	Country	INPI invention patent & utility model filings by non-residents	
			No.	Share of total (%)
1	The Procter & Gamble Company	United States	2,038	2.3
2	Bayer Aktiengesellschaft	Germany	939	1.1
3	Minnesota Mining and Manufacturing Company	United States	816	0.9
4	Unilever N.V.	Netherlands	778	0.9
5	Basf Aktiengesellschaft	Germany	723	0.8
6	Hoechst Aktiengesellschaft	Germany	703	0.8
7	Xerox Corporation	United States	627	0.7
8	Robert Bosch GmbH	Germany	614	0.7
9	The Goodyear Tire & Rubber Company	United States	609	0.7
10	Johnson & Johnson	United States	606	0.7
11	Motorola, Inc.	United States	595	0.7
12	The Dow Chemical Company	United States	541	0.6
13	E.I. Du Pont de Nemours and Company	United States	528	0.6
14	Rohm and Haas Company	United States	483	0.5
15	L'Oreal	France	453	0.5
16	International Business Machines Corporation	United States	437	0.5
17	Siemens Aktiengesellschaft	Germany	402	0.5
18	Praxair Technology, Inc.	United States	394	0.4
19	Eaton Corporation	United States	378	0.4
20	Eli Lilly and Company	United States	362	0.4
21	American Cyanamid Company	United States	323	0.4
22	Ciba-Geigy AG	Switzerland	306	0.3
23	Qualcomm Incorporated	United States	301	0.3
24	Telefonaktiebolaget LM Ericsson (publ)	Sweden	274	0.3
25	Shell Internationale Research Maatschappij B.V	Netherlands	268	0.3
26	Kimberly-Clark Worldwide, Inc.	United States	267	0.3
27	Ericsson, Inc.	United States	260	0.3
28	Colgate-Palmolive Company	United States	246	0.3
29	Pfizer, Inc.	United States	243	0.3
30	Novo Nordisk A/S	Denmark	234	0.3
	Subtotal		15,748	17.9
	Other		72,096	82.1
	Total		**87,844**	**100.0**

Source: INPI.

Table 5.18D
Top 30 companies filing non-resident applications with INPI for invention patents (PIs) and utility models (MUs) – Brazil, 2000-2005

Rank	Company	Country	INPI invention patent & utility model filings by non-residents	
			No.	Share of total (%)
1	Qualcomm Incorporated	United States	1,031	1.3
2	Basf Aktiengesellschaft	Germany	906	1.2
3	Unilever N.V.	Netherlands	842	1.1
4	The Procter & Gamble Company	United States	801	1.0
5	3M Innovative Properties Company	United States	695	0.9
6	Microsoft Corporation	United States	600	0.8
7	Johnson & Johnson	United States	598	0.8
8	Xerox Corporation	United States	554	0.7
9	L'Oreal	France	522	0.7
10	Astrazeneca AB	Sweden	521	0.7
11	The Goodyear Tire & Rubber Company	United States	474	0.6
12	Robert Bosch GmbH	Germany	465	0.6
13	Bayer Aktiengesellschaft	Germany	462	0.6
14	Novartis AG	Switzerland	461	0.6
15	Nokia Corporation	Finland	460	0.6
16	Pfizer Products, Inc.	United States	440	0.6
17	Siemens Aktiengesellschaft	Germany	431	0.5
18	General Electric Company	United States	417	0.5
19	E.I. Du Pont de Nemours And Company	United States	417	0.5
20	Kimberly-Clark Worldwide, Inc.	United States	412	0.5
21	Wyeth	United States	375	0.5
22	F. Hoffmann-La Roche AG	Switzerland	352	0.4
23	Deere & Company	United States	332	0.4
24	Rohm And Haas Company	United States	319	0.4
25	Honda Giken Kogyo Kabushiki Kaisha	Japan	285	0.4
26	Dow Global Technologies, Inc.	United States	279	0.4
27	Motorola, Inc.	United States	255	0.3
28	LG Electronics, Inc.	South Korea	253	0.3
29	Akzo Nobel N.V.	Netherlands	245	0.3
30	Eaton Corporation	United States	239	0.3
	Subtotal		14,443	18.4
	Other		64,034	81.6
	Total		**78,477**	**100.0**

Source: INPI.

