Chapter 7

Technological innovation by business in São Paulo State: an analysis based on the findings of the PINTEC survey

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

1. Introduction

Innovation is at the heart of economic and social development. Supported by the findings of IBGE's Survey of Technological Innovation in Industry (PINTEC), this chapter presents key indicators of technological innovation by companies located in São Paulo State and compares them with the national average. The methodology used derives from the internationally accepted principles first propounded in the *Oslo Manual* (OECD, 1997). The chapter aims to capture the innovation process from the business angle, with particular emphasis on inputs and impact on economic activity.

Technological innovation by business is a topic that has acquired growing importance in the debate on economic and social development in recent decades. It has become increasingly evident that a country needs more than production capacity, which must be grounded in a growing propensity, to innovate. This perception has been bolstered by steady integration and globalization of the world economy, in a process whereby competitiveness is one of the key sources of the wealth of nations. Environmental and energy challenges have also forced countries to seek greater economic efficiency and to change their production systems continuously in pursuit of sustainability. These issues show that science, technology and innovation (ST&I) are no longer the concern only of scientists and engineers, but require the attention of society as a whole.

The growing importance of innovation for the development agenda of nations requires the construction of indicators capable of apprehending innovation efforts and the results of the innovation process more comprehensively, and of contributing to a deeper understanding of the drivers of the changes that lead to higher productivity in business organizations. It has also become clearer to the theoreticians of innovation that firms do not innovate in isolation but within systems with which they interact in the process of gestation and diffusion of new products and processes. Focusing on measures of research and development (R&D) and patenting, albeit indispensable, has been found insufficient for a real grasp of the various facets of the innovation process.

Against this background, important advances were achieved in the 1980s and early 1990s, with the publication of the first surveys of technological innovation in European countries, such as Italy, France and the Scandinavian countries. These first steps were soon translated into the first edition of the *Oslo Manual*, published in 1992 by OECD as a compilation of the principal methodological efforts of the developed countries in the construction and use of ST&I indicators. Widespread acceptance in the member states of the European Union enabled innovation surveys to be coordinated on a continental scale by Eurostat, the Statistical Office of the European Commission. The Community Innovation Surveys (CIS), produced in 27 member states of the E.U. as well as three EFTA countries and E.U. candidate countries, are the main data source for measuring innovation in Europe.

The methodology set out in the *Oslo Manual* has developed significantly since the first edition was published in 1992. The second edition, issued in 1997, extended the coverage of business innovation from manufacturing to services, while the third edition, published in 2005, extended the concept of innovation to include organization and marketing innovations as well as technological innovations.

In Brazil, the first nationwide survey of technological innovation in manufacturing (PINTEC) was published by IBGE in 2001, covering the period 1998-2000. Besides applying the methodology proposed by OECD/Eurostat in CIS2, for the first time PINTEC 2000 systematically surveyed investment in R&D by industrial firms throughout Brazil. Since this first round, there have been two more editions of PINTEC, in 2003 and 2005. The main novelty in PINTEC 2005 was the collection of data on some knowledge-intensive segments of the service sector.

A comparison between PINTEC and international innovation surveys shows not only that IBGE collects a broad spectrum of information and follows internationally established conventions but also that its sample coverage is very large, permitting very fine analysis at the industry level, by size of firm, origin of capital and regional distribution. The PINTEC database also permits cross-referencing to other IBGE databases, such as its annual survey of industry (PIA), and to the statistics produced by the Department of Foreign Trade (Secex), enabling innovation statistics to be cross-tabulated with other commercial and economic information relating to business activity.

As stressed below, the wealth and variety of information contained in the three editions of PINTEC, alongside the possibility of working with disaggregated data for São Paulo State, create an opportunity to compare São Paulo and Brazil by industry, origin of capital and size of firm. In addition, because the data collection methodology follows international standards, comparison with other countries, also part of this chapter, makes the indicators presented more pertinent and significant. On the other hand, the fact that the standards of business activity and innovation used are largely those of the advanced countries requires that the analyst take qualitative differences between the corresponding contexts into account when analyzing the indicators in quantitative terms.

The chapter comprises seven sections besides this introduction. The next section outlines the PINTEC survey methodology on which the chapter is based. The following section presents the first group of indicators relating to the introduction of technological innovations by firms and protection mechanisms. The fourth section addresses the relations between innovative firms and the external environment, in terms of the outside information sources used in innovation and cooperation with other players. The fifth section discusses innovative firms' innovation processes and efforts using the most classic indicators in innovation studies, especially those relating to R&D activities. The sixth section focuses on the economic impact of innovative firms. The last section presents the conclusions.

2. PINTEC, IBGE's innovation survey: methodology and evolution

The indicators discussed in this chapter are based on IBGE's Survey of Technological Innovation (PINTEC). With PINTEC 2000, IBGE began the periodic production of statistics on technological innovation activities by Brazilian business organizations. PINTEC 2000 took the period 1998-2000 as the basis for the occurrence of innovative events and the year 2000 for the measurement of the parameters relating to innovation activities. The second round, PINTEC 2003, maintained the triennial base, covering the period subsequent to the first (2002-03). With PINTEC 2005, however, the survey became biennial, using the period 2003-05 as the base for variables relating to innovative events and the year 2005 for variables with recorded values. The chapter uses information from the last two rounds, with PINTEC 2005 predominating. This section sets out the salient features of IBGE's methodology and the evolution of PINTEC since the first edition.

PINTEC uses the *Oslo Manual* methodology developed by OECD. The central concept on which this type of survey is based is that of technological innovation. Innovation was first posited by Joseph Schumpeter as the main driver of economic development (Schumpeter, 1982). Schumpeter defined innovation broadly as encompassing the introduction of new products and processes, the penetration of new markets, the use of new raw materials or inputs, and/or the establishment of new organizational structures. The more restricted concept of technological innovation that later became widely accepted refers specifically to the introduction of technologically new or significantly enhanced products or processes. Technological innovations may derive from advances in scientific and technological knowledge or from new applications of existing scientific and technological knowledge.

Another fundamental aspect of the new approach proposed by Schumpeter was the direct link between innovation and business. Thus he distinguished between invention, which consists of the creation of new technology, and innovation, which involves the marketing of novelties by business organizations. Schumpeter's aim was to show that the key to innovation is not just new technology but the entrepreneur's ability to create a new market for it. He also saw innovation as a significant driver of economic development.

This change of focus influenced by Schumpeter was eventually reflected in the production of specific innovation indicators. Following publication of the *Frascati Manual*, which established a methodology for measuring human resources in R&D, OECD decided to focus on developing a specific methodology to measure innovation by business organizations. The *Oslo Manual*, whose first edition published in 1992 resulted from this effort, was designed to consolidate the innovation survey methodologies used in various developed countries.

Innovation surveys constructed in accordance with the *Oslo Manual* address technological innovation by business organizations in both products and processes. The main survey questions ask whether the firm has introduced at least one innovation during a specified reference period, usually the previous three years. The concept of an innovative firm is broadly defined to include not just firms that develop innovations themselves but also firms that adopt innovations created by others. Thus innovation is seen from the standpoint of business and may already exist in other local or foreign firms. Having been defined as innovative, the respondent firm then answers a set of questions on its innovative efforts, the factors influencing them, and their impact.

The first edition of the *Oslo Manual* defined the concept of technological innovation and applied it to industrial firms. Two major revisions have since been published. The second edition, issued in 1997, extended application of the concept of technological innovation to the service sector. In addition, it distinguished between in-house innovations and innovations acquired from third parties, and between innovations new to the firm and innovations new to the home market or world markets. The third round of the innovation survey covering the member countries of the E.U. took place in the late 1990s. This round gave rise to a major controversy because of the difficulty of differentiating between technological and other forms of innovation in the service sector. For this reason, the 2005 edition of the *Oslo Manual*, taking its inspiration from Schumpeter's original approach, extended the concept of innovation to encompass organizational and marketing innovations as well as technological innovations.

The processes whereby innovations are created and absorbed by firms are crucial to economic development. From this insight derives the institutional importance of the production of information to support knowledge of inputs and of the economic drivers and impacts of technological innovation at the national, regional and industry levels of a country's business sector. However, contrary to what happens in other areas of economic statistics, the methodologies used to produce statistics on the technological activities of firms are relatively new and less disseminated and consolidated.

By adopting the second version of the *Oslo Manual* (OECD, 1997) as a conceptual and methodological framework for PINTEC, IBGE filled a long-standing gap with grave implications for such surveys, which was the absence of reliable indicators on the basic aspects of technological activities in Brazil's business sector. This absence was twofold. On one hand, there was a lack of systematically collected data on business investment and use of human resources in R&D. On the other, Brazil had never before conducted a nationwide survey capable of producing indicators of technological innovation. These omissions were a particular concern of the community of ST&I policymakers but they also affected other government areas as well as investment planning by business organizations. The option embodied in PINTEC consisted of filling this gap in the data on Brazilian firms by making appropriate use of the *Oslo Manual's* approach. This methodology also called for the measurement of business spending on R&D both internally and externally, as part of the cost of innovation.[1] The PINTEC survey questionnaire requested this breakdown of R&D expenditure, in addition to information on human resources dedicated to R&D activities. As a result this survey brought to an end the lack of information in Brazil on the effective R&D efforts of industrial firms.[2]

By opting for the *Oslo Manual* methodology in its second version (1997), IBGE institutionalized the systematic production of reliable statistics on the most significant aggregates relating to the technological activities of industrial firms and, in PINTEC 2005, in knowledge-intensive services, enabling PINTEC to introduce a comprehensive vision of innovation processes in Brazil. This approach is designed to measure investment in R&D and other types of business spending on innovation activities, as well as sources of information for technological innovation, including technological cooperation with various types of entity, and the impact of technological innovation on the performance of business organizations. This would seem to be the most suitable approach for surveys of innovation in developing economies, where R&D activities are limited in terms of both volume and the proportion of firms engaged in such activities.

The OECD methodology reflects the progress of multidisciplinary knowledge on the drivers and characteristics of business innovation. This progress corresponds to the transcendence of the linear sequential approach to innovation, which saw public academic research and in-house technological research by firms as the only activities that effectively produced or originated technological innovations. On this view, other key functions such as production, planning and marketing were merely means of putting into practice the solutions delivered by R&D. Hence the almost exclusive emphasis in initial ST&I surveys on measuring R&D as a technological effort geared to innovation, and patenting as its main outcome.

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1. The methodology proposed by the *Oslo Manual* for surveying business investment in R&D was derived from the already widely used approach developed for the *Frascati Manual*. However, there are differences in the coverage of business organizations by the two methodologies. While the *Frascati Manual* approach is confined to firms with regular R&D activities, with regular meaning that at least one person is employed full-time or the equivalent in such activities, the *Oslo Manual* includes firms with both regular and intermittent engagement in R&D activities. Another difference in coverage between the two methodologies derives from the fact that innovation survey questionnaires are applied only to firms that have introduced at least one technological innovation during the reference period, whereas no such restriction is prescribed by the *Frascati Manual* (for more details, see Sirilli, 1998).

2. Data on R&D spending and human resources dedicated to R&D in business are collected by means of specific surveys in the OECD countries using the *Frascati Manual* methodology (OECD, 2002).

In contrast to the linear approach, which still strongly influences commonsense ideas of innovation, the *Oslo Manual's* systemic approach presents innovation as a learning process anchored in the innovative firm but also involving action and interaction by various actors internal and external to it. This more complex vision benefited from the progress of knowledge in the field of innovation studies. Decisive contributions to this progress were made by economists such as Nathan Rosenberg (Kline & Rosenberg, 1986), with the chain-linked model of innovation, as well as Christopher Freeman (1988, 1995), Bengt-Åke Lundvall (1992) and Richard Nelson (1993), with the concepts of national and local innovation systems.

According to this view, innovation is a process in which technological research and knowledge (*technology push*) are combined, in a manner that is not always foreseeable, with market research and knowledge (*demand pull*). R&D, market management and operations are functions that converge and collaborate in the creation of innovations. Thus other activities considered here as important elements of the innovation process that must be measured include acquisition of disembodied technology, in the form of licensing, technology transfer and technical assistance; acquisition of software; innovation activities relating to production, such as acquisition of plant and equipment for innovation, as well as industrial design and basic industrial technology required for innovation (and the respective necessary competencies); and innovation marketing efforts.

Equally importantly, innovative firms do not innovate in isolation. Innovation is a process in which interaction with customers, suppliers, research institutions, consultant engineers, providers of vocational training and technological services, and even competitors play a significant role. All these players can be sources of information or formal partners in cooperation agreements. For this reason, any opportunities offered by virtuous aspects of national and local innovation systems, including regulatory dimensions and industrial and technological policies, are highlighted in this approach.

Albeit subject to systematic criticism for its emphasis on the technological dimension of innovation to the detriment of purely organizational and market-related aspects, the OECD methodology for innovation surveys was widely disseminated in its first two versions, establishing a framework for comparability across countries. The production of innovation statistics is now consolidated in E.U. countries, where they date from before the first edition of the *Oslo Manual in* 1993. In addition to national surveys in all E.U. countries, the Community Innovation Surveys (CIS) have reached their fifth edition. The practice is also disseminated in most of the OECD countries that are not E.U. members, such as Australia, Canada, South Korea, Japan, Mexico and Turkey. Major non-OECD countries, such as South Africa, Argentina, Brazil, India, Indonesia and Russia, have also conducted innovation surveys, although not always on a regular basis.

As well as adopting the second edition of the *Oslo Manua*l as a conceptual and methodological benchmark, PINTEC 2005 was based specifically on the approach used in the third round of *Community Innovation Surveys* (*CIS3)* by Eurostat (IBGE, 2005). The model applied by IBGE modified a number of concepts in order to adapt them to the Brazilian context. The 2005 PINTEC survey focused above all on technological innovation in products and processes, seeking to collect data on how business enterprises go about introducing innovations, on their innovation activities, on the impacts of innovations, and on the factors that influence business innovation, such as incentives and obstacles.

PINTEC 2005 covers technology-intensive firms as well as the universe of manufacturing and mining firms covered by IBGE in previous rounds of the survey. Thus it includes firms in National Economic Activity Classification (CNAE) Group 64.2 (Telecommunications) and CNAE Divisions 72 and 73 (Information Technology and R&D). The survey population comprised firms with ten or more employees. A partially intentional stratified sample design was used to compensate for the fact that innovation is not a phenomenon found in the majority of firms. The take-all stratum comprised manufacturing and mining firms with 500 or more employees, and telecom and IT firms with 100 or more employees. The sampling plan took into account criteria of representativity by branch of industry to 2 or 3 digits of the CNAE, and by economic region for major regions and the most industrialized states. This led to a final sample of 13,575 manufacturing and mining firms and 759 telecom and IT service providers.

The R&D division (CNAE 73.0) was given differentiated treatment. The sample included 46 R&D institutions, identified as those in which R&D activities account for most of their expenditure. It is important to note that this segment of the sample comprised institutions legally incorporated as business enterprises, government bodies or nonprofits. This inclusion of non-business institutions is the main reason for not discussing the segment in this chapter.

The analysis set out below is based on the two-digit classification for the manufacturing industry, except in the case of Chemicals, subdivided into Pharmaceuticals and Chemicals excluding pharmaceuticals, and in that of Other transport materials, subdivided into Aircraft and Other transport materials excluding aircraft. These subdivisions are designed to facilitate comparisons with developed-country sectoral indicators. Firms in the mining industry are grouped at the one-digit level. Knowledge-intensive services are subdivided into Telecommunications (64.2) and Information Technology (72).

The indicators discussed in this chapter belong to four major categories presented in the ensuing sections. The first set, relating to the population of innovative firms, comprises indicators of innovation rates that determine the relative importance of innovative firms in the overall universe of business organizations. The second comprises indicators that measure the links between innovative firms and their environment. These indicators are also rates, showing the number of innovative firms that cite some kind of highly important link to external players in proportion to all innovative firms. The third set can be understood as comprising innovation inputs or innovation efforts. This third set of indicators is made up of intensities, which estimate the effort made by firms to innovate in relation to net sales. R&D indicators are included in this set. The fourth set comprises impact indicators, which relate the value of innovation to total sales.

3. Innovative firms in industry and knowledge-intensive services

Technological innovation, understood in the broad sense covering technological change from creation of new technology to its adoption in production, is at the heart of the country's economic development, especially in São Paulo State, which leads that development process.