5. Patenting by universities and research institutions

As discussed in 3.2 above, one of the key changes identified is the growing number of patent applications filed by universities and research institutions, which account for 10% of corporate patent applications by Brazilian residents in the last subperiod (2000-05).

This trend is not exclusive to Brazil. Academic patenting has increased in the U.S., according to the National Science Foundation, which devotes a topic to the subject in a recent report (NSB, 2008, p. 5-50/5-52).[20] Patent grants to universities and colleges totalled 2,725, or 3.57% of all grants to U.S. residents, in 2005 (NSB, 2008, p. A5-76). In 2007, however, the top 20 corporate patentees in the U.S. included only one academic institution, the University of California, with 333 patents (USPTO, 2008). This contrasts with the data presented in Table 5.11, showing that the top 20 in Brazil include nine academic and research institutions: Universidade Estadual de Campinas (Unicamp), FAPESP, Universidade Federal de Minas Gerais (UFMG), Universidade Federal do Rio de Janeiro (UFRJ), CNPq, Embrapa, USP, Centro de Desenvolvimento de Tecnologia Nuclear (CDTN) and Universidade Estadual Paulista (Unesp).

The main drivers of this growth in academic patenting in Brazil are globalization, changes in patent law at home, and more widespread concern with intellectual property protection among universities and research institutions, grounded in technological capabilities built up over time.

Table 5.19 presents the top 20 academic and research institutions in terms of INPI patent applications in the period 1980-2005.

Nine of these patentees are universities. As noted above (3.2), in the subperiod 1980-89 the leader in this group for Brazil is IPT, with 48 patents (Table 5.9). Participation by universities increases in the ensuing decades. Póvoa (2008) points to a difference between the behavior of universities and other research institutions in the sense that patenting by universities rises significantly from the 1990s on, whereas patenting by other research institutions is more stable in aggregate.

Research institutions that specialize in certain fields, such as Embrapa, Fiocruz, IPT and CDTN, also play an important role. Most of IPT's patent applications are filed in the first subperiod and most of CDTN's in the third, as shown by the tables in subsection 3.3 (Tables 5.12-5.15).

The presence of CNPq, FAPESP and Fapemig, its counterpart in Minas Gerais, among the leaders in Table 5.19 reflects increased concern on the part of these research funding institutions to protect intellectual property deriving from the research activities they support.

Table 5.20 presents the specific contribution of academic patenting in terms of a breakdown by OST technology subdomains for the period 1980-2005.

This table indicates academic and research institutions' potential to renew the nation's technology base. The subdomains worth noting, for both Brazil and São Paulo State, are "Pharmaceuticals and cosmetics" in second place, "Medical engineering" in fourth, and "Biotechnology" in eighth and fifth respectively. Thus the technological specialization of these universities and research institutions differs perceptibly from Brazil's general specialization, shown by Table 5.4A. This difference suggests that academic and research institutions have a role to play in the renovation of the country's technology base.

In Table 5.20, patents associated with ICT are not particularly high in the rank order ("Telecommunications" is 15th, "Information technology" 18th and "Semiconductors" 29th), suggesting that these institutions require more investment to deal with the leading technologies in the prevailing paradigm.

The data presented in this subsection, especially on the growth in academic patenting activity, place new topics on the S&T policy agenda. This discussion is important because several specialized studies have found that patents are not the most significant mechanism for transferring technology from universities to companies (Cohen et al., 2002, for the U.S.; Póvoa, 2008, for Brazil). In any event, academic patents are not a panacea for overcoming the problems that beset university-business interaction.[21]

The definition of an adequate institutional division of labor among universities, research institutions and business will make a decisive contribution to the maturing of the Brazilian innovation system.

20. The significance of academic patents is controversial. For a critical position, the work of Richard Nelson is an important reference (see, for example, NELSON, 2006).

21. The chapter on academic patenting in the National Science Foundation's report ends with an important finding: the annual number of startup companies established as a result of university-based inventions exceeded 400 in both 2004 and 2005 (NSB, 2008, p. 5-52).

Table 5.19
Top 20 universities and research institutions filing applications with INPI for invention patents (PIs) and utility models (MUs) – Brazil & São Paulo State, 1980-2005

Rank	INPI invention patent & utility model filings					
	Brazil			São Paulo State		
	First-named inventor	No.	Share of total (%)	First-named inventor	No.	Share of total (%)
1	Unicamp	409	22.0	Unicamp	409	38.8
2	Embrapa	196	7.3	USP	136	12.9
3	USP	136	6.9	FAPESP	128	12.1
4	FAPESP	128	10.6	IPT	99	9.4
5	UFMG	113	6.1	Unesp	51	4.8
6	IPT	100	5.4	CTA	38	3.6
7	CDTN	73	3.9	Embrapa	33	3.1
8	Unesp	51	2.7	UFSCar	22	2.1
9	Fiocruz	48	2.6	Fundação Butantan	17	1.6
10	CTA	38	2.0	Inpe	14	1.3
11	UFRGS	38	2.0	Liceu de Artes e Ofícios de São Paulo	12	1.1
12	UFV	36	1.9	Cesp	12	1.1
13	UFPE	32	1.7	CPqD	11	1.0
14	CNPq	28	1.1	Unifesp	8	0.8
15	Inpe	23	1.5	IMT	8	0.8
16	UFSCar	22	1.2	CNPq	5	0.5
17	Fundação Universidade de Brasília	21	1.0	Associação de Ensino de Marília Ltda.	5	0.5
18	Cepel	19	0.9	NPA	4	0.4
19	Fundação Butantan	17	0.9	Osec	4	0.4
20	Fapemig	17	0.0	Cetesb	4	0.4
	Subtotal	1,545	83.3	Subtotal	1,020	96.7
	Others	310	16.7	Others	35	3.3
	Total	**1,855**	**100.0**	**Total**	**1,055**	**100.0**

Source: INPI.

Note: The analysis included the following universities and research institutions not classified under CNAE categories "Higher education", "Public administration in general" or "Research and development": IPT, Fundação Butantan, Liceu de Artes e Ofícios de São Paulo, Cesp and UFSCar. This explains the differences between the data in this table and Table 5.8.

Table 5.20
University and research institution applications filed with INPI for invention patents (PIs) and utility models (MUs) by OST technology subdomain – Brazil & São Paulo State, 1980-2005

Rank	INPI invention patent & utility model filings by universities & research institutions					
	Brazil			São Paulo State		
	OST technology subdomain	No.	Share of total (%)	OST technology subdomain	No.	Share of total (%)
	Total	**1,855**	**100.0**	**Total**	**1,055**	**100.0**
1	7. Analysis, measurement, control	261	14.1	7. Analysis, measurement, control	158	15.0
2	11. Pharmaceuticals, cosmetics	209	1.6	11. Pharmaceuticals, cosmetics	104	9.9
3	17. Materials, metallurgy	135	0.1	17. Materials, metallurgy	88	8.3
4	8. Medical engineering	114	0.0	8. Medical engineering	71	6.7
5	19. Basic materials chemistry	112	0.0	12. Biotechnology	57	5.4
6	25. Agricultural & food processing apparatus	94	0.0	19. Basic materials chemistry	48	4.5
7	14. Technical procedures	87	0.0	14. Technical procedures	43	4.1
8	12. Biotechnology	84	0.0	20. Environment, pollution	43	4.1
9	13. Agricultural & food products	77	0.0	13. Agricultural & food products	40	3.8
10	20. Environment, pollution	67	0.0	16. Materials processing	38	3.6
11	9. Organic fine chemicals	64	0.0	10. Macromolecular chemistry	37	3.5
12	16. Materials processing	57	0.0	1. Electrical components	33	3.1
13	1. Electrical components	53	0.0	9. Organic fine chemicals	31	2.9
14	10. Macromolecular chemistry	52	0.0	3. Telecommunications	26	2.5
15	3. Telecommunications	42	0.0	30. Civil engineering, building	26	2.5
16	30. Civil engineering, building	42	0.0	25. Agricultural & food processing apparatus	24	2.3
17	29. Consumer goods & equipment	40	0.0	6. Surface treatment	23	2.2
18	4. Information technology	34	0.0	29. Consumer goods & equipment	20	1.9
19	15. Surface treatment	31	0.0	15. Surface treatment	18	1.7
20	6. Surface treatment	30	0.0	4. Information technology	18	1.7
21	24. Handing, printing	24	0.0	22. Engines, pumps, turbines	14	1.3
22	27. Nuclear techniques	22	0.0	21. Machine-tools	12	1.1
23	21. Machine-tools	19	0.0	24. Handing, printing	12	1.1
24	22. Engines, pumps, turbines	17	0.0	26. Transport	12	1.1
25	26. Transport	17	0.0	18. Thermal procedures	11	1.0
26	2. Audiovisual technology	16	0.0	2. Audiovisual technology	10	0.9
27	23. Mechanical components	15	0.0	27. Nuclear techniques	10	0.9
28	18. Thermal procedures	14	0.0	23. Mechanical components	8	0.8
29	5. Semiconductors	9	0.0	5. Semiconductors	7	0.7
30	28. Space technology, weapons	3	0.0	28. Space technology, weapons	3	0.3
31	Unclassified	14	0.0	Unclassified	10	0.9