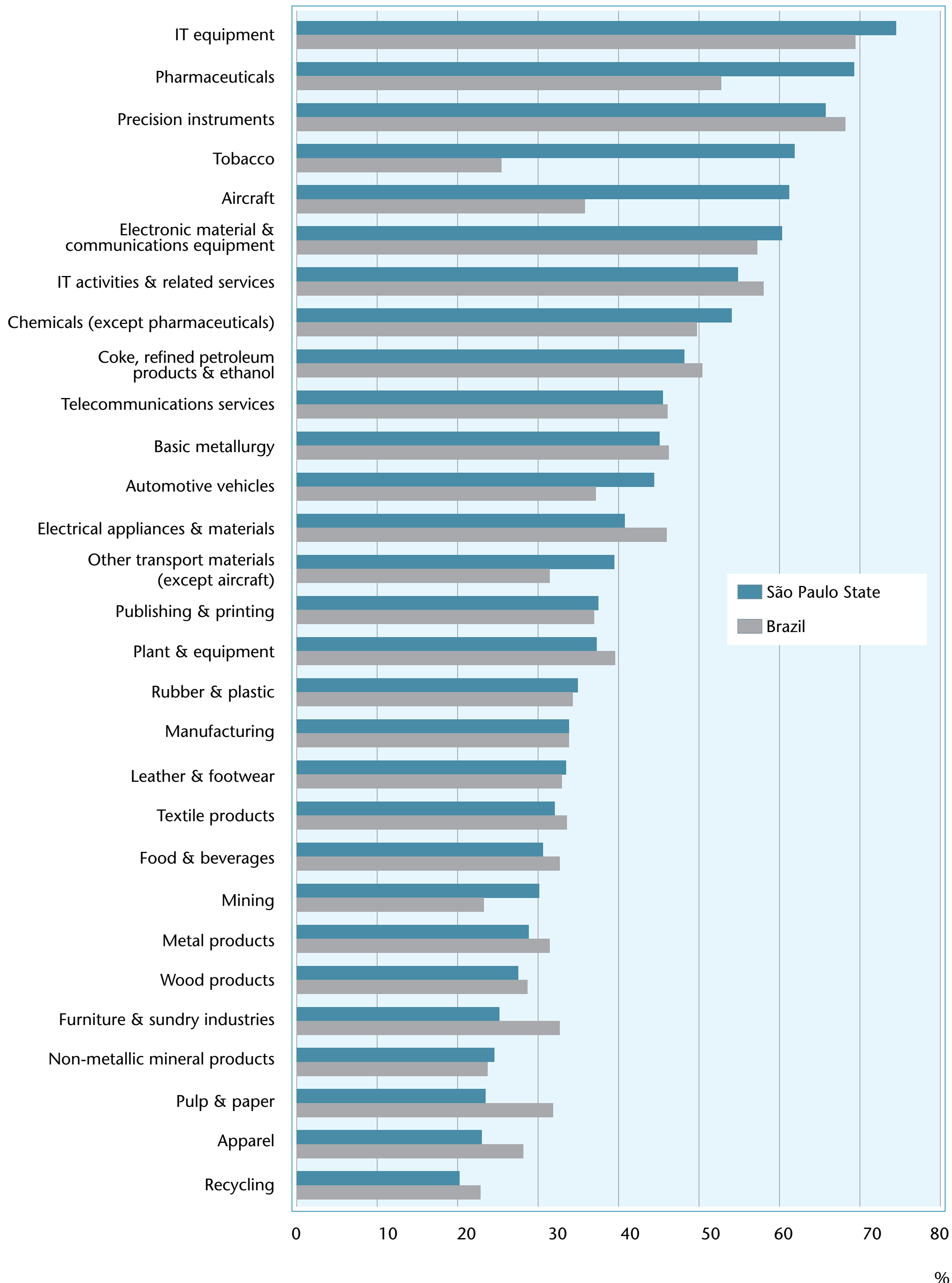
The innovation rate is the most frequently cited indicator of technological change in both academic and political circles. This indicator measures the number of firms introducing some kind of technological innovation in products and/or processes as a percentage of all firms surveyed. Figure 7.1 presents innovation rates in selected segments of manufacturing and services in the period 2003-05 for São Paulo State and Brazil. Approximately a third of Brazil's industrial firms (33.6%) introduced at least one technological process or product innovation during the three-year period. Because the Oslo Manual methodology is also used by the E.U. countries, it is possible to establish relevant international comparisons.[3] According to Eurostat (2008), roughly 41% of industrial firms were innovative in 2004 in the 27 E.U. countries. Brazil falls sort of this average. While Germany, the leading European country on this criterion, has an innovation rate of 72.8%, the rate for France is 36.1%, only slightly higher than Brazil's.

Technological innovations are divided into product and process innovations. According to Pavitt (1984), product innovations include those used in different sectors from the sectors in which they are created. On the other hand, process innovations are used in the same sectors as those for which they are created. Data for 2005 referring to product and process innovation rates in São Paulo State show that some 20% of industrial firms innovated in products, about 26% in processes, and fewer than 13% in both products and processes (Table 7.1).

The data in Table 7.1 show that there is very little difference between the innovation rate in São Paulo State and the national average. This does not necessarily mean that firms in São Paulo do not differ from the rest in terms of technological innovation. As noted in the preceding section, the concept of innovation used in the *Oslo Manual* is very broad and extends to firms that adopt innovations. Thus the innovation rates in Table 7.1 refer to the broad concept of technological innovation, understood as new to the firm, whether created in house or by others. In most cases, these innovations are new only to the firms that adopt them, so that the process reflected is mainly one of diffusion of technologies already present in the marketplace.

3. The methodology used by the E.U. countries is not exactly the same as that used by PINTEC. The fourth edition of the European innovation survey, CIS4, follows the methodology of the third version of the *Oslo Manual*, which uses a broad concept of innovation including organizational and marketing innovations as well as technological innovations. In all other respects, the two surveys are very similar. The firms surveyed have ten or more employees and the concept of innovation is new to the firm.

Figure 7.1
Innovation rates (1) in manufacturing, mining and selected segments of the service sector – Brazil & São Paulo State, 2003-2005



Source: IBGE, PINTEC 2005.

Note: See Detailed Table 7.1.

(1) Number of firms introducing at least one new product and/or process during the period considered by PINTEC, as a percentage of the total number of firms surveyed.

Table 7.1
Innovation rates (1) in manufacturing and mining by type of innovation – Brazil & São Paulo State, 2003-2005

Type of innovation	Innovation rate in industry (% innovative firms)	
	Brazil	São Paulo State
Total	**33.4**	**33.6**
Product	19.5	20.4
Process	26.9	26.0
Product + process	13.1	12.8

Source: IBGE, PINTEC 2005.

Note: See Detailed Table 7.2.

(1) Number of firms introducing at least one new product and/or process during the period considered by PINTEC, as a percentage of the total number of firms surveyed.

The innovation rate remained practically unchanged between PINTEC 2003 and PINTEC 2005. In São Paulo State, it rose moderately between 2001-03 and 2003-05 (Table 7.2). The improvement in the industrial sector's performance was reflected to a moderate extent by the innovation rate.

On the other hand, the fact that innovative firms were in the minority should not overshadow their enormous economic importance. While firms that innovated in products and/or processes accounted for only a third of all the industrial firms surveyed across Brazil, they were responsible for 81.3% of net sales and 86.3% of exports by the manufacturing industry (Detailed Table 7.3).

Innovation theory emphasizes substantial differences between sectors in terms of technological regime (Freeman, 1974; Dosi, 1984; Pavitt, 1984). Some sectors display a fast pace of technological change due to greater inherent opportunities for innovation. The innovation rate is an important measure and a yardstick for comparing the pace of technological change across industries. The most innovative industries in the Brazilian case are part of the so-called electronics complex and include Information technology, with 69.2%; Precision instruments, with 68%; and Electronic & communications material, with 56.9% (Figure 7.1).

A second group of industries related to the chemicals complex display lower innovation rates (in the range of 50%). These industries, not necessarily associated with high technology, include pharmaceuticals, the rest of the chemical industry, and refined petroleum products. A third group, in the range of 40%, includes Plant & equipment, Electrical appliances, Automotive vehicles, Aircraft, and Publishing & printing.

Knowledge-intensive services, especially in IT, are closest to the electronics complex. The innovation rate for the IT industry is 57.6%, while the innovation rate for telecommunications services is 45.9%. In these sectors, technological opportunities are also very significant.

Although industry in São Paulo State displays an innovation rate that is very similar to the national average, this similarity hides important sectoral differences. Aerospace and pharmaceuticals, which are high-tech sectors according to the OECD classification, display innovation rates well above the national average. From this it can be inferred that creative activities in these two industries are strongly concentrated in São Paulo State. Tobacco is at the opposite extreme: most of the industry's economic activities are located outside the state, but a majority of the relatively few tobacco firms in São Paulo are innovative (61.8% innovation rate).

Size of firm is also a key driver of the propensity to innovate, mainly because the larger the organization the more resources it is able to allocate to the innovation process. Large firms also have complementary assets[4] (Teece, 1986) that guarantee their ability to capture the profits generated by their innovations.

The PINTEC findings show that large firms employing 500 or more workers are the most

4. Complementary assets are resources beyond R&D and patents that enable firms to appropriate the returns on their innovations, such as marketing, competitive manufacturing, and distribution and maintenance networks.

Table 7.2
Innovation rates (1) in manufacturing and mining by type of innovation – São Paulo State, 2001-2005

Type of innovation	Innovation rate in industry (% innovative firms)	
	2001-2003	2003-2005
Total	**31.1**	**33.6**
Product	18.8	20.4
Process	24.6	26.0
Product & process	12.3	12.8

Source: IBGE, PINTEC 2003 & 2005.

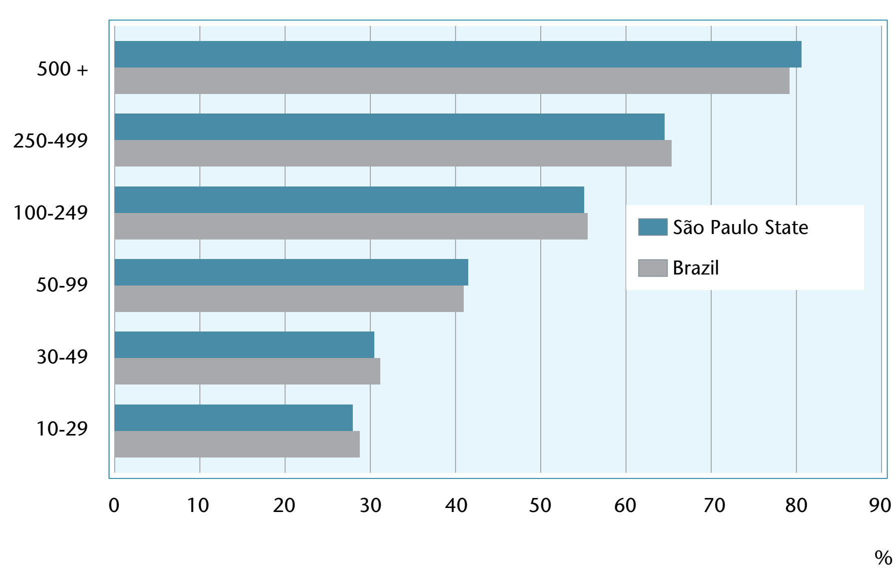
Note: See Detailed Table 7.2.

(1) Number of firms introducing at least one new product and/or process during the period considered by PINTEC, as a percentage of the total number of firms surveyed.

innovative in the Brazilian industrial sector. In São Paulo State, the innovation rate for this set is just under 81% and thus a little above the national average, whereas the innovation rate for smaller firms (10-29 employees) located in the state is about 28%, the lowest among all strata of firms segregated by size. As clearly shown in Figure 7.2, firm size and innovation rate correlate positively. In other words, the larger the firm the greater the likelihood that it will be innovative.

Origin of capital is another important variable for explaining why firms innovate. Multinational corporations almost always see technological progress as the main reason for their presence in another country. Easier access to intrafirm knowledge flows contributes to a fast pace of technological change

Figure 7.2
Innovation rates (1) in manufacturing and mining by size of workforce – Brazil & São Paulo State, 2003-2005



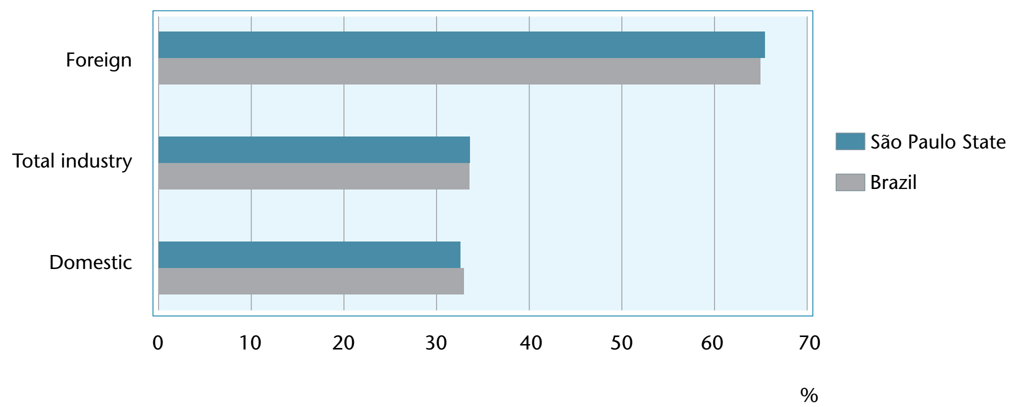
Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.4.

(1) Number of firms introducing at least one new product and/or process during the period considered by PINTEC, as a percentage of the total number of firms surveyed.

in these organizations. For this reason, the average innovation rate for foreign firms is much higher than for domestic firms (Figure 7.3). However, a simple comparison between foreign and domestic firms is misleading. Foreign firms are a small group whose composition by size and industry differs starkly from the average for domestic firms. However, they account for a major share of manufacturing GDP in Brazil and São Paulo State. Thus it may be more relevant to analize the importance of foreign firms to the national innovation system in Brazil and their key characteristics (Box 1).

Figure 7.3
Innovation rate (1) in manufacturing and mining by origin of capital – Brazil & São Paulo State, 2003-2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.6.

(1) Number of firms introducing at least one new product and/or process during the period considered by PINTEC, as a percentage of the total number of firms surveyed.

Box 1 – Multinational corporations

Subsidiaries of multinationals, understood as Brazilian firms with foreign parent companies, whether or not they have a majority equity interest, account for a significant proportion of Brazil's economic activity and industrial exports. Foreign firms contributed 35.4% of net industrial sales and 43.8% of industrial exports between 2003 and 2005 (Table 7.3). The proportions are even greater for innovative firms. It is important to note that foreign firms are very strongly concentrated in São Paulo, accounting for over 50% of net industrial sales in the state.

Foreign firms display much higher innovation rates than locally-owned firms. Besides being larger than domestic firms, they can more easily access external sources of technology within their own group and this a key element in their significance to the overall economy. As a result, these firms are far more likely to lead their respective markets in terms of technology. The proportion of foreign firms that brought new products to market in Brazil in the period 2003-05 was over 30%, compared with under 4% for domestic firms (Figure 7.4).

The share of foreign-owned firms in Brazil's industrial R&D is even larger than their share of total industrial sales, accounting for 44.4% of intramural R&D spending by industry (Table 7.4), or more than their share of nationwide net sales. These numbers clearly illustrate the importance of foreign firms to both technological efforts and the impact of innovation in Brazil.

Although Brazil is not cited as a preferred location for the decentralization of R&D activities by multinationals, even among emerging-market countries, these firms are highly important to industrial R&D efforts in Brazil.* Corresponding figures for OECD countries show that Brazil, and São Paulo State to an even greater extent, is among the top-ranking countries in terms of the share of multinationals in internal R&D spending. Countries where subsidiaries of multinationals play

Table 7.3
Innovative foreign and domestic firms in mining and manufacturing by share of net sales and exports – Brazil & São Paulo State, 2005

Origin of capital	Share of total (%)			
	Net sales		Industrial exports	
	Total	Innovative firms	Total	Innovative firms
Brazil	**100.0**	100.0	**100.0**	100.0
Domestic	**64.6**	60.6	**56.2**	53.7
Foreign	**35.4**	39.4	**43.8**	46.3
São Paulo State	**100.0**	100.0	**100.0**	100.0
Domestic	**49.4**	42.7	**38.5**	33.7
Foreign	**50.6**	57.3	**61.5**	66.3

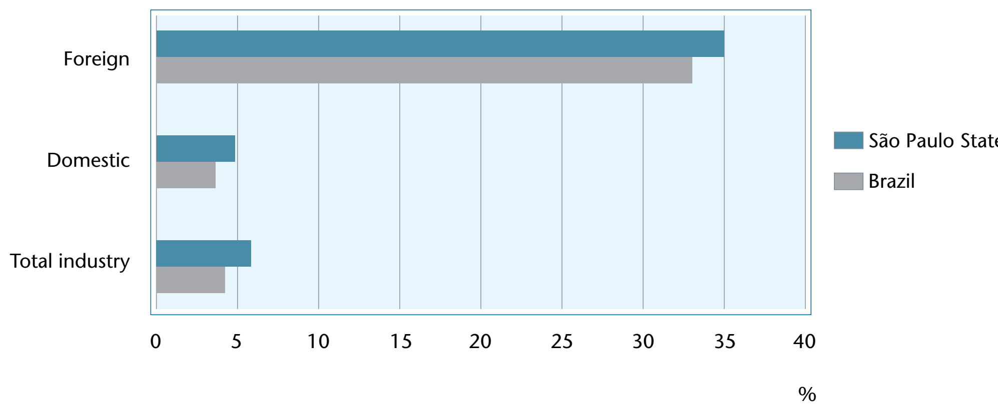
Source: IBGE, PINTEC 2005.

Notes: 1. Firms were considered innovative if they introduced at least one new product and/or process during the reference period for PINTEC.

2. See Detailed Table 7.5.

* The data on R&D spending captured by PINTEC do not distinguish between basic research, applied research and experimental development, as recommended by the *Frascati Manual*. However, a large proportion of spending by subsidiaries of multinationals can be attributed to experimental development. The proportion may vary considerably according to sector, possibly being larger in Transport material. The evidence available is insufficient to show whether the proportion spent on experimental development is greater for foreign than domestic firms, especially when the sectoral dimension is taken into account.

Figure 7.4
Innovation for the home market (1) in manufacturing and mining by origin of capital – Brazil & São Paulo State, 2003-2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.6.

(1) Number of firms introducing at least one new product and/or process to the home market during the period considered by PINTEC, as a percentage of the total number of firms surveyed.

Table 7.4
Structure and intensity of internal R&D spending in mining and manufacturing by origin of capital – Brazil & São Paulo State, 2003-2005

Origin of capital	Structure & intensity of internal R&D spending (%)			
	2003		2005	
	R&D spending	R&D/net revenue	R&D spending	R&D/net sales
Brazil	**100.0**	**0.5**	**100.0**	**0.6**
Domestic	52.2	0.4	55.6	0.5
Foreign	47.8	0.7	44.4	0.7
São Paulo State	**100.0**	**0.7**	**100.0**	**0.7**
Domestic	41.9	0.6	43.4	0.7
Foreign	58.1	0.8	56.6	0.8

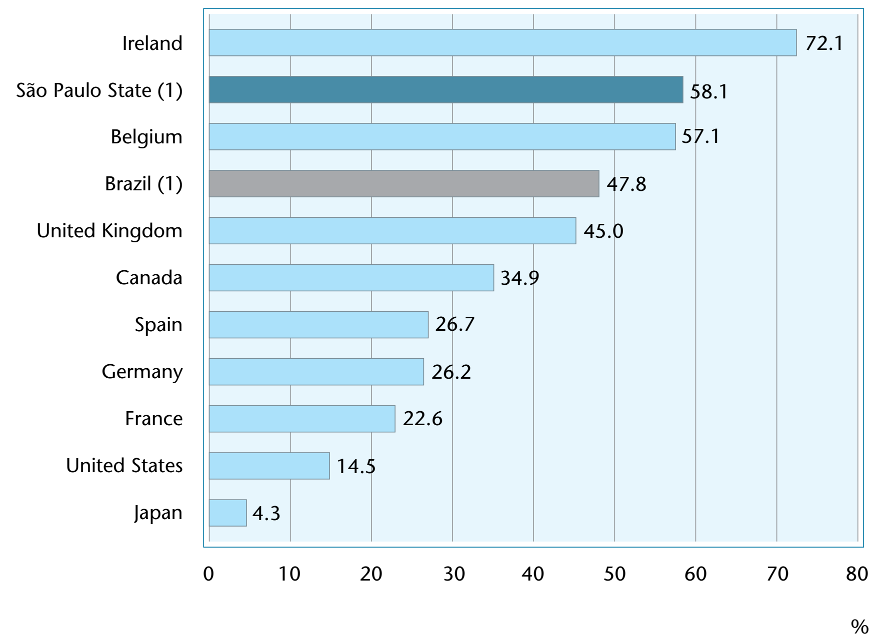
Source: IBGE, PINTEC 2003 & 2005.