Source: INPI.

6. Conclusions

This chapter aims to identify Brazil's international positioning in terms of patenting activity according to the available statistics on this subject from USPTO and OECD. On one hand, the fact that Brazil has conserved its position in the international rank order suggests that its S&T policy has been capable of preventing the descent undergone by other countries. On the other hand, for Brazil to improve its position it needs industrial and S&T policies with bolder targets, focusing explicitly on the penetration of new industrial markets, especially in emerging technologies.

The problem of the quantity of patents is associated with their quality, given Brazil's weakness in key fields of the more recent technological paradigms.

The analysis of patent applications filed with INPI includes a comparison between filings by Brazilian residents and non-residents. Here too there are quantitative and qualitative problems. Quantitatively speaking, the predominance of non-resident patents is substantial, as is typical of countries with immature innovation systems. Qualitatively speaking, non-resident patents predominate strongly in technology subdomains typical of more recent paradigms, such as "Organic fine chemicals", "Pharmaceuticals and cosmetics", "Macromolecular chemistry", "Biotechnology", "Semiconductors", and "Information technology". Because patents grant a monopoly to their owners, albeit temporarily, this weakness in Brazil may signify a major barrier in the sectors and technologies concerned, which are indispensable to a successful catching-up process.

With regard to patenting activity by Brazilian residents, the analysis found consistent predominance of patents with less technological content (utility models) and filings by individuals (which do not predominate only in more sophisticated technology subdomains such as "Pharmaceuticals and cosmetics", "Macromolecular chemistry", and "Biotechnology"). The fact that the same technology subdomains lead the rank order in all three subperiods analyzed can be seen as positive, indicating continuity of technological efforts in these fields, but at the same time points to low capacity to penetrate the new fields that are increasingly important on the global scene.

Among the most important changes in resident patenting is the increasing weight of academic and research institutions among the leaders (nine of the top 20). This phenomenon requires careful reflection, since its importance is not merely quantitative but also qualitative: the most significant technology subdomains for these institutions are associated with more recent paradigms, indicating their contribution to renewal of Brazil's technology base. In other words, it is important to include on the agenda a discussion of the inter-institutional division of labor inside the Brazilian innovation system, in order to define more clearly the role of universities and research institutions.

Unfortunately the importance of patenting by academic and research institutions is heightened by the timidity of business patenting. This timidity is associated with the findings of Chapter 7 regarding the low level of investment by Brazilian companies in R&D, as well as the small share of high-technology sectors in the structure of Brazilian industry. The timidity of business patenting in Brazil identified in this chapter should serve as an alert to the need for more audacious industrial and technological policies, given the importance of bolstering the involvement of business with innovative activities.

According to the S&T interaction matrix analysis presented in subsection 2.3 of this chapter, these industrial and technological policies are increasingly dependent on the contributions of Brazil's science infrastructure. By analyzing citations of technical and scientific literature in patent filings it is possible to gauge the growing importance of various science and engineering fields to the development of patentable innovations. Thus the rise in patent numbers is directly associated with an improvement in quality and an increase in the scientific content of the technologies created. Once again, quantitative and qualitative changes are presuppositions for more effective interaction between science and technology in Brazil. S&T interaction matrix analysis can be of assistance in constructing industrial and technological policies that take into consideration the important and growing contributions of science to technological production.

Finally, the patenting statistics analyzed in this chapter reaffirm São Paulo State's consistent leadership on the Brazilian technological scene. As the leading state, therefore, São Paulo State has a key role to play in inducing the changes recommended here as indispensable to a successful catching-up process and as the goal of the development policy Brazil so urgently needs.

References

ALBUQUERQUE, E. Science and technology systems in less developed countries: identifying a threshold level and focusing in the cases of India and Brazil. In: MOED, H., GLÄNZEL, W. & SCHMOCH, U. (eds.), **Handbook of Quantitative Science and Technology Research: the Use of Publication and Patent Statistics in Studies of S&T systems**. Dordrecht: Kluwer Academic Publishers, 2004.

ARCHIBUGI, D. & PIANTA, M. Innovation surveys and patents as technology indicators: the state of the art. In: OECD. **Innovation, Patents and Technological Strategies**. Paris: OECD, 1996.

COHEN, W. & LEVIN, R.C. Empirical studies of innovation and market structure. In: SCHMALENSEE, R. & WILLIG, R.D. (eds.), **Handbook of Industrial Organization**. Amsterdam: Elsevier Science, 1989. v. 2. pp. 1059-1107.

COHEN, W., NELSON, R. & WALSH, J. Links and impacts: the influence of public R&D on industrial research. **Management Science**, v. 48, n. 1, pp. 1-23, 2002.

DOSI, G. **Technical Change and Industrial Transformation**: the theory and an application to the semiconductor industry. London: Macmillan, 1984.

DOSI, G., MALERBA, F., RAMELLO, G. B. & SILVA, F. Information, appropriability, and the generation of innovative knowledge four decades after Arrow and Nelson: an introduction. **Industrial and Corporate Change**, v. 15, n. 6, pp. 891-901, 2006.

FAPESP (FUNDAÇÃO DE AMPARO À PESQUISA DO ESTADO DE SÃO PAULO). **Indicadores de Ciência, Tecnologia e Inovação em São Paulo**, *2004*. São Paulo: FAPESP, 2005. 2 v.

FREEMAN, C. & LOUÇÃ, F. **As Time Goes By:** from the industrial revolutions to the information revolution. Oxford: Oxford University, 2001.

FURTADO, C. **Teoria e Política do Desenvolvimento Econômico**. 2. ed. São Paulo: Nova Cultural, 1986.

GRILICHES, Z. Patent statistics as economic indicators: a survey. **Journal of Economic Literature**, v. 28, Dec. 1990.

KLEVORICK, A., LEVIN, R. C., NELSON, R. R. & WINTER, S. G. On the sources and significance of inter-industry differences in technological opportunities. **Research Policy**, v. 24, pp. 185-205, 1995.

LEVIN, R. A new look at the patent system. **American Economic Review**, v. 76, n. 2, pp. 199-202, May 1986.

LEVIN, R., KLEVORICK, A. K., NELSON, R. R. & WINTER, S. G. Appropriating the returns from industrial research and development. **Brookings Papers on Economic Activity**, Washington, v. 3, pp. 783-832, 1987.

MADDISON, A. **The World Economy**: a millennial perspective. Paris: OECD, 2002.

MANSFIELD, E., SCHWARTZ, M. & WAGNER, S. Imitation costs and patents: an empirical study. **The Economic Journal**, n. 91, 1981.

MOED, H., GLÄNZEL, W. & SCHMOCH, U. (eds.). **Handbook of Quantitative Science and Technology Research**: the use of publication and patent statistics in studies of S&T systems. Dordrecht: Kluwer Academic Publishers, 2004.

NARIN, F., HAMILTON, K.S. & OLIVASTRO, D. The increasing linkage between U.S. technology and public science. **Research Policy**, v. 26, n. 3, pp. 317-330, 1997.

NELSON, R. What is "commercial" and what is "public" about technology, and what should be? In: ROSENBERG, N., LANDAU, R. & MOWERY, D. (eds.). **Technology and the Wealth of Nations**. Stanford: Stanford University, 1992.