Note: See Detailed Table 7.7.

a major role, such as the United Kingdom, Canada and Spain, rank below Brazil in this respect. Only Ireland is ahead of São Paulo State (Figure 7.5).

In the case of São Paulo, the relative importance of multinationals is even greater: the state accounted in 2005 for 63.4% of net sales by all innovative multinationals operating in Brazil, compared with only 30.8% for innovative domestic firms (Detailed Table 7.5). For this reason, foreign firms accounted for most of industrial production and for 56.6% of industrial R&D in the state (Table 7.4).

Figure 7.5
Share of multinationals in internal R&D spending in mining and manufacturing as % of total intramural R&D spending by businesses – Brazil, São Paulo State & selected countries, 2003



Source: IBGE. PINTEC 2003; OECD (2006).

Note: See Detailed Table 7.8.

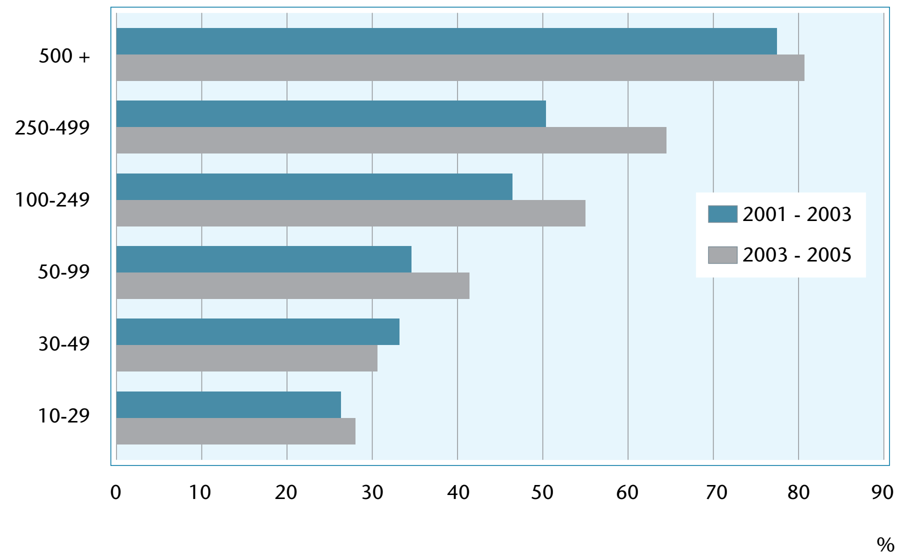
(1) Percentage of total industry only.

In São Paulo State, innovation rates rose most sharply between 2001-03 and 2003-05 for medium-size firms with 50-499 employees (Figure 7.6). These firms responded faster to the improvement in Brazil's economic situation from 2004 on.

Since the third iteration of the Community Innovation Survey, CIS3, which served as a model for PINTEC, more detailed data have been collected on events associated with technological innovation in order to distinguish between innovation and diffusion. An additional question has been included to identify whether the events cited by firms match the traditional concept of innovation, which refers to the first-hand introduction of new technology into the domestic or global market, or adoption of existing technology. This distinction represents an important dividing line between innovative firms in the Schumpeterian sense and follower firms. In industry overall, the proportion of firms responsible for introducing a technological innovation to the home market is 4.2%, far smaller than the 33.6% rate mentioned previously (Detailed Table 7.4). This shows that most technological innovations actually entail the diffusion of technologies already in existence in the domestic market. The small proportion of innovative firms in the Schumpeterian sense reflects the passivity and dependency of most industrial firms in Brazil. A comparison with the findings of CIS4 shows that the innovation rate for Brazil is much lower than the rates for the main European countries.[5]

5. According to data obtained from the *Eurostat Data Explorer*, the proportion of industrial and service firms introducing new products or processes in 2004 was 14.1% for all 27 E.U. countries, 17.5% for Germany, 7.3% for Spain, 12.6% for France, 11.3% for Italy, 21.5% for Finland, and 20.5% for the U.K. (Available at http://nui.epp.eurostat.ec.europa.eu/nui/show.do?dataset=inn_cis4_prod&lang=en. Last accessed on June 6, 2009.)

Figure 7.6
Innovation rates (1) in manufacturing and mining by size of workforce – São Paulo State, 2001-2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.9.

(1) Number of firms introducing at least one new product and/or process during the period considered by PINTEC, as a percentage of the total number of firms surveyed.

The difference between innovation rates for large firms (with 500 employees or more) and medium and small firms is even greater when only innovations for the home market are considered. Practically 42% of large firms innovated for the home market, assuming technological leadership positions in their respective segments. The proportion was far lower for small firms, with firms employing between ten and 29 people achieving an innovation rate of only 2.7%. The disproportion between the innovation rates for small and large firms is a clear reflection of the significant structural heterogeneity of Brazilian industry.

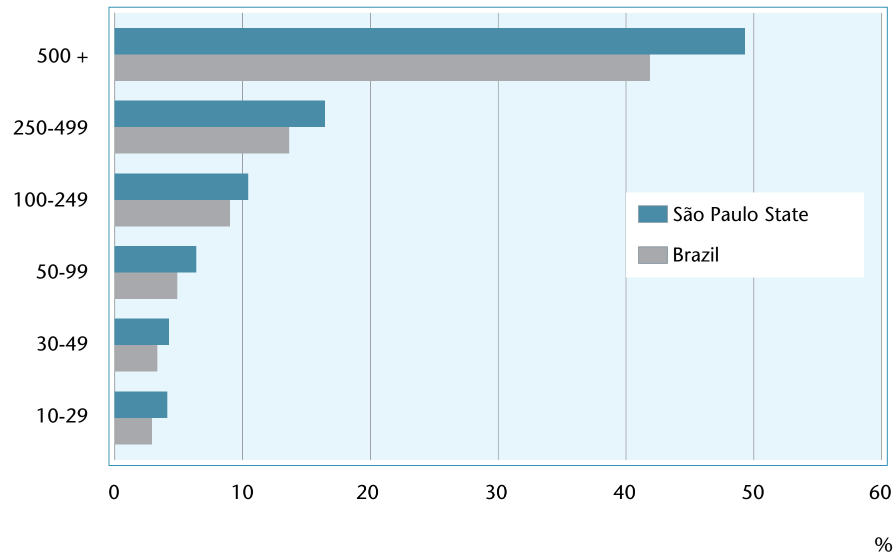
According to this narrower definition of technological innovation, firms in São Paulo State outperform the national average, showing the leadership of these firms in the Brazilian context. The proportion of innovators in industry is 5.8%, compared with a national average of 4.2%. The difference is greater still for large firms, which display an innovation rate in excess of 49% (Figure 7.7).

Innovation rates in São Paulo also vary between industries. In some industries the proportion of firms innovating for the home market is well above the national average. This is the case, for example, in Other transport materials, with 22.3%, and Pharmaceuticals, with 22.7% (Figure 7.8). Knowledge-intensive services in São Paulo also perform strongly, with an innovation rate similar to those for high-tech industries. Innovation clearly takes place outside São Paulo in some industries, however, such as Tobacco, Coke, refined petroleum products & ethanol, and IT equipment.

The concept of innovative firms used in innovation surveys is broad enough to cover a diverse array of situations, in which what matters is not who produces innovations but who applies them. Thus distinguishing between firms that create innovations and firms that only apply them clarifies the extent to which firms effectively participate in the generation of innovations. The term innovation originators is used to refer to those firms that create innovations, either alone or in cooperation. The innovation rate for originators is a proportion of the total number of innovative firms (in products and/or processes). This proportion is an important dividing line between firms that create innovations and other innovative firms that adopt innovations created by third parties.

The proportion of innovation originators in manufacturing is 60% for Brazil (Detailed Table 7.1). However, caution is required with regard to this percentage, which does not mean firms are innovative in the Schumpeterian sense of being market leaders. Many of these firms play a more

Figure 7.7
Innovation for the home market (1) in manufacturing and mining by size of workforce – Brazil & São Paulo State, 2003-2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.4.

(1) Number of firms introducing at least one new product and/or process to the home market during the period considered by PINTEC, as a percentage of the total number of firms surveyed.

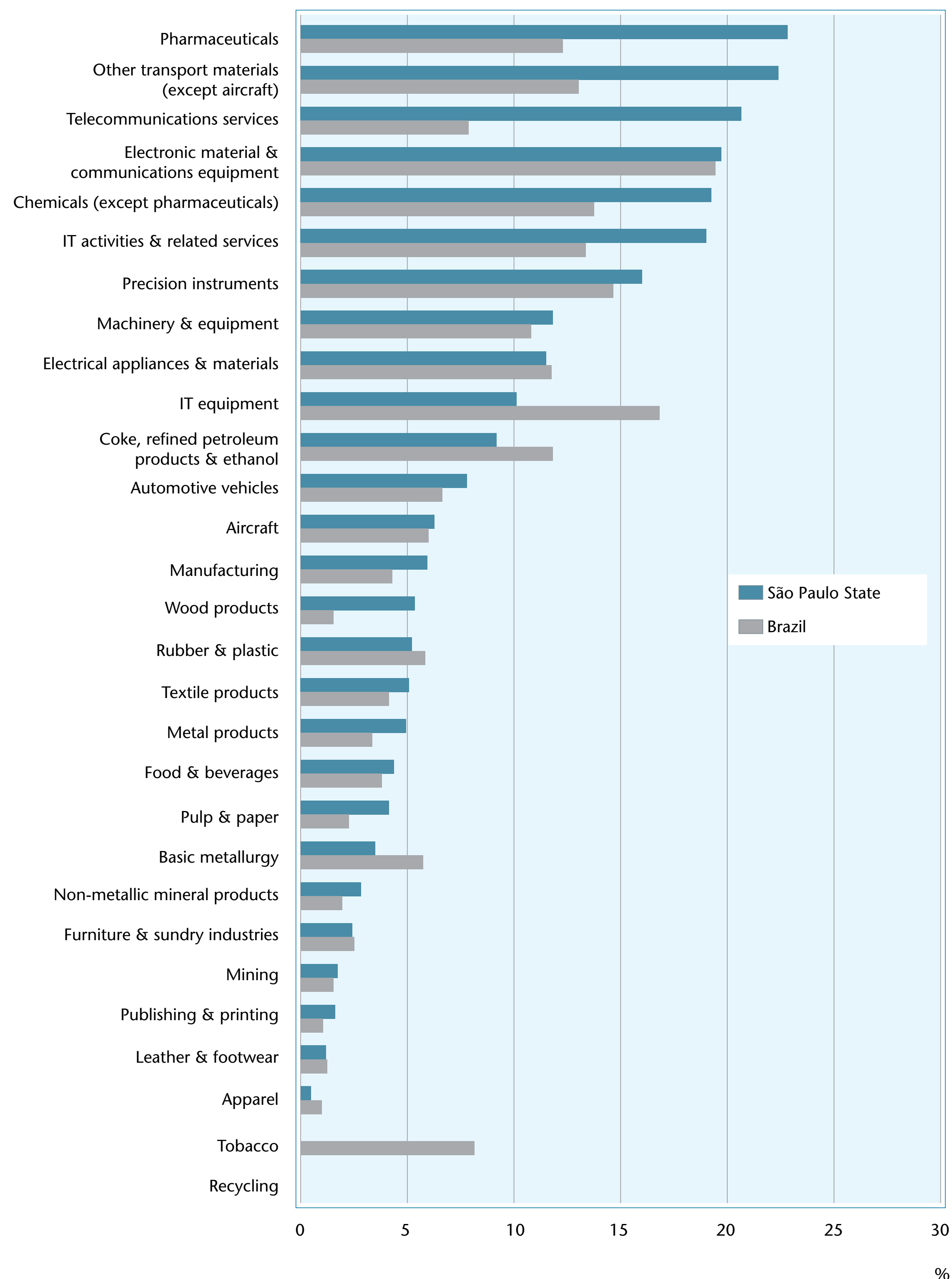
active role in creating innovations but are not the first to innovate in their markets.

A sectoral breakdown shows the highest proportion of innovation originators in the most technology-intensive industries, such as IT equipment, with 89.5%; Precision instruments, with 83.4%; and Electronic material & communications equipment, with 79.1%. In these industries, in which technological change is fastest, for this very reason firms play a more active role in the innovation process. Other leading industries are Plant & equipment, with 77.7%, Chemicals, with 82.1%, and Other Transport materials, with 82.3%. The proportion is also high in knowledge-intensive services: according to PINTEC 2005, IT activities & related services (including software) and Telecommunications services displayed rates of 78.3% and 76.6% respectively (Figure 7.9).

The proportion of innovation originators in São Paulo State's manufacturing industry is 63%, slightly higher than the national average, which is 60%. Firms in São Paulo are leaders of innovation both in low-tech industries such as Wood products, Furniture, Pulp & paper, and Non-metallic mineral products, and in more technology-intensive industries such as Automotive Vehicles, Aircraft, and Electronic material, as well as in knowledge-intensive services.

The proportion of innovation originators in São Paulo State rose slightly between the last two rounds of PINTEC (2003 and 2005), as can be seen from Figure 7.10. While the average rose only a little, it rose significantly in Chemicals, Electronic material & communications equipment, and Plant & equipment.

Figure 7.8
Innovation for the home market (1) in mining, manufacturing, and selected segments of the service sector – Brazil & São Paulo State, 2003-2005

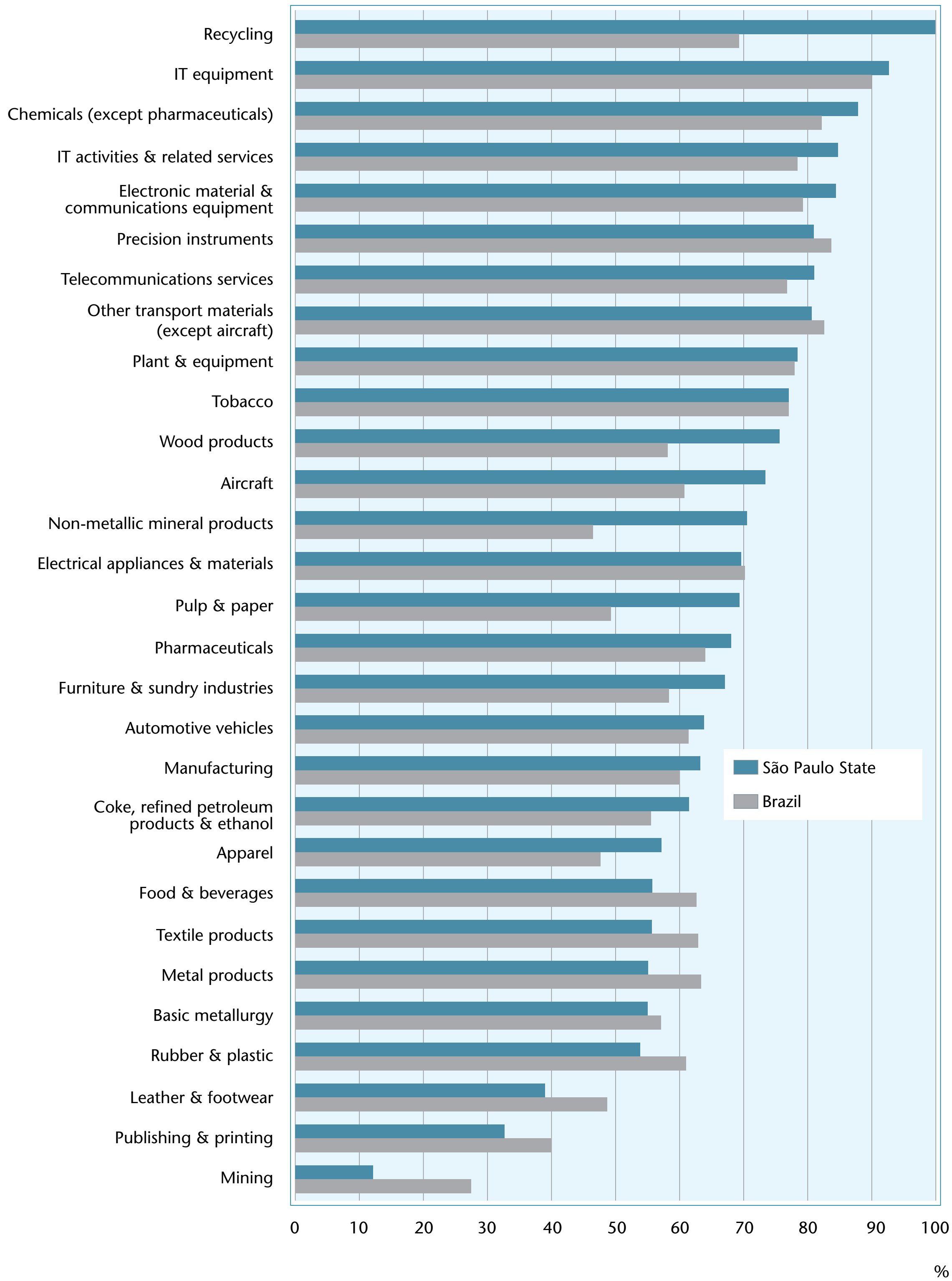


Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.1.

(1) The rate is calculated on the number of companies that have introduced at least one new product and/or process on the domestic market during the period considered by PINTEC in relation to the total survey.

Figure 7.9
Innovation originators (1) in manufacturing, mining, and selected segments of the service sector – Brazil & São Paulo State, 2003-2005

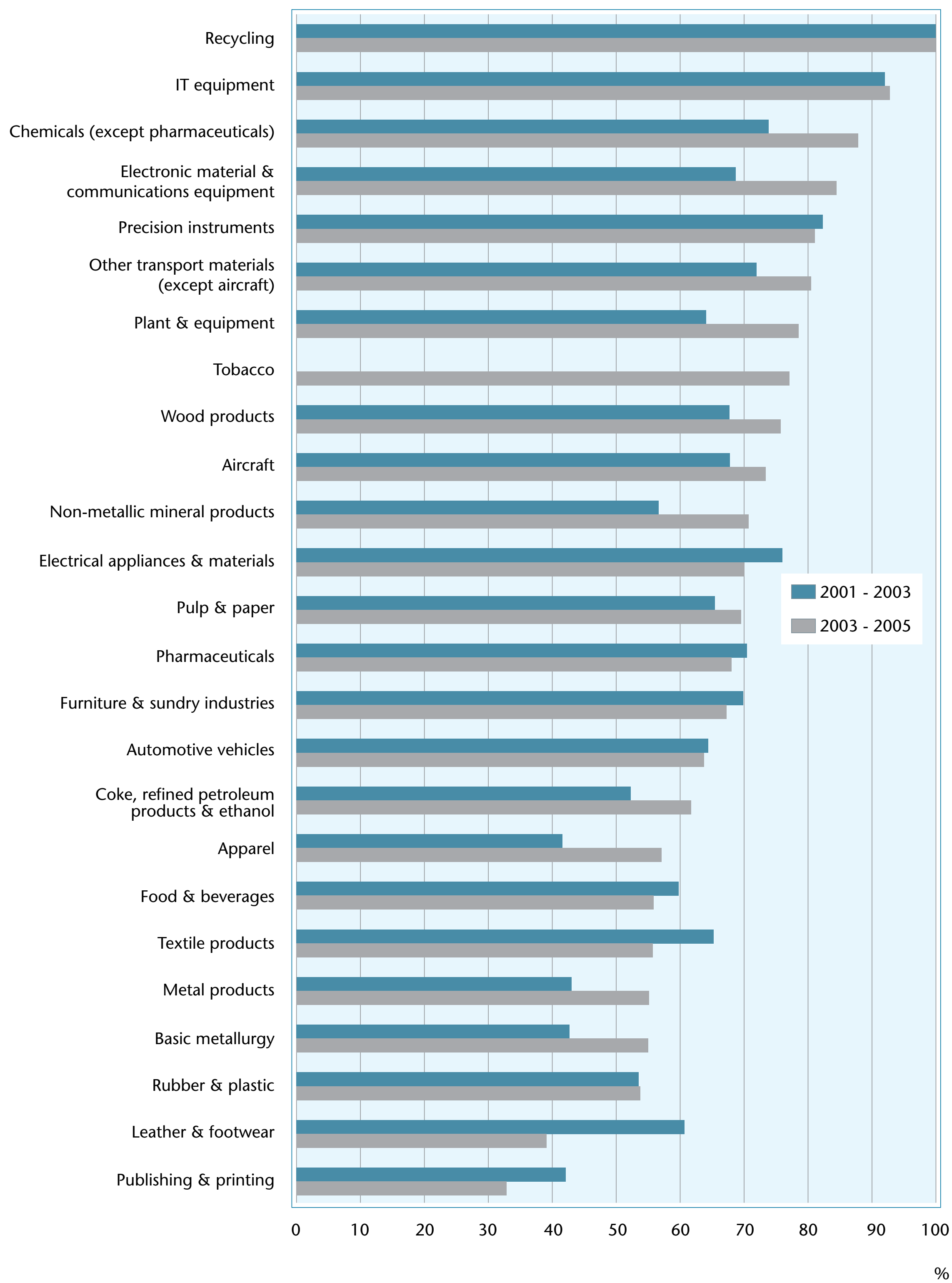


Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.1.

(1) Firms creating (not just applying) product and/or process innovations during the reference period for PINTEC, alone or in cooperation, as a percentage of the total number of innovative firms.

Figure 7.10
Innovation originators (1) in manufacturing – São Paulo State, 2001-2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.10.

(1) Firms creating (not just applying) product and/or process innovations during the reference period for PINTEC, alone or in cooperation, as a percentage of the total number of innovative firms.

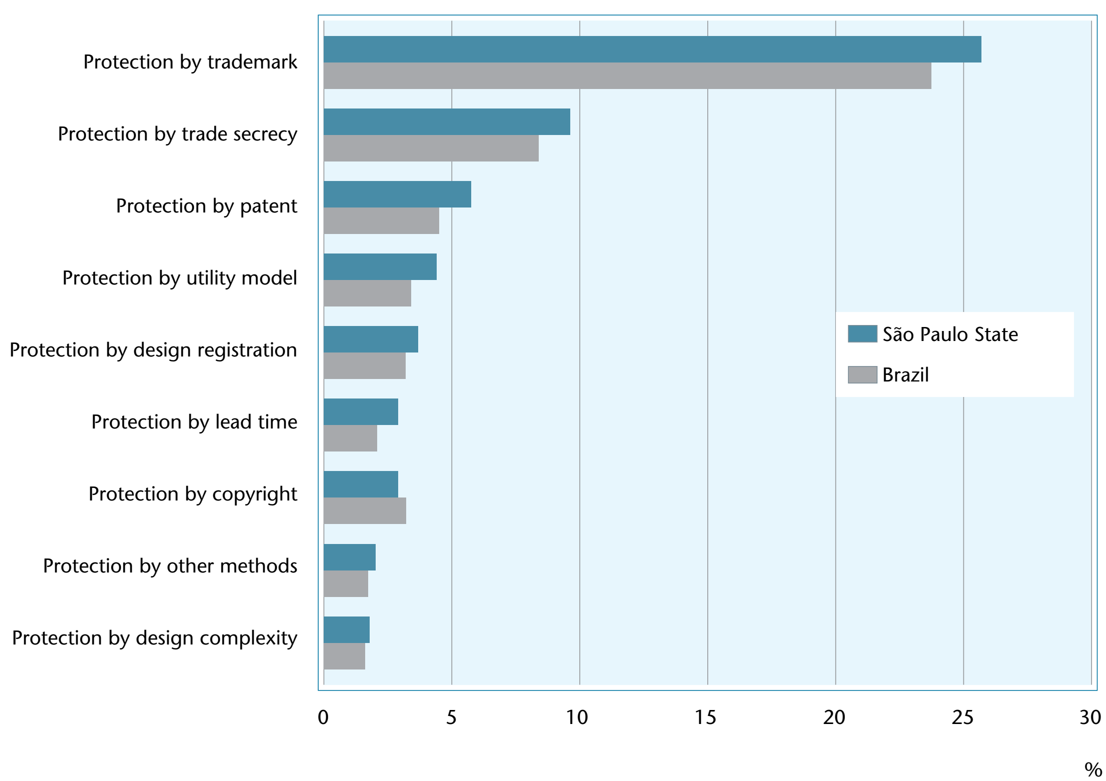
Patents and other innovation protection methods

Invention patents play an important role in protecting intellectual property, but are not the only IP protection mechanism. Firms have a wide variety of mechanisms for appropriating the profits from technological innovation at their disposal. The economic literature stresses that patents are not the mechanism preferred by firms to protect their technological knowledge. Patents come after trade secrets and lead time as the mechanism most used by U.S. manufacturers to protect their innovations (Levin *et al.*, 1987). The situation in Brazilian industry, however, is qualitatively different, as shown by Figure 7.11.

Trademarks are the main mechanism for protecting innovations used by manufacturers in Brazil. Almost a quarter of innovative firms in the manufacturing industry use trademarks to protect their innovations. This reflects the relative lack of market structure in Brazil, where the firm's prestige embodied in its trademarks guarantees the quality of the products it offers. The mechanisms associated with technological innovation are less widely used. Some 8% of innovative firms prefer secrecy as a form of protection. Patents rank third, followed by utility models and industrial designs. Paradoxically, lead time is not considered especially important in Brazil, despite its outstanding significance in developed-country sectors subject to rapid change (Figure 7.11).

When patents are associated with technological innovations, they can be seen as a key indicator of the degree of novelty and originality attributed to innovations. Only 6.2% of Brazilian innovative

Figure 7.11
Innovation protection rates (1) in manufacturing by type of protection – Brazil & São Paulo State, 2003-2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.11.

(1) Innovative firms declaring the use of at least one method of innovation protection during the reference period for PINTEC, as a percentage of all innovative firms.

firms filed patent applications in the period 2003-05 (Detailed Table 7.1). However, the economic literature recognizes that patents are seen as the main mechanism for protecting innovations only in sectors where the cost of imitating innovations is low compared with the cost of innovating (Mansfield, Schwartz & Wagner, 1981). An example is the chemical-pharmaceutical industry, where the cost of developing a new molecule is far higher than the cost of copying one.

The situation in Brazil is entirely different. The tobacco industry filed the most patent applications to protect product or process innovations in 2003-05, with 27.6%, followed by Recycling, with 18%, Plant & equipment, with 16.6%, and Precision instruments, with 16.5% (Figure 7.12). Pharmaceuticals and Chemicals ranked slightly above the overall average for the industrial sector, because most innovations developed in Brazil by these industries are not of the type for which patent protection is suitable. They are incremental innovations or products with expired patents, as in the case of generic medical drugs.

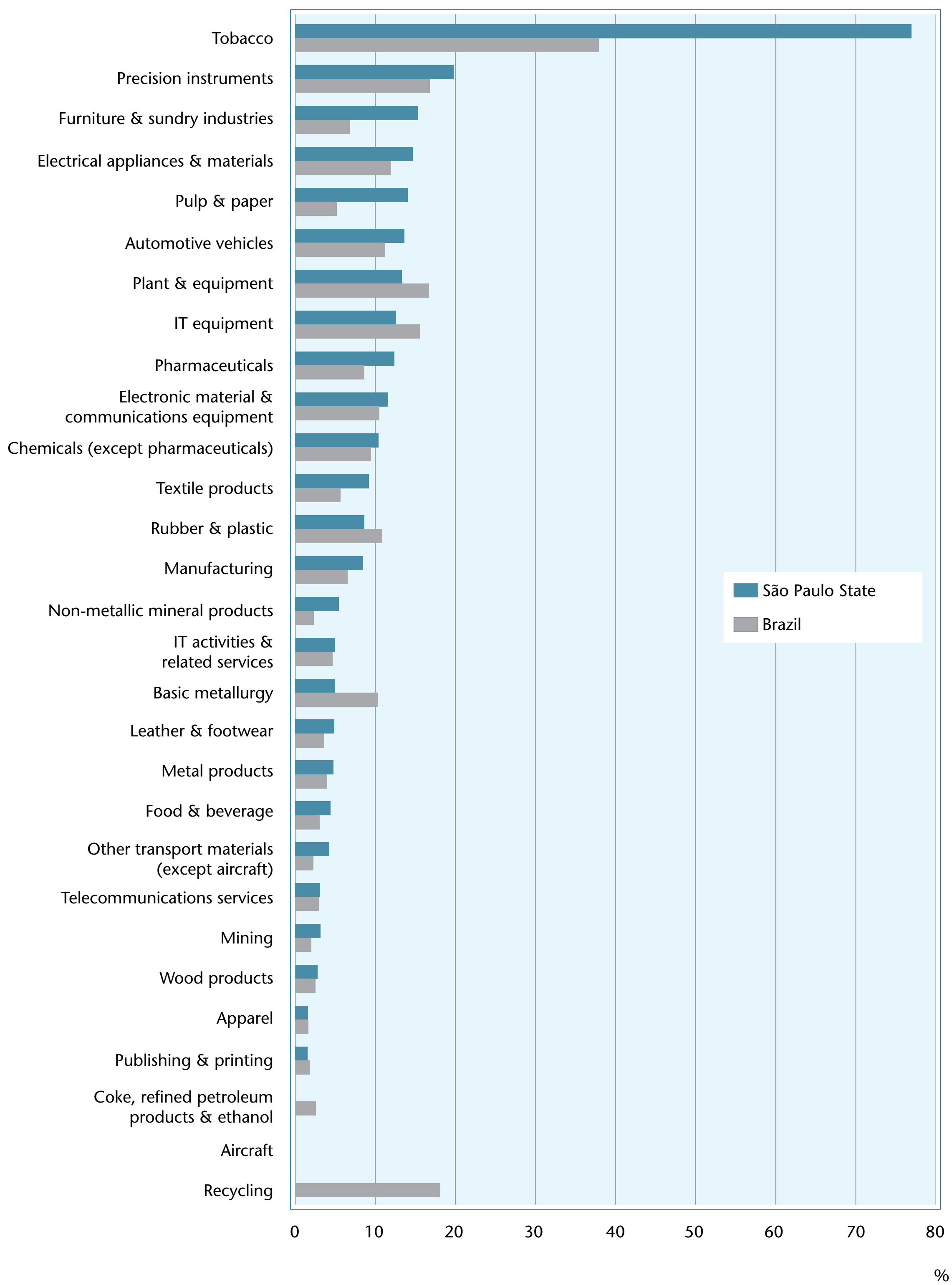
Knowledge-intensive services display a below-average propensity to patent compared with the manufacturing industry. In telecommunications the rate is only 2.8%, while in information technology it is 4.5%. Innovation in services does not always have sufficient technological content to justify patent protection. Moreover, in the software industry copyright is still the preferred IP protection mechanism.

Manufacturing firms in São Paulo State display an above-average propensity to patent: 8.3%, compared with an average of 6.2%. This is particularly so in the case of industries such as Tobacco, Textile products, Pulp & paper, Pharmaceuticals, Precision instruments, Automotive vehicles, and Furniture & sundry industries.

Size is also a key factor in explaining the differences between firms in terms of propensity to patent. The rate in 2005 was 29.2% for large firms and only 3% for small firms (10-29 employees). Size tends to make a firm more capable of creating innovations and of protecting them. The leadership of industrial firms in São Paulo State is also clearer in this area in the case of medium and large firms. For large firms (500 or more employees), propensity to patent was 37.3% in 2005 (Figure 7.13).

It is worth noting that despite the strong emphasis placed by official policies on encouraging business organizations to seek IP protection, the proportion of innovators that patented in São Paulo State did not increase between PINTEC 2003 and PINTEC 2005 (Figure 7.14). Only firms with 50-99 employees and large firms with 500 or more employees displayed increasing propensity to patent in this period.

Figure 7.12
Patenting rates (1) in mining, manufacturing and selected service industries – Brazil & São Paulo State, 2003-2005

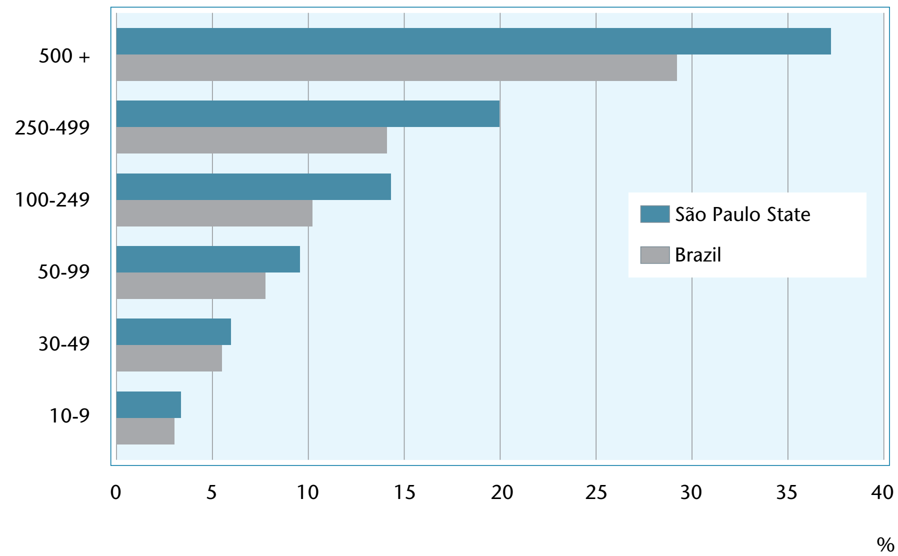


Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.1

(1) Innovative firms filing patent applications with patent offices during the reference period for PINTEC, as a percentage of all innovative firms.

Figure 7.13
Patenting rates (1) for innovative firms in manufacturing and mining by size of workforce – Brazil & São Paulo State, 2003-2005

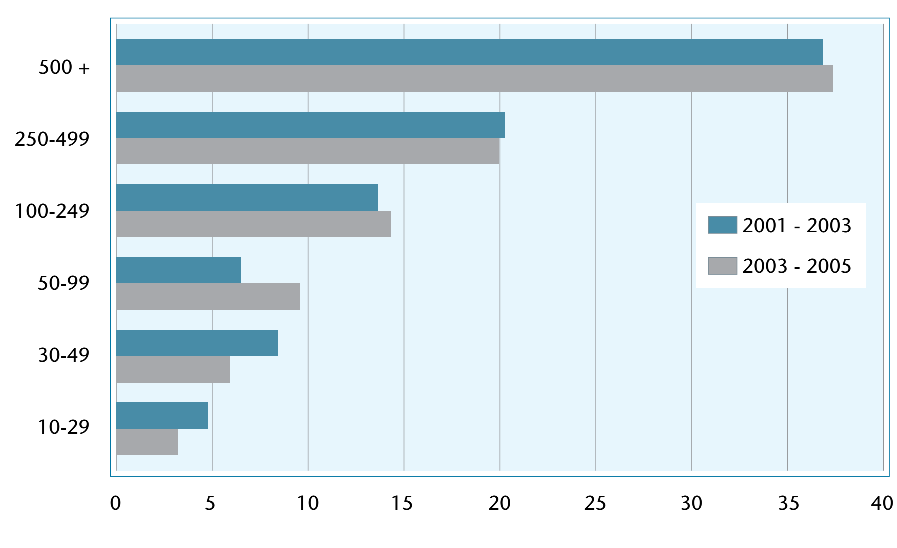


Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.12.

(1) Innovative firms filing patent applications with patent offices during the reference period for PINTEC, as a percentage of all innovative firms.

Figure 7.14
Patenting rates (1) for innovative firms in manufacturing and mining by size of workforce – São Paulo State, 2001-2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.12.

(1) Innovative firms filing patent applications with patent offices during the reference period for PINTEC, as a percentage of all innovative firms.