NELSON, R.R. Reflections on "The simple economics of basic science": looking back and looking forward. **Industrial and Corporate Change**, v. 15, n. 6, pp. 903-917, 2006.

NSB (NATIONAL SCIENCE BOARD). **Science and Engineering Indicators 2002**. Arlington, VA: 2002. Available at <http://www.nsf.gov/statistics/seind02/>.

__________. **Science and Engineering Indicators 2004**. Arlington, VA: 2004. Available at <http://www.nsf.gov/statistics/seind04/>.

__________. **Science and Engineering Indicators 2006**. Arlington, VA: 2006. Available at <http://www.nsf.gov/statistics/seind06/>.

__________. **Science and Engineering Indicators 2008**. Arlington, VA: 2008. Available at <http://www.nsf.gov/statistics/seind08/>.

OECD (ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT). **Patents and Innovation in the International Context**. Paris: OECD, 1997.

__________. **Triadic patent families methodology**. STI Working Paper 2004/2. Paris, OECD, 2004. Available at <http://www.oecd-ilibrary.org/science-and-technology/triadic-patent-families-methodology_443844125004>.

__________. **Patent Database**. Paris: OECD, June 2007.

OST (OBSERVATOIRE DES SCIENCES ET DES TECHNIQUES). **Science & Technologie: indicateurs 2006**. Paris: Economica, 2006. Available at <http://www.obs-ost.fr/le-savoir-faire/etudes-en-ligne/etudes-2006/rapport-2006.html>.

PATEL, P. & PAVITT, K. Patterns of technological activity: their measurement and interpretation. In: STONEMAN, P. (ed.). **Handbook of the Economics of Innovation and Technological Change**. Oxford: Blackwell, 1995.

PAVITT, K. Uses and abuses of patent statistics. In: VAN RAAN, A.F.J. (ed.). **Handbook of Quantitative Studies of Science and Technology.** Amsterdam: North Holland, 1988.

PENROSE, E. International patenting and less-developed countries. **Economic Journal**, v. 83, n. 331, pp. 768-788, 1973.

PÓVOA, L.M. **Patentes de universidades e institutos públicos de pesquisa e a transferência de tecnologia para empresas no Brasil.** PhD theses. Belo Horizonte: UFMG - Cadeplar, 2008

RIBEIRO, L.C., RUIZ, R. M., BERNARDES, A. T. & ALBUQUERQUE, E. M. Matrices of science and technology interactions and patterns of structured growth: implications for development. **Scientometrics**, June 2009. Available at <http://www.springerlink.com/content/2174610530365460/fulltext.pdf>.

TIJSSEN, R. Measuring and evaluating science-technology connections and interactions. In: MOED, H., GLÄNZEL, W. & SCHMOCH, U. (eds.). **Handbook of Quantitative Science and Technology Research**: the use of publication and patent statistics in studies of S&T systems. Dordrecht: Kluwer Academic Publishers, 2004. pp. 695-715.

UNDP (UNITED NATIONS DEVELOPMENT PROGRAM). **Human Development Report 2007/2008**. New York: UNDP, 2007. Available at <www.undp.org>.

UPOV (INTERNATIONAL UNION FOR THE PROTECTION OF NEW VARIETIES OF PLANTS). **Statistiques sur la protection des obtentions végétales**. Genève: UPOV, 2007. Available at <www.upov.org>.

USPTO (UNITED STATES PATENT AND TRADEMARK OFFICE). **Number of utility patents applications filed in the United States**, by country of origin – calendar year 1965 to present. Alexandria, VA: USPTO, 2007. Available at <www.uspto.gov/web/offices/ac/ido/oeip/taf/appl_yr.pdf>.

__________. **Patenting by organizations 2007**. Alexandria, VA: USPTO, 2008. Available at <www.uspto.gov/web/offices/ac/ido/oeip/taf/topo_07.pdf>.

WILSON, C.S. & MARKUSOVA, V.A. Changes in the scientific output of Russia, from 1980 to 2000, as reflected in the Science Citation Index, in relation to national-political changes. Scientometrics, v. 59, n. 3, pp. 345-389, 2004.