4. Sources of innovation and technological cooperation

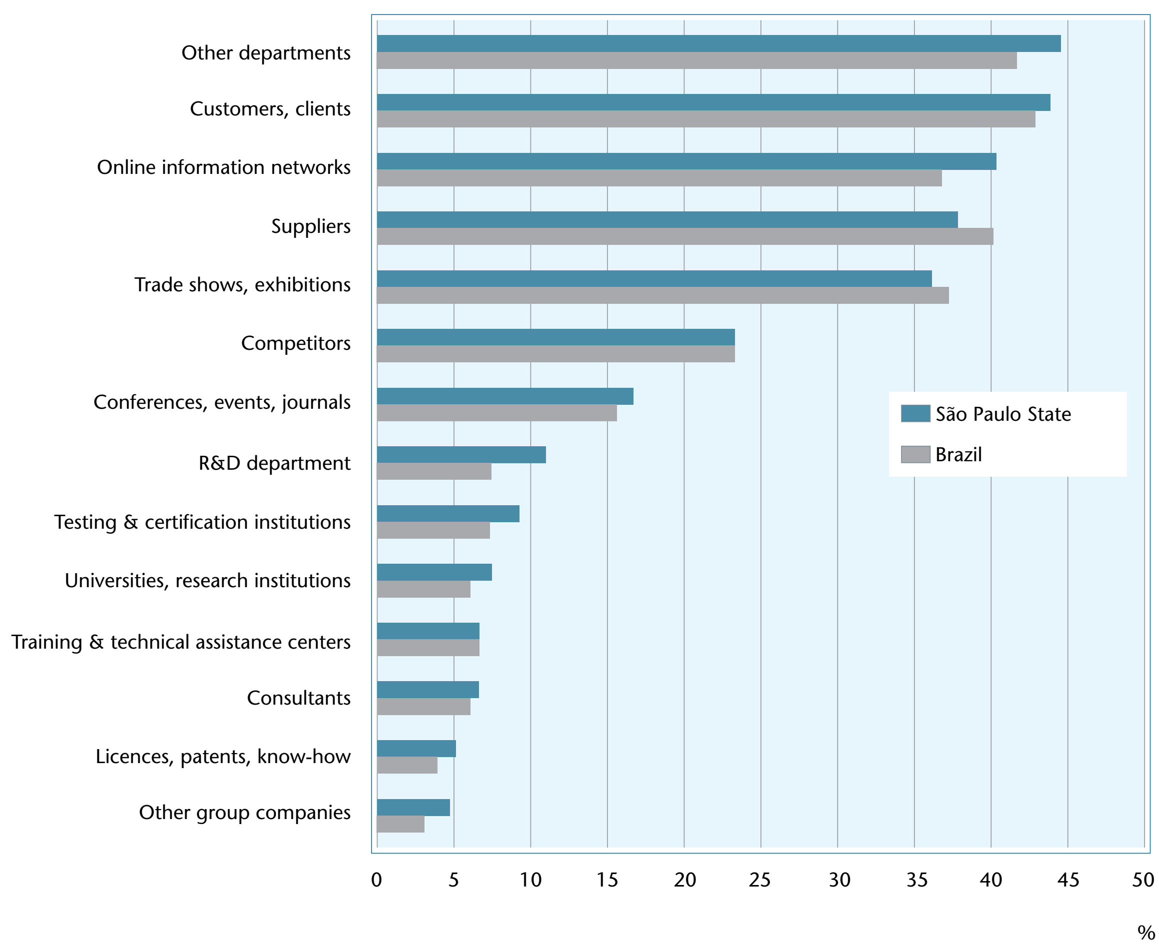
Innovation is not an activity in which firms engage independently from the context within which they operate. On the contrary, innovation requires a wide variety of inputs, some of which are obtained from outside sources of various kinds. The proximity of other firms and technological institutions is an important element that favours innovation by firms. IBGE set out to capture interaction by firms with the external environment, both locally and globally, including in its PINTEC innovation survey variables designed to measure the intensity of this interaction and to identify the geographic origin of the sources.

Public or private information sources are important knowledge inputs for innovation by business organizations. For present purposes, only those sources to which firms themselves assign great importance have been selected. The intensity indicator corresponds to the number of firms citing a source as highly important, as a percentage of all innovative firms.

External sources and internal sources associated with other departments predominate strongly in developing countries such as Brazil because firms lack structured innovation activities, especially in R&D (Figure 7.15).

The main sources by descending order of importance for the firms surveyed are as follows:

Figure 7.15
Information sources for innovation in manufacturing as % of all innovative firms by type of source – Brazil & São Paulo State, 2003-2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.13.

other departments within the same firm; customers or clients; and suppliers. Among external sources, relationships established along the value chain are essential to innovation. Horizontal relationships with competitors are seen as less important. Information in the pubic domain comprises a second type of external source for industrial firms. The statistics suggest that trade shows, exhibitions and online information networks are acquiring increasing importance, while conferences and specialized publications continue to be considered key sources of information for innovation. A third group made up of knowledge sources such as universities and research institutions is assigned a far lower level of importance (Box 2).

Box 2 – University-business relationships

Public policy for science and technology is focusing increasingly on university-business relationships. Universities and research centers are more and more frequently seen as key players in the innovation process. The conceptual models on which these relationships are based take their inspiration directly from the linear idea of innovation. This analytical model assumes that the university is responsible for generating the basic knowledge necessary to technological progress, extending as far as the application of new knowledge and the creation of inventions, and that the business organization is a user of new knowledge produced by the university. Public policy follows this model by seeking to facilitate technology transfer from universities to industry.

While it cannot be denied that universities can play this role, their function should be understood far more broadly than as a source of inventions for development by industry. Universities are key to the education and training of human resources. An important part of the transfer of knowledge from universities to business is performed via the human resources who learn methods and procedures that will later be applied to concrete problems faced by industry. However, this type of transfer is limited owing to the fact that the number of researchers with post-graduate research degrees – master's and above all PhDs – in industrial research labs is still relatively small.

PINTEC clearly shows the more indirect participation of universities in the innovation process. For firms to benefit effectively from relationships with universities, they have to do their own research and recruit qualified human resources capable of making good use of such relationships. In Brazil, 6% of innovative firms, or 1,812 manufacturers, consider universities and research institutions to be important sources of information for innovation (Figure 7.15). An even smaller group, comprising 855 firms in the manufacturing industry, have cooperative links with universities and research institutions, corresponding to a cooperation rate of 2.9%. Of these, 812 cooperate with institutions located in Brazil, corresponding to 2.7% of innovative firms (Detailed Table 7.19). This indicator is low, reflecting the limited extent of university-business relationships in Brazil. For the sake of comparison, it is worth noting that rates of cooperation between innovative industrial and service firms and universities alone in Europe range from 2% for Cyprus to 33% for Finland. Rates for France and the U.K. are in the range of 10%, Germany 8%, Italy and Spain 5% (Eurostat 2008, p. 131). Within the group of Brazilian manufacturers with cooperation relationships, an even smaller group comprising 424 firms cooperate with universities and research universities specifically in R&D (Detailed Table 7.19).

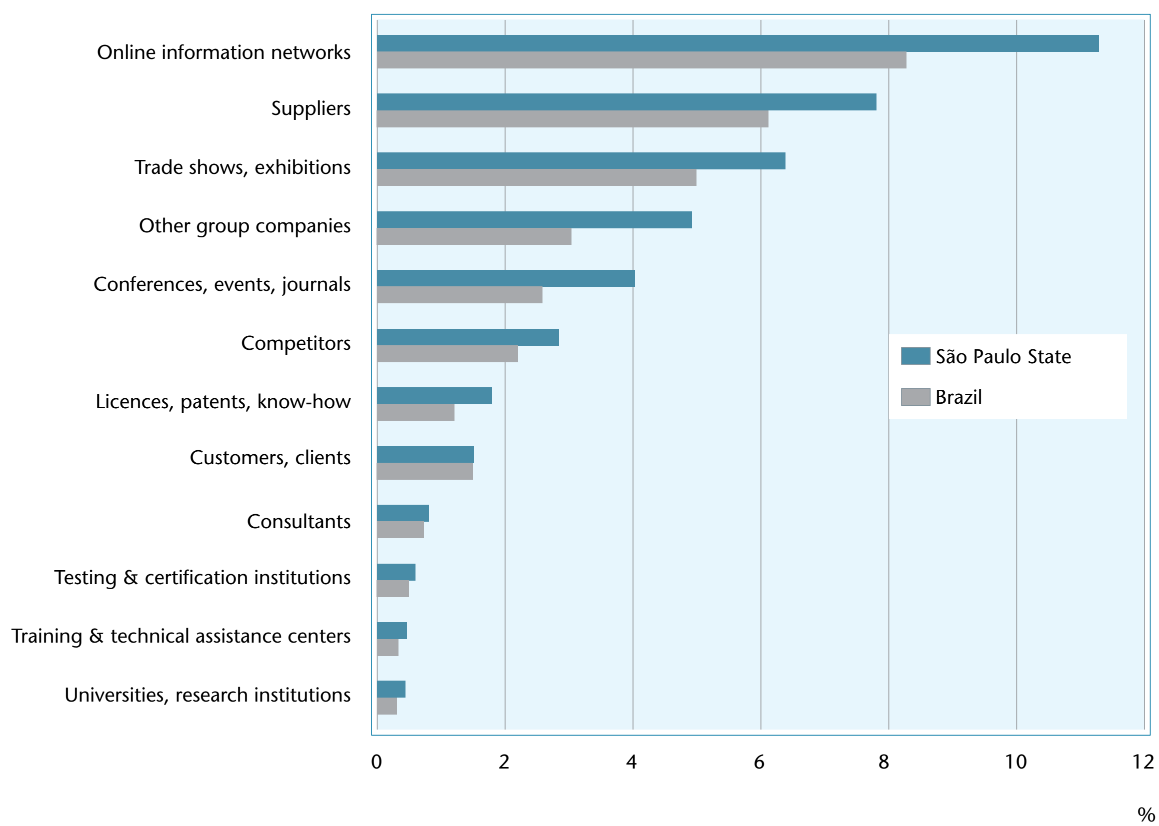
Thus while a small group of firms effectively partner with the academic circuit for research purposes, the universities' sphere of influence is significantly larger. Universities and research institutions rank third among the most important technological cooperation partners. Public policy to promote university-industry partnerships has contributed significantly to the expansion of this type of formal interaction. The PINTEC findings show that 369 manufacturing firms participate in research projects in partnership with universities supported by government. According to the same survey, the number of innovative firms that cooperate is similar to the number that receive government support. It can be inferred from this that public policy to promote interaction between these two key elements of Brazil's national innovation system appears to be at the root of a large proportion of these partnerships.

Figure 7.15 also shows that industry in São Paulo State differs very little from the national average in terms of its use of sources for innovation. However, the most qualified sources, such as R&D departments, licenses and patents, testing institutions and universities, are used more than the national average.

The most conspicuous differences between industry in São Paulo State and the national average relate to information sources located abroad. Firms in São Paulo establish closer ties with foreign sources of all kinds than the national average (Figure 7.16).

These differences are especially striking with regard to other group companies, since more subsidiaries of multinationals are located in São Paulo State than elsewhere, and to suppliers, given the importance of foreign suppliers to technology transfer in the state. Firms in São Paulo also make more intensive use of public channels of technological information located abroad. A clear link can be seen between the higher level of technological capability among industrial firms in São Paulo and their greater use of foreign information sources compared with firms located in other parts of Brazil.

Figure 7.16
Innovative firms in manufacturing citing foreign sources of information for innovation by type of source – Brazil & São Paulo State, 2003-2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.14.

4.1 Cooperation for innovation

Innovation surveys ask firms to identify the partners with which they cooperate for innovation and the importance of each kind of partnership. The proportion of firms that cooperate for innovation is relatively small in the Brazilian industrial sector. Only 7.1% of manufacturing firms establish ties of this kind in Brazil. The proportion in São Paulo State is 8.7% (Figure 7.17). Cooperation for innovation is much more frequent in Europe, with proportions ranging from 17% for Italy to 56% for Lithuania (Eurostat, 2008, p. 127).

The propensity to cooperate for innovation varies greatly from one industry to another. Nationally speaking, the firms most disposed to cooperate belong to the more technology-intensive industries, such as Other transport materials, Electronic material & communications equipment, Chemicals, and Aircraft, in descending order (Figure 7.17).

The situation in the service sector is very different. The cooperation rate for firms in Telecommunications services exceeds 60%, while the rate for IT services is slightly below 20%. The greater propensity to cooperate among firms in knowledge-intensive services reflects the interactive nature of technological innovation in this market, requiring intense participation by users and equipment vendors. This characteristic is emphasised in the literature on knowledge-intensive services (Bernardes & Kallup, 2007).

The ranking is entirely different in São Paulo State, reflecting significant regional variations in innovative firms' propensity to cooperate. In the case of São Paulo, the firms most inclined to cooperate do not necessarily belong to relatively technology-intensive industries. Thus the industries with the highest cooperation rates are as follows, by order of importance: Pharmaceuticals, Non-metallic mineral products, Aircraft, Automotive vehicles, and Wood products (Figure 7.17).

The propensity to cooperate can be associated with higher production capacity and more sophisticated technological capabilities in local industry, but also with geographical proximity to local partners. The fact that firms in Tobacco, Other transport materials, IT equipment and Electronic material & communications equipment are mostly located outside São Paulo State appears to be the main reason for the lower propensity to cooperate among firms in the state. The reverse is true of Aircraft, Automotive vehicles and Precision instruments.

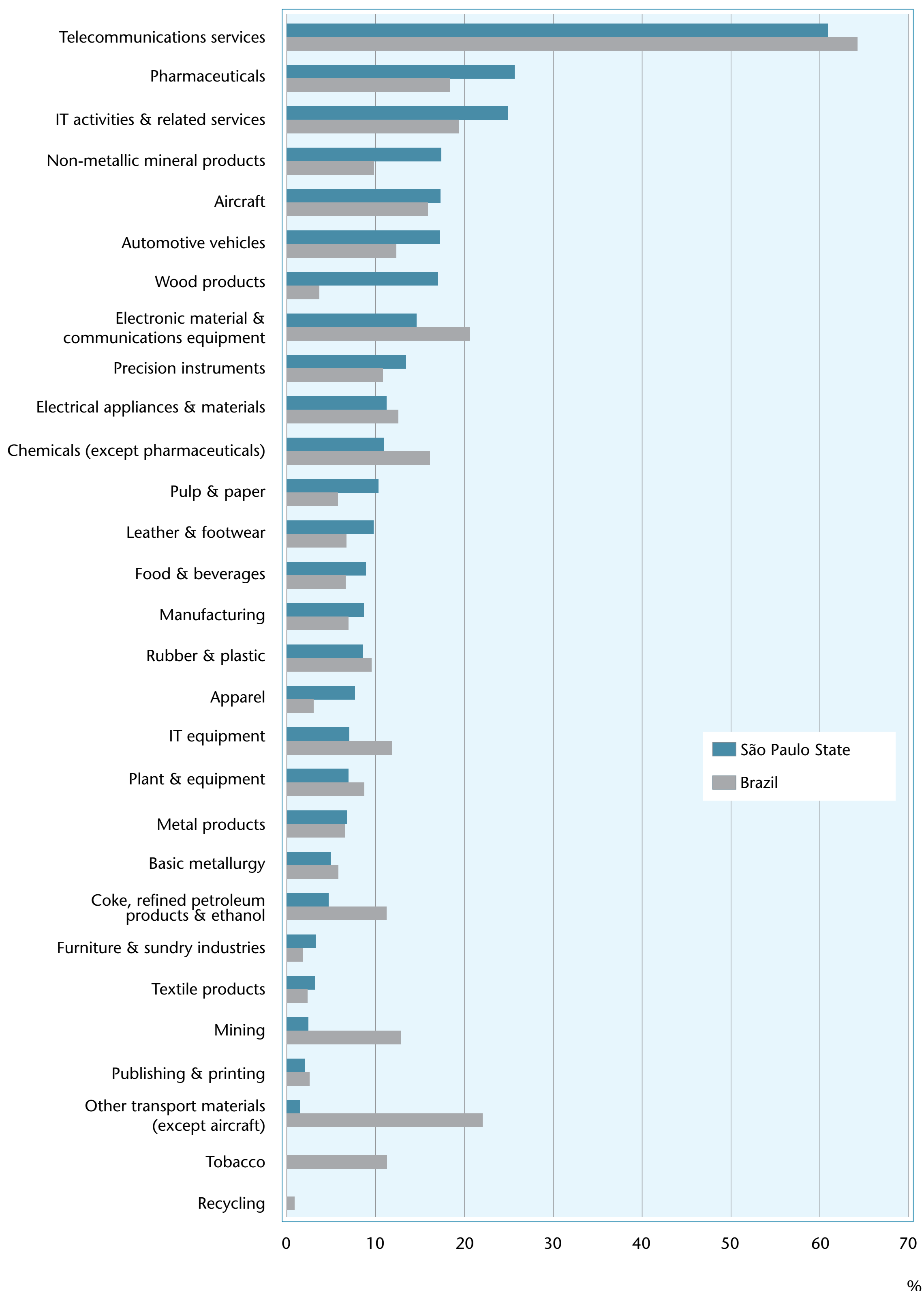
The institutions chosen for the purposes of cooperation are mostly part of the value chain. Innovative firms cooperate first among themselves in accordance with the logic of user-supplier interaction (Lundvall, 1992). Thus customers and suppliers rank first and second among the domestic institutions with which firms prefer to cooperate. Some 58% of Brazilian firms that have cooperative ties interact with customers and suppliers. Universities rank third with 40%. In absolute terms this corresponds to about 810 firms establishing cooperative ties with academic and research institutions (Figure 7.18).

Firms in São Paulo State differ sharply from the national average in this regard, establishing links with other firms more frequently but cooperating less with universities and research institutions, consultants and training centers. This is surprising in light of the dynamism of São Paulo's innovation system and the fact that in addition to significant support from national development agencies the state has its own research funding agency, FAPESP, and other agencies of the state government that promote university-business cooperation. The difference cannot be attributed to the stronger presence of subsidiaries of multinationals in São Paulo State. Domestic firms in the state display a much higher propensity to cooperate with universities and research institutions across Brazil (Detailed Table 7.16).

Cooperative ties specifically for R&D follow a pattern that closely resembles those of other cooperative activities, such as technical assistance, product testing, industrial design and training, among others. Interaction with other links in the value chain predominate, and universities and research institutions again rank third among the most frequent partners (Figure 7.19). The difference between São Paulo and the national average is far smaller in the specific case of R&D cooperation, but the propensity to establish this type of cooperation with customers or clients, other group companies and consultants tends to be greater among firms in São Paulo State than elsewhere in Brazil. The difference practically disappears in the case of R&D cooperation with universities, research institutions and suppliers.

The fact that universities and research institutions have lost position and relative importance among the most frequent partners of firms in the innovation process in São Paulo State is a noteworthy finding that testifies to the failure of federal and state initiatives to strengthen such ties (Figure 7.20). More details and information on this type of interaction within the national innovation system are presented in Box 2.

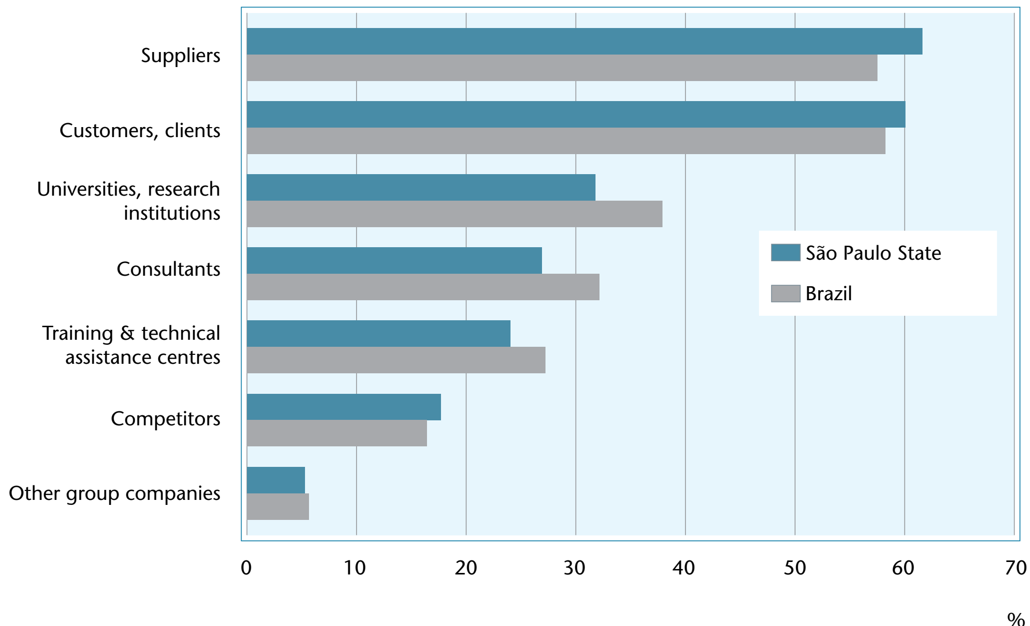
Figure 7.17
Cooperation rates in manufacturing, mining and selected segments of the service sector as % of all innovative firms – Brazil & São Paulo State, 2003-2005



Souce: IBGE. PINTEC 2005.

Note: See Detailed Table 7.1.

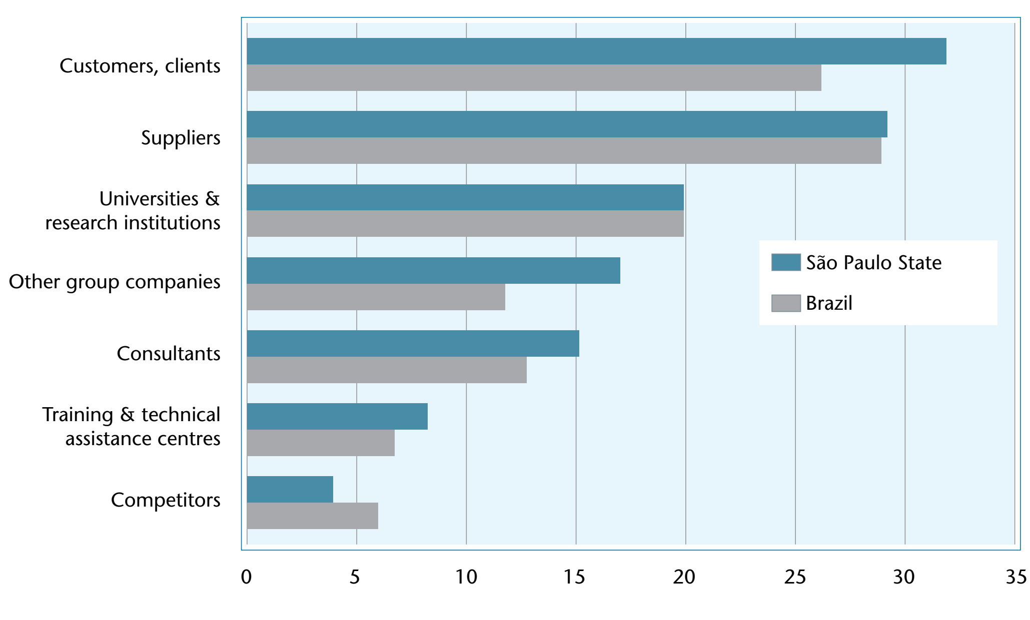
Figure 7.18
Innovative firms in manufacturing with domestic cooperative relations by type of partner – Brazil & São Paulo State, 2003-2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.15.

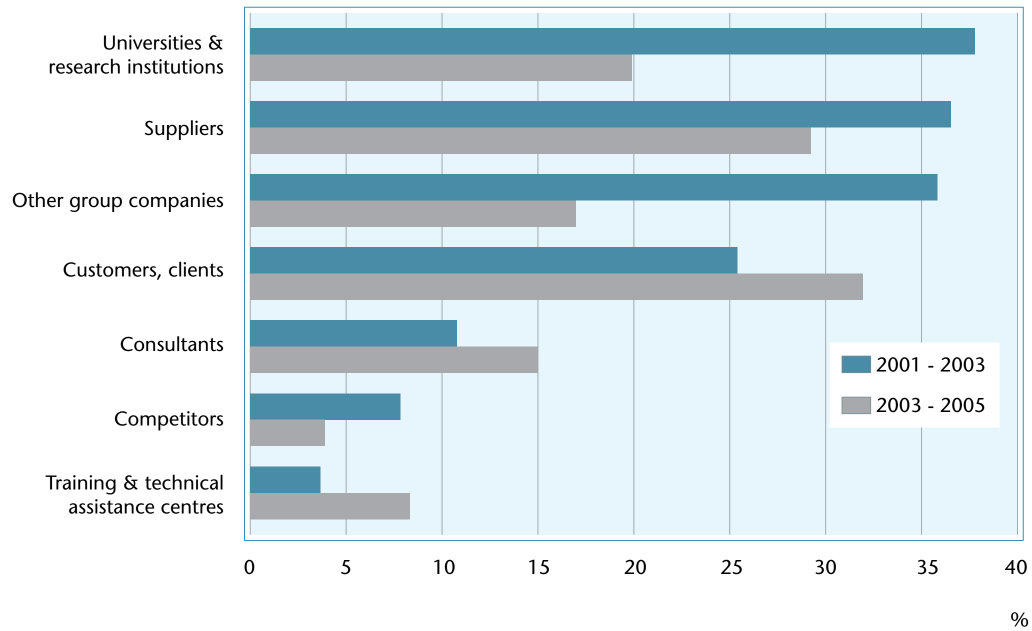
Figure 7.19
Innovative firms in manufacturing with R&D cooperative relations by type of partner – Brazil & São Paulo State, 2003-2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.17.

Figure 7.20
Innovative firms in manufacturing with R&D cooperative relations by type of partner – São Paulo State, 2001-2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.18.

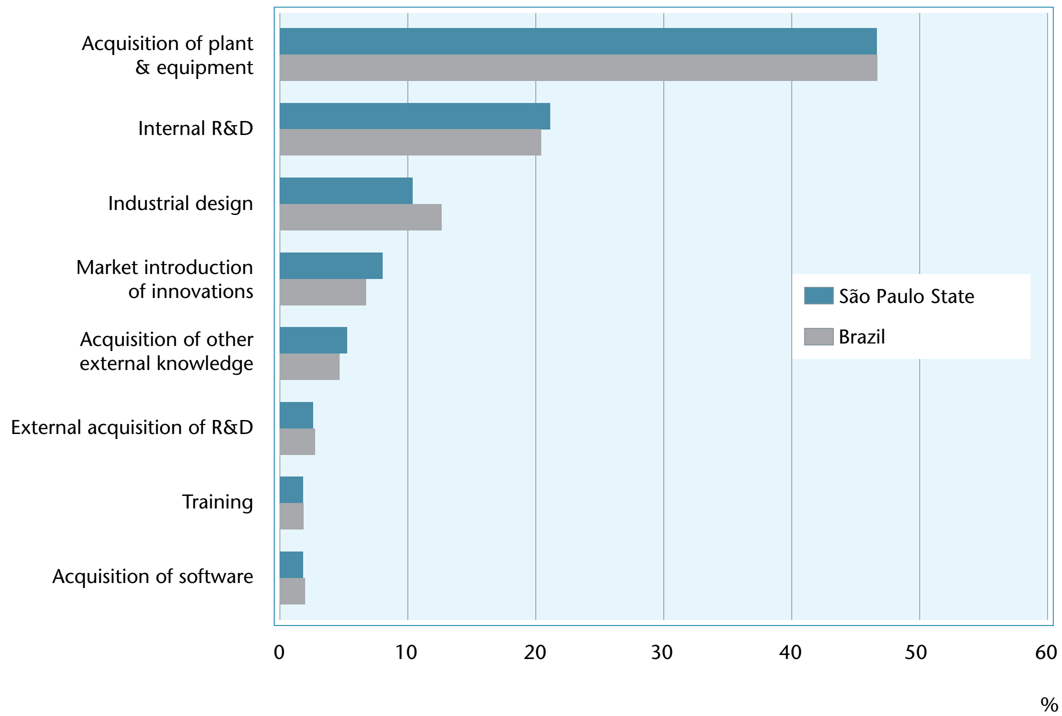
5. Innovation activities and R&D spending by innovative firms

Business expenditure on innovation activities is a key item in terms of the information it provides on the amount of inputs and effort firms deploy to innovate. Innovative manufacturers spent 2.8% of net sales on these activities in 2005. Acquisition of plant and equipment was the main driver of this innovation intensity. This shows that the principal input for business innovation is external and is absorbed in the form of capital goods. Because this is an aggregate indicator, it suggests a closer correlation between innovative efforts by Brazilian industry and technology adoption than technology creation properly speaking. In the most advanced European countries, internal R&D is the leader among the different types of innovative effort (Eurostat, 2008, p. 117).[6] In Brazil, R&D ranks second, accounting for almost 21% of innovative efforts. Industrial design and market introduction of products rank third and fourth. The other types of innovative effort account for much smaller proportions (Figure 7.21). São Paulo State differs little from Brazil overall on this measure, with only a slightly greater emphasis on R&D, acquisition of other external knowledge and market introduction of innovations.

Industry in São Paulo State performs better in terms of the intensity of innovation efforts, however. Industrial firms in the state display an innovation intensity rate of 3.5%, compared with a national average of 2.8%. The difference in favor of São Paulo is most pronounced in the case of plant and equipment acquisition and R&D, but it can also be seen in external

6. According to Eurostat, internal R&D accounted in 2004 for 68.4% of business spending in innovation activities in France, 61.7% in Denmark, 43.9% in Germany, 59.8% in the Netherlands, 62.8% in Sweden, 37% in Spain, and 32.1% in Italy.

Figure 7.21
Structure of spending on innovation activities in manufacturing by type of activity – Brazil & São Paulo State, 2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.20.

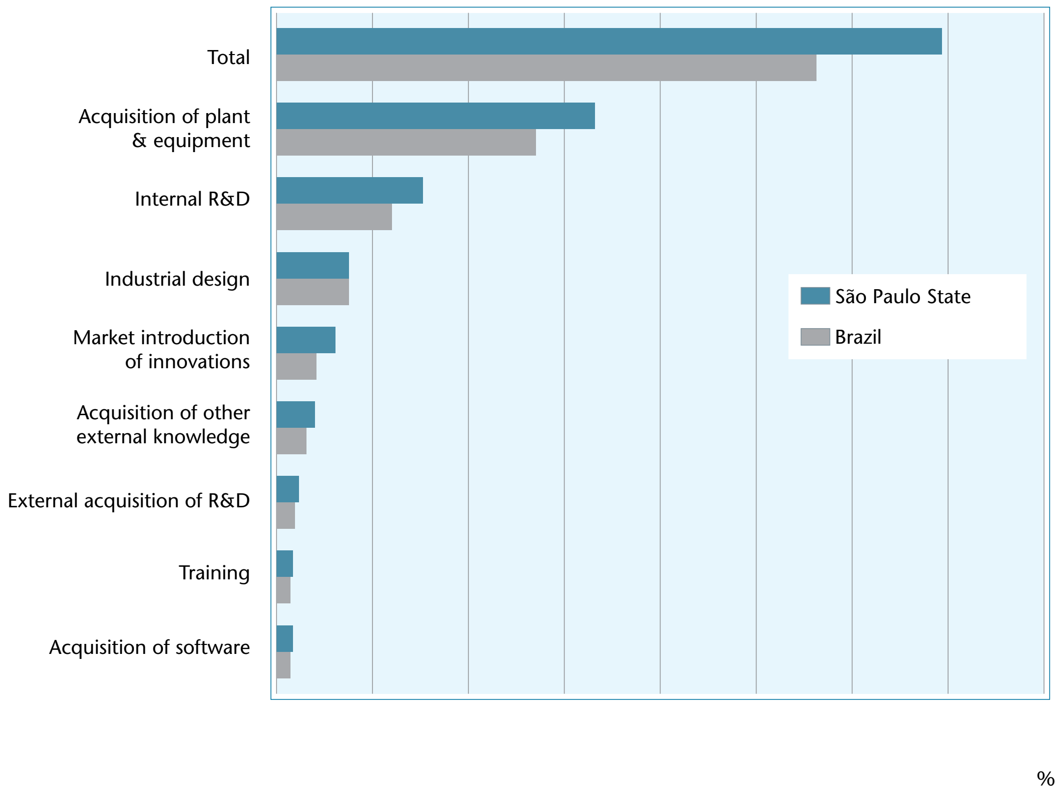
knowledge acquisition and market introduction of products (Figure 7.22).

Innovation efforts vary according to firm size. PINTEC findings for industry in São Paulo State show that the innovative efforts of small firms (with between 10-29 and 30-49 employees) are substantial and much more intense than those of medium and large firms (Table 7.5). These efforts are concentrated in the acquisition of plant and equipment, so that technology is mainly absorbed in embodied form from external sources. The efforts made by these firms to innovate are noteworthy and these statistics show an intensification of technology diffusion in the industrial sector.

Even so, small firms invested significantly in R&D, at a rate similar to the average for industry. Firms with 30-49 employees not only comprise the group with the highest intensity of innovation efforts but also invest in a much wider range of innovation activities, including the acquisition of external knowledge, training and market introduction of innovations.

Large firms differ from small firms by devoting relatively more innovation efforts to intramural and extramural R&D. In this respect they resemble the predominant pattern seen in the developed countries. Indeed, the statistics show a very sharp difference between small and large firms in this area. Small firms focus on absorbing external knowledge, although there is a clear distinction between very small firms, with 10-29 employees, which are still absorbing innovations through embodied technology, and somewhat larger firms with 30-49 employees, which tend to pursue other disembodied sources.

Figure 7.22
Spending on innovation activities in manufacturing by type of activity as % of net sales – Brazil & São Paulo State, 2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.21.

Table 7.5
Intensity of innovative activities in manufacturing and mining by size of workforce as % of net sales – São Paulo State, 2005

No. of employees	Intensity of innovative activities in manufacturing & mining (% net sales)								
	Total	Internal R&D	External R&D	Other external knowledge	Software	Plant & equipment	Training	Market introduction of innovations	Industrial design
Total	**3.45**	**0.75**	**0.09**	**0.18**	**0.06**	**1.65**	**0.07**	**0.28**	**0.37**
10-29	**7.77**	0.63	0.06	0.03	0.07	6.23	0.07	0.40	0.28
30-49	**9.15**	0.59	0.02	3.10	0.03	3.99	0.50	0.66	0.25
50-99	**3.79**	0.47	0.05	0.05	0.04	2.84	0.04	0.14	0.18
100-249	**2.32**	0.44	0.07	0.06	0.05	1.33	0.03	0.13	0.22
250-499	**3.49**	0.53	0.02	0.08	0.06	2.24	0.03	0.18	0.34
500+	**3.16**	0.86	0.12	0.13	0.07	1.19	0.06	0.32	0.42

Source: IBGE. PINTEC 2005.

5.1 Intensity of internal R&D

Industrial R&D is defined by OECD as consisting of R&D activities in the business sector regardless of the origin of their funding. This definition applies to what PINTEC classifies as internal R&D activities, i.e. intramural R&D. R&D intensity is defined here as the ratio of spending on intramural R&D to manufacturing value added (MVA), which approximates to the value added by the firm. This is a better measure of a firm's effective technological efforts, since net sales or revenue encompasses other items such as externally acquired inputs whose relative importance can vary substantially from one sector to another. In some industries, such as intermediate goods, the value of inputs represents a large proportion of final revenue. MVA measures the value effectively created by the firm. Thus measuring R&D intensity as a ratio between R&D expenditure and MVA more accurately gauges the proportion of value added invested in R&D by the firm. The statistics on the intensity of industrial R&D published by OECD use MVA and are therefore comparable with the PINTEC findings.

Innovation intensity for Brazilian manufacturing averages only 1.5%, well below the developed-country average. According to OECD (2006), the average for its member countries was 7.7% in 2001. This indicator clearly reflects the weakness of Brazilian industry in the field of innovation. Innovation intensity for São Paulo State is 2.1%, significantly higher than the national average but still far below the developed-country average.

The innovation intensity indicators for both Brazil and São Paulo State show that external knowledge sources still predominate over internal sources.

The sectoral statistics are especially eloquent (Figure 7.23). The international literature places considerable emphasis on differences in technological regime between sectors of economic activity. OECD has sought to measure such differences by introducing a sectoral classification by technological intensity. This classification distinguishes between high, medium-high, medium-low and low technological intensity. It is based essentially on indicators of intramural R&D intensity calculated for the OECD countries en bloc.

Sectoral indicators of intramural R&D intensity for specific developed countries differ widely from the aggregate average on which OECD's sectoral classification is based. However, as noted in a previous study (Furtado & Carvalho, 2005), this variation is due to country specialization in sectors where specific countries enjoy dynamic competitive advantages. Generally speaking, these sectors belong to the high and medium-high technological intensity group.

In the Brazilian case, technological intensity is much lower in these sectors, which are the flagships of technological development (Figure 7.23). A more precise measure of the sectors in which technological intensity is greatest has been obtained here by using the same sectoral breakdown as OECD, segregating pharmaceuticals from the rest of the chemical industry and aerospace from other transport materials. This approach displays more clearly the behavior of high-tech industries in terms of intramural R&D spending as a percentage of value added.

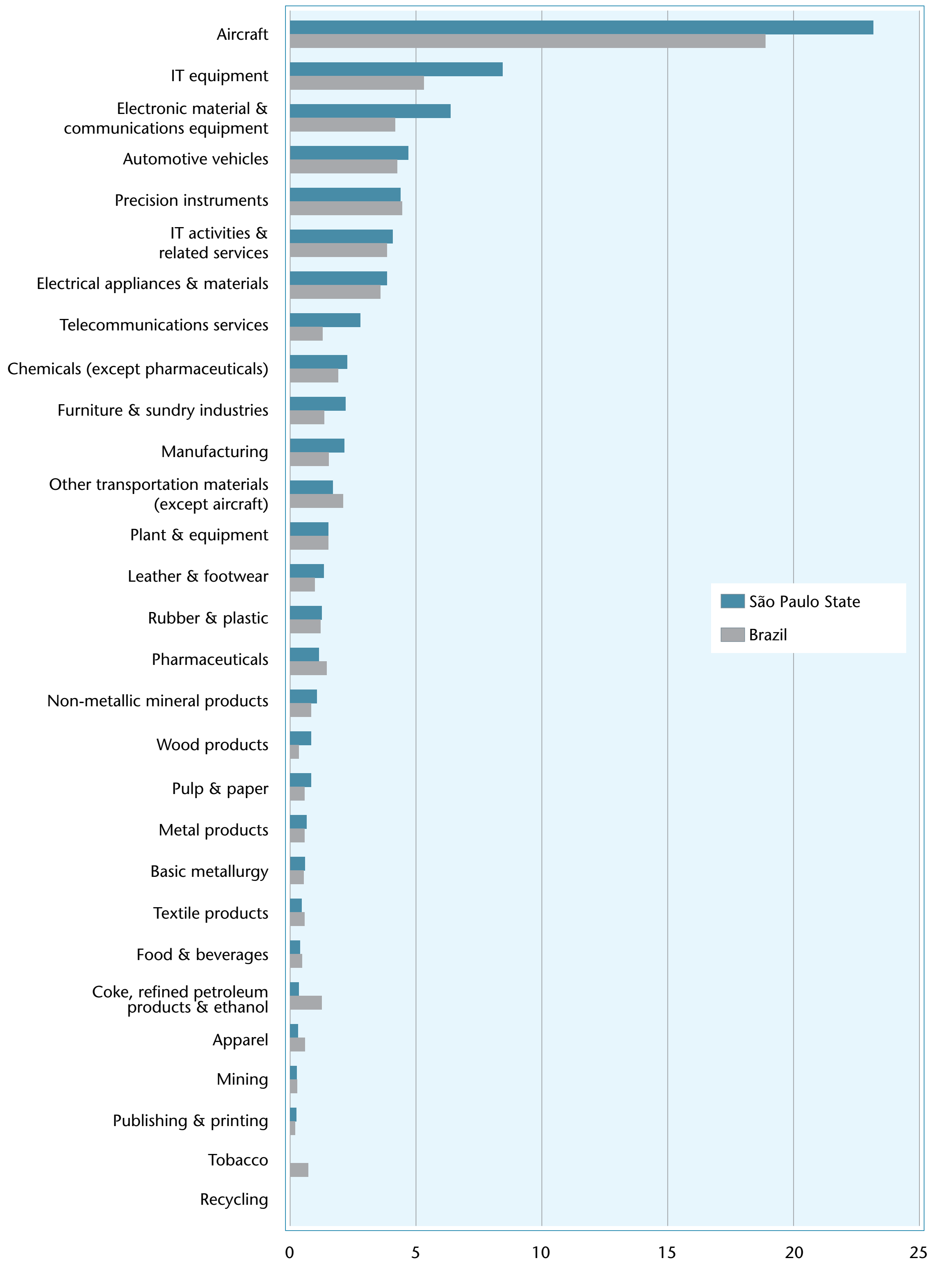
The pharmaceutical industry, which leads the intensity of technological efforts in the developed countries, displays low intramural R&D intensity in Brazil. This is undoubtedly the most extreme example of Brazil's technological fragility in the high-tech group. To date the Brazilian pharmaceutical industry has not developed a single internationally significant drug. Intensity in this industry is only 1.3%, compared with 21.1% in the U.S. and 52.4% in the U.K. Even countries with average intramural R&D intensity rates for manufacturing similar to Brazil's, such as Spain and Italy, display much higher intensities than Brazil in the pharmaceutical industry (Detailed Table 7.22).

The only high-tech industry in which Brazil stands out is aerospace, where its position resembles that of the OECD countries. The Brazilian industry's intensity is 18.8%, close to Canada (15.5%), the U.S. (18.5%) and the U.K. (23.6%). This strong international position is associated with the existence of Embraer, a leading aircraft manufacturer with its own innovation capacity and a focus on exports.

Besides these opposite poles of technological competitiveness in Brazilian industry, several technology-intensive industries are almost always below the OECD average but are also important in terms of internal R&D efforts. In particular, such high-tech industries as IT equipment, Electronic material & communications equipment and Precision instruments are well behind the developed countries in terms of R&D intensity. In medium-high tech industries such as Automotive vehicles (4.2%) and Electrical material (3.5%), the gap is narrower but still substantial. Moreover, these industries are noticeably more competitive than most on a global scale.

The technological intensity of industry in São Paulo State surpasses the national average. In this state, intensity is 2.1%, compared with 1.5% for Brazil overall, but well below the developed-country level. The gap between São Paulo State and the national average varies considerably from one branch of industry to another. It is greatest in high-tech industries, especially aerospace, IT and electronic and telecommunications products. The technological intensity of industry in São Paulo State is above the national average in most sectors, but R&D activities

Figure 7.23
Intensity of intramural R&D in manufacturing, mining and selected segments of the service sector as % of value added – Brazil & São Paulo State, 2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.1.

are not located in the state in some cases, such as oil and gas, tobacco, food and beverages, textiles, apparel and other transport materials except aircraft. Generally speaking, less technology-intensive sectors are more important outside the state.

5.2 Intensity of external R&D

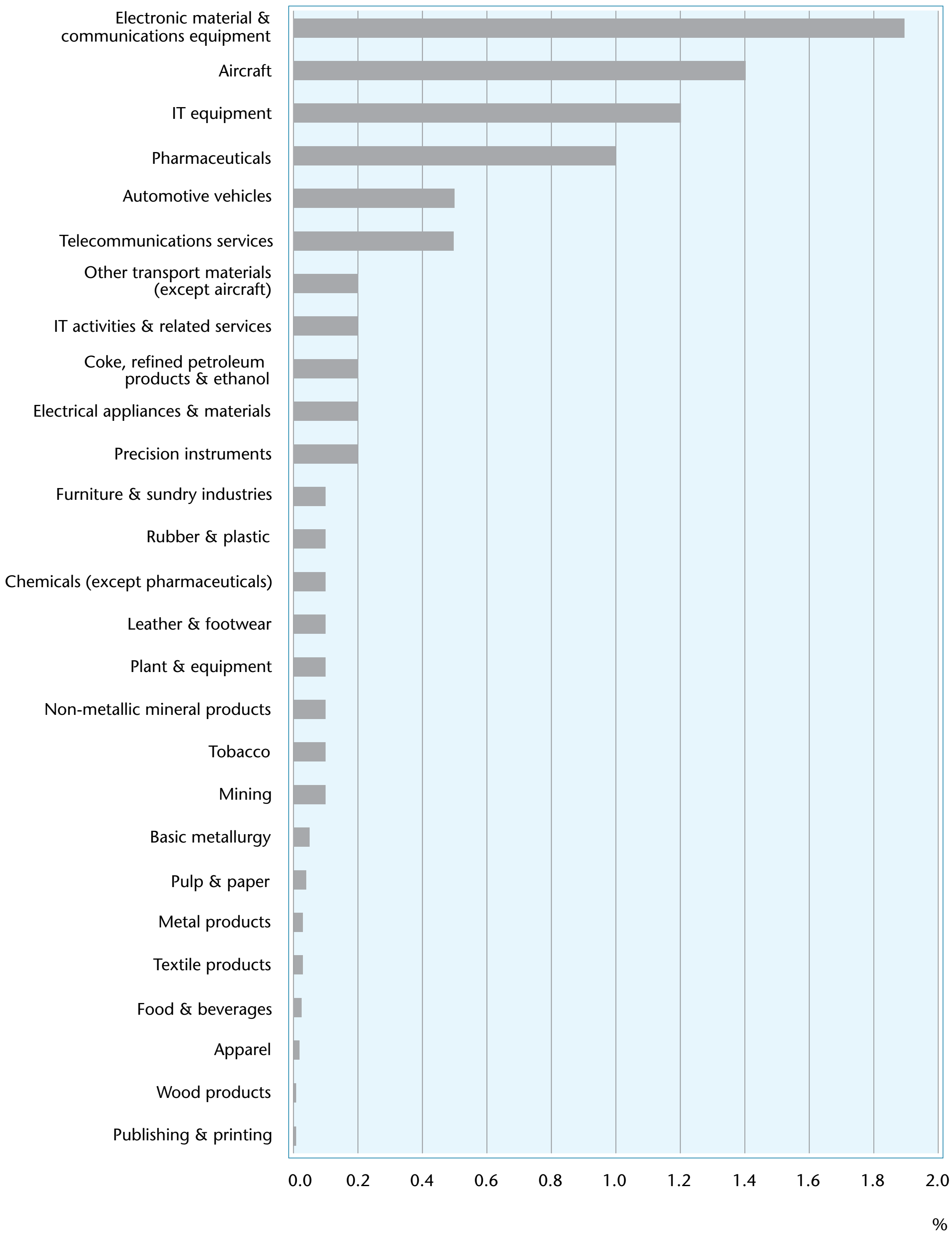
PINTEC asks firms to cite externally acquired R&D activities but does not break the response data down by type of organization. Extramural R&D can be acquired from other firms, research institutions or universities. When purchased from other manufacturing firms or service providers, it results in double counting as far as R&D spending estimates are concerned, since these estimates are based on total investment in R&D regardless of whether the source of funding is internal or external. For this reason, it is not methodologically acceptable to add internal and external R&D spending together.

This section discusses the significance of business organizations' bought-in R&D efforts measured in terms of intensity as a ratio of spending on external R&D to value added, just as was done above with internal R&D. Thus while the average intensity in manufacturing is only 0.20%, high-tech industries make far greater use of external knowledge sources. The top four, with intensities of 1% or more, are as follows in descending order: Electronic material & communications equipment, Aircraft, IT equipment and Pharmaceuticals (Figure 7.24). High-tech firms habitually establish strong linkages with academic research and for this reason are termed "science-based" by Pavitt (1984). A major proportion of external R&D is acquired from academic institutions.

In Brazil, these stronger linkages with external sources acquire particular overtones that reflect public policy and the position of these firms, when they are subsidiaries of multinationals, relative to other group companies and their own parent companies. In the case of telecommunications and IT equipment, the government's IT policy plays a key role by granting tax incentives to firms that conduct R&D in Brazil and requires at least 40% of their investment in R&D to be spent on activities acquired from universities, research centers and technology-based firms. In the case of the aircraft industry, government incentives designed to foster university-business cooperation were still limited at the time PINTEC 2005 was conducted, but Embraer's very strong historical relationships with Departamento de Ciência e Tecnologia Aeroespacial (DCTA) and Instituto Tecnológico de Aeronáutica (ITA) for the testing and certification of new aircraft are its main items of R&D spending. Firms in the pharmaceutical industry, especially subsidiaries of multinationals, have commercial agreements with Brazilian universities for clinical trials of new drugs developed abroad.

São Paulo State's extramural R&D intensity is 0.26%, compared with a national average of 0.20%. A breakdown by industry shows significant contrasts with the national average, however. High-tech industries such as Electronic material & communications equipment, Aircraft and Pharmaceuticals display higher extramural R&D intensities (Figure 7.25). The opposite is the case for IT equipment, most of whose production lies outside the state. Similarly, the higher intensity of tobacco firms in São Paulo State masks their smaller economic significance, besides the fact that they acquire all R&D from outside.

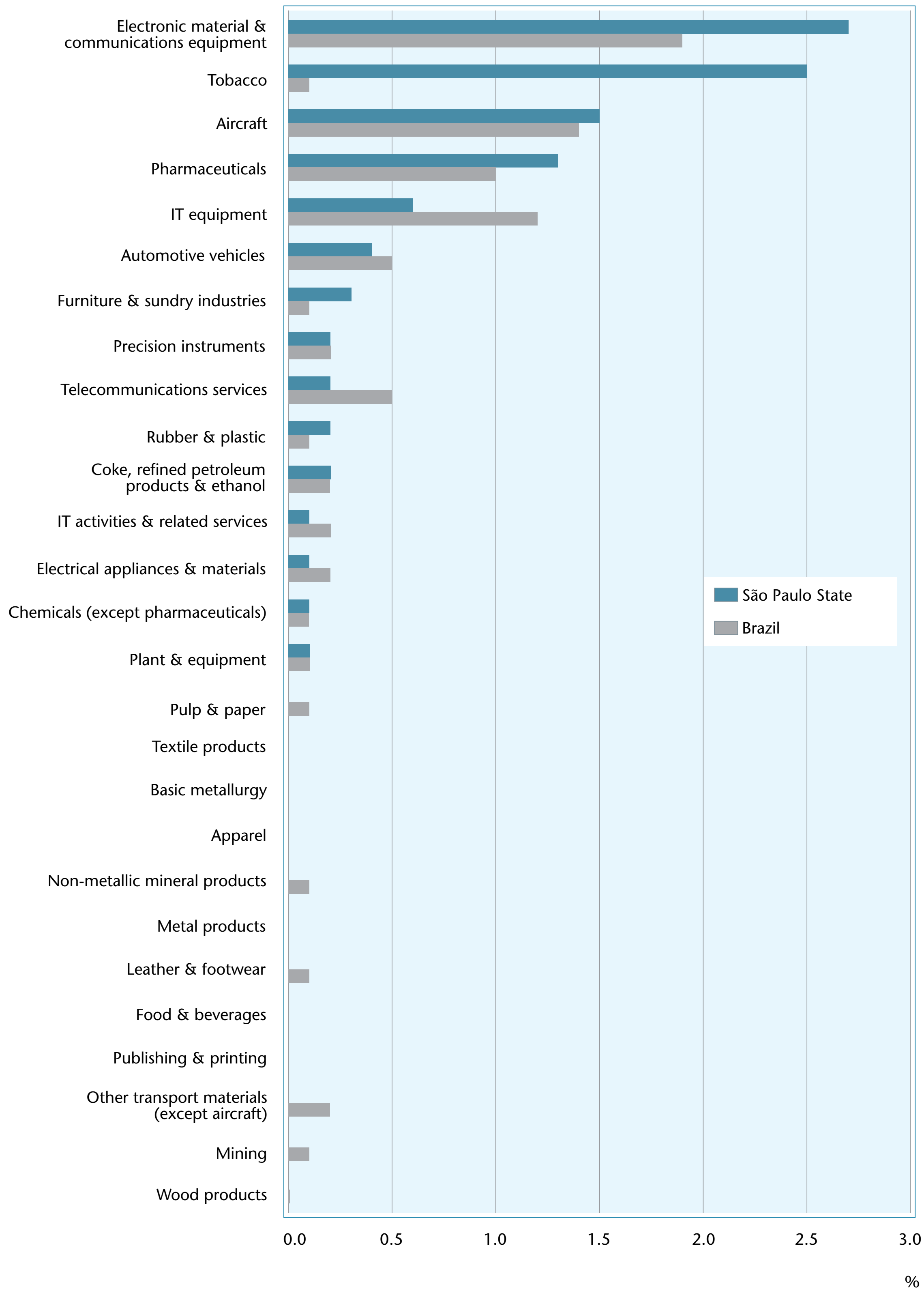
Figure 7.24
Intensity of extramural R&D in manufacturing, mining and selected segments of the service sector as % of value added – Brazil, 2005



Fonte: IBGE. PINTEC 2005.

Nota: See Detailed Table 7.24.

Figure 7.25
Intensity of extramural R&D in manufacturing, mining and selected segments of the service sector as % of value added – Brazil & São Paulo State, 2005



Fonte: IBGE. PINTEC 2005.

Nota: See Detailed Table 7.24.

5.3 Structure of internal R&D

The data on R&D spending structure complement the data on intensity and enable the specificities of the Brazilian technological pattern to be described more clearly. In contrast with the developed countries, where technological efforts are concentrated mainly in high-tech industries, in Brazil these efforts are most intense in medium-tech industries according to the OECD classification. Table 7.6 presents the structure of R&D spending in manufacturing for Brazil and São Paulo State.

These findings show the automotive industry accounting for practically a quarter of R&D spending by manufacturers in Brazil. Much of this effort is undoubtedly concentrated in experimental development, with applied research accounting for a small proportion. Nevertheless, the automotive industry clearly plays a significant role in Brazil's economic development on this criterion, with a far larger share of technological

Table 7.6
Structure of internal R&D spending by innovative manufacturing firms in selected sectors – Brazil & São Paulo State, 2005

Sector	R&D spending by innovative manufacturers as % of total R&D spending in manufacturing	
	Brazil	São Paulo State
Manufacturing	**100.0**	**100.0**
Automotive vehicles	24.1	31.9
Aircraft	9.8	16.8
Chemicals (except pharmaceuticals)	9.7	11.2
Electrical appliances & materials	5.6	6.9
Electronic material & communications equipment	5.9	6.2
Plant & equipment	5.3	5.4
Food & beverages	4.2	2.9
Pharmaceuticals	2.6	2.7
Rubber & plastic	2.8	2.7
Precision instruments	2.4	2.5
Non-metallic mineral products	1.6	1.7
Pulp & paper	1.2	1.6
IT equipment & office machines	2.2	1.6
Furniture & sundry industries	1.2	1.5
Basic metallurgy	2.5	1.2
Metal products	1.2	1.0
Leather & footwear	1.0	0.6
Textile products	0.8	0.5
Other transport materials (except aircraft)	1.2	0.4
Wood products	0.3	0.4
Publishing & printing	0.3	0.3
Coke, refined petroleum products & ethanol	13.5	0.2
Apparel	0.5	0.1
Tobacco	0.3	-

Source: IBGE, PINTEC 2005.

Note: See Detailed Table 7.23.

efforts than other branches of industry. It comprises several manufacturers of cars, trucks and buses, followed by an even more numerous group of auto parts suppliers. R&D activities are distributed throughout the automotive industry's dense value chain, albeit strongly concentrated in the carmaking segment.[7] This effort is reflected in significant productive dynamism and a major share of Brazilian exports.

The industries ranked second and third on this criterion are Coke, refined petroleum products & ethanol and Aircraft. These industries differ significantly in terms of technological intensity, but in the Brazilian case their efforts are of similar magnitude, although the oil industry is clearly ahead. The efforts of these two industries are concentrated above all in the two leading firms. Petrobras accounts for a considerable proportion of R&D efforts in the former, and Embraer in the latter. Both have strong links to public policy for the industries concerned. Petrobras is state-owned; Embraer was privatized in the 1990s.

Technology policies and strategies have been highly successful in these sectors. In oil and gas, Brazil had always been an importer for structural reasons until Petrobras was set up to achieve self-sufficiency. This goal was reached thanks to a policy that allowed Petrobras considerable management autonomy. Given the difficulty of finding oil in Brazil, Petrobras had to invest in human resources and R&D from its inception.

The challenge presented by the need to explore for deepwater offshore oil led Petrobras to intensify its R&D efforts. In 1986 it launched a deepwater technology program called Procap 1000 (Furtado, 1996) to develop technology for production at 1,000 meters. Until then the industry had reached less than half this depth. R&D efforts were necessarily intensified to address this challenge and the venture was highly successful in terms of significantly higher levels of oil and gas production in Brazil. Domestic production of crude more than tripled between 1995 and 2007 thanks to investment in technology for deepwater and ultra deepwater production.

The case of Embraer is qualitatively different. Aircraft manufacturing is mostly performed by a small number of developed countries, which invest heavily in military technology. The existence of an arms industry, however, does not guarantee success in the civilian area, which requires substantial investment in specific assets and the acquisition of sophisticated capabilities. From its inception, Embraer considered the civilian market its key strategic target for commercial development. This strategy entailed the selection of a number of market niches in regional aviation, where barriers to entry were considerably lower than in other markets.

Embraer took the right decision in focusing on the civilian market to expand, given that the military aviation market proved far more limited than had been foreseen. Nevertheless, this strategy severely limited its ability to build up a network of suppliers in Brazil, in contrast with aircraft manufacturers in the developed countries. In the latter, the industry has its own extensive local supplier network whereas in Brazil both production and R&D efforts are concentrated by Embraer.

Ever since privatization Embraer has always prioritized international partnerships, usually with major suppliers, for new aircraft designs. This management model has enhanced the effectiveness of the innovation process, shortening its cycle and considerably reducing commercial risk. Thanks to the success of its commercial jets, Embraer has achieved the position of fourth-ranking aircraft manufacturer on a global scale.

These three sectors – the automotive, oil & gas and aircraft industries – which together account for 47.4% of Brazil's industrial GDP (Table 7.6), display important structural difference. The automotive industry is dominated by foreign capital and has prospered largely thanks to strong technological linkages between suppliers and manufacturers. In the case of the oil and aircraft industries, the main driver of technological development has been public policy with strong ties to the market.

Four other sectors play a key role in Brazilian R&D efforts. They are Chemicals (9.7%), Electronic material & communications equipment (5.8%), Electrical appliances & materials (5.6%) and Plant & equipment (5.3%) (Table 7.6). Three of these are medium-tech and only one is high-tech. All four are closely associated with the construction of heavy industry in Brazil in the second half of the 20th century. Overall, the top seven industries account for 73.8% of industrial R&D in Brazil. São Paulo State is home to most of the nation's industrial R&D.

7. Automotive manufacturers account for 84.4% the industry's R&D spending, auto parts manufacturers for 14.6%, and producers of cabs and bodies for the rest.

The state accounts for 58.4% of the total, but this R&D effort is concentrated in a relatively small number of industries. The automotive and aerospace industries are the mainstay of R&D in São Paulo's manufacturing sector. The chemical industry ranks third. The automotive industry alone accounts for almost a third of São Paulo's industrial R&D effort. The oil industry, which plays a highly significant role nationwide, is virtually absent from São Paulo as far as R&D investment is concerned (Detailed Table 7.1).

5.4 Funding of internal and external R&D

Schumpeter (1982) noted the financial system's importance to the success of innovation. The banks could provide the funding required to finance future wealth, he argued. In the developed countries this role has been performed since World War II by the state, which has assumed the responsibility for funding industrial R&D directly and indirectly, facilitating the intensification of innovation by business.

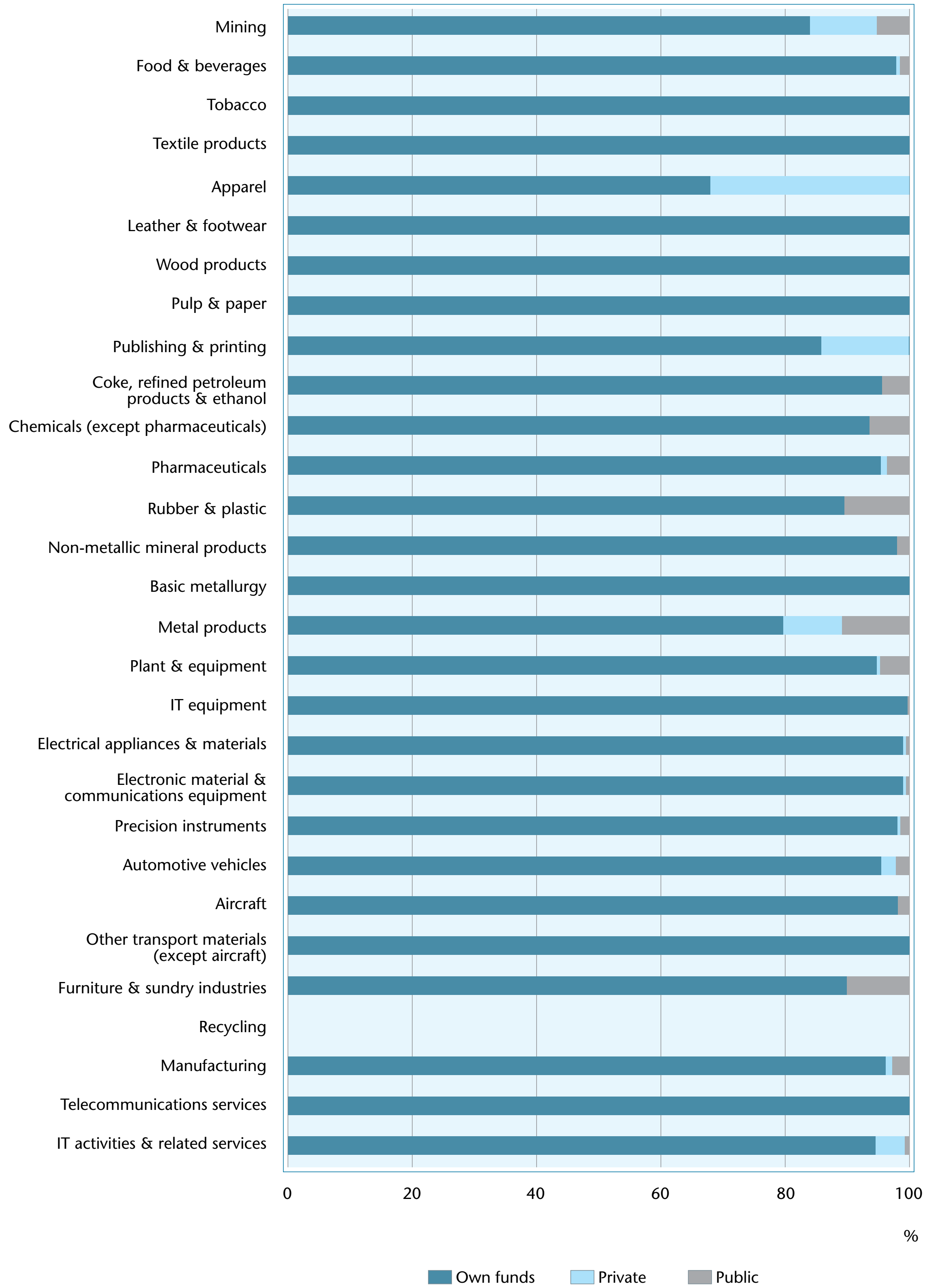
In Brazil, the banking system did not play a significant role in financing business R&D until very recently. Private-sector banks have not participated in the process, and public policy in support of industrial research via public-sector banks and development agencies has almost always been very timid. This can be attributed to the essentially academic bias of the Brazilian development system, which forces business organizations to rely intensely on internal funding for their intramural R&D activities (Figure 7.26). Two laws passed in 2004 and 2005 (Law 10973, known as Lei da Inovação, and Law 11196, known as Lei do Bem) are changing this situation a little. Since 2006 FINEP, the national technological development and innovation agency, has offered subsidies in the form of direct grants to support research and innovation by firms. The results of these policy measures can be captured only in future editions of PINTEC.

According to PINTEC 2005, some 96% of the funding for intramural and extramural R&D by manufacturing firms in São Paulo State was provided by the firms themselves[8], while 2.8% came from government agencies and only 1.1% from private-sector organizations (Figure 7.26). The shares of the public and private sectors vary across industries, however. Public sources are more significant in Metal products, Rubber & plastic, and Furniture, whereas private sources are uppermost in Apparel and in Publishing & printing. This variability reflects differing strategies for access to public funding in different industries, but it also points to the existence of huge gaps that must be filled by public policy if industrial R&D activities are to grow significantly.

Government programs to finance the purchase of plant and equipment stand out from the rest. BNDES, the national development bank, is responsible for the main programs, which reach a far larger number of firms. Other government initiatives that affect a smaller number include programs to foster partnerships between business and universities or public research institutions, as well as R&D funding programs. Public funding for R&D in ICT is also available under Law 10176 (2001), known as Lei de Informática, but this also has a narrower scope since it applies only to firms in the IT and telecommunications industries (Figure 7.27).

9. Internal sources consist basically of the firm's own funds, including tax incentives. External sources mainly comprise financing, loans and grants.

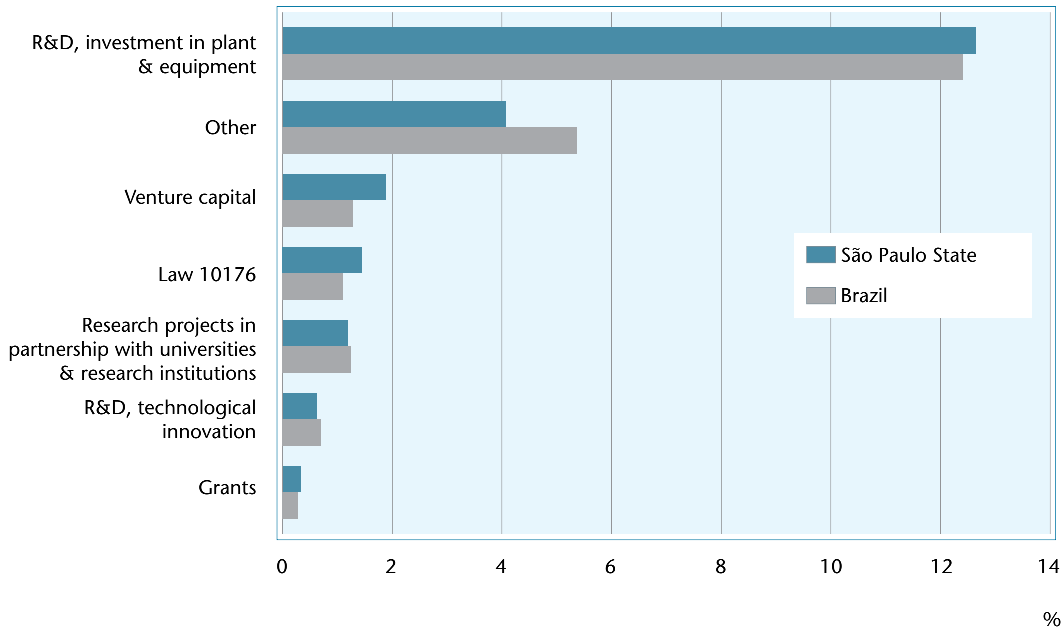
Figure 7.26
Funding for internal and external R&D in manufacturing, mining and selected segments of the service sector as % of spending on R&D – São Paulo State, 2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.25.

Figure 7.27
Innovative firms in manufacturing that received government support as % of all innovative firms by type of program – Brazil & São Paulo State, 2003-2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.26.

6. Economic impact of product innovations

Increased economic activity is the best measure of the effective impact of technological innovation. Because firms do not have specific accounting systems to capture the results of innovation, such measures are hard to obtain. The PINTEC survey findings include only data on the percentage share of revenue firms attribute to innovation in the period covered. Moreover, it collects such information only for product innovations, since the economic impact of process innovations is even harder to gauge.

Notwithstanding the above reservations, this chapter presents for the first time an indicator designed to quantify the impact of product innovation in terms of turnover from innovation as a percentage of net sales or exports.[9] Figure 7.28 presents the breakdown by sector for São Paulo State and Brazil.

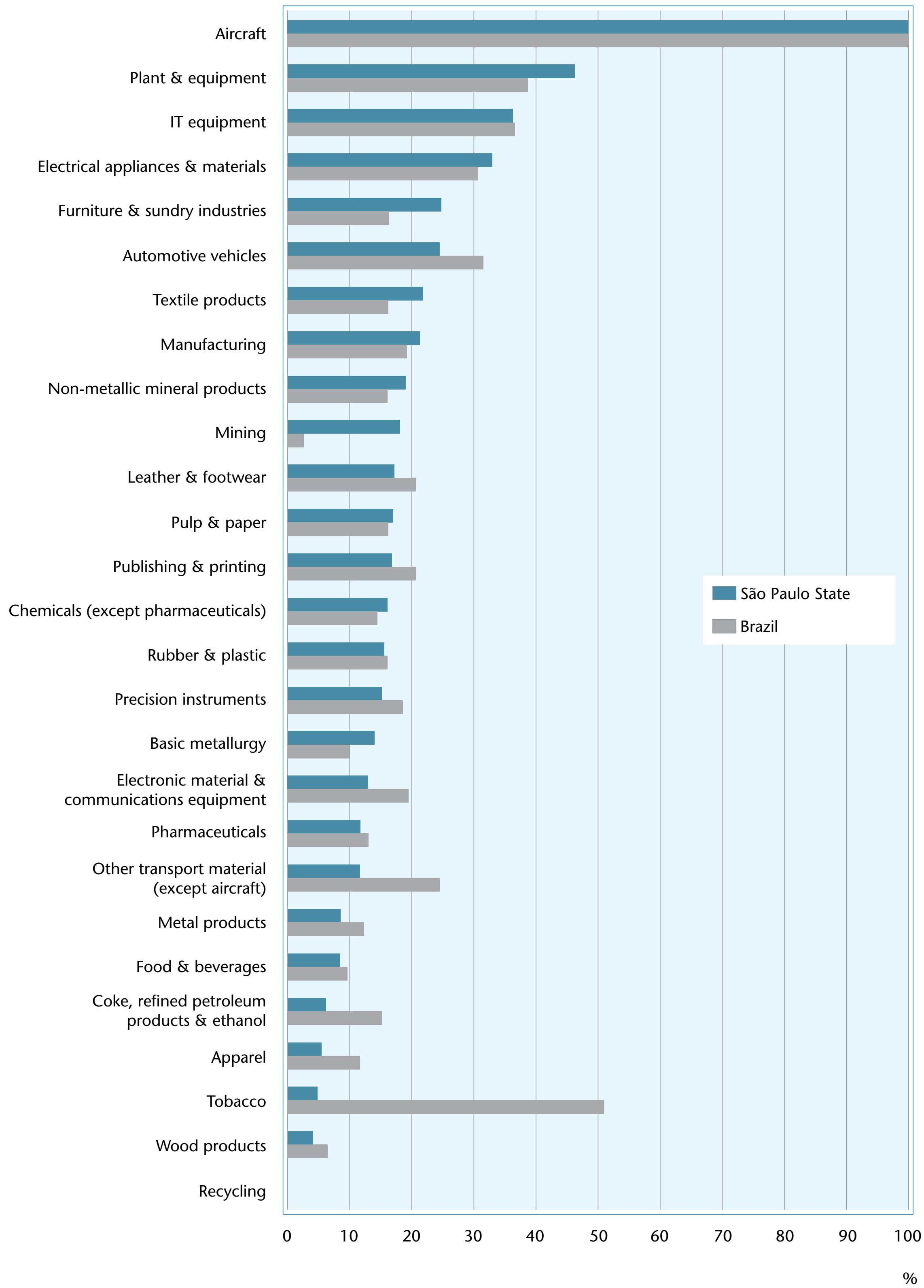
The manufacturing firms that responded to the PINTEC survey attributed 18.9% of net sales in 2005 to product innovations introduced between 2003 and 2005 (Detailed Table 7.1). This percentage points to a low product innovation rate in Brazilian industry, given that over 80% of sales by the firms surveyed came from products that were over three years old.[10]

Performance on this criterion varies significantly from one industry to another. The aircraft industry is the top performer in terms of the economic impact of product innovation. This is consistent with the high level of technological intensity in the Brazilian aircraft industry, and with the levels seen in the countries that

9. Calculated by IBGE multiplying each percentage cited by the firm's net sales, adding up all the responses and dividing the total by aggregate net sales for the industry concerned.

10. This figure (18.9%) matches the developed-country average, nonetheless. According to Eurostat, turnover from innovation in industry was 23.3% of total sales in Germany in 2004, 16.4% in France, 16.7% in the U.K., 11.5% in Italy and 15.4% in Spain. Available at: <http://epp.eurostat.ec.europa.eu/tgm/download.do?tab=table&plugin=0&language=en&pcode=tsdec340>. Last visited on June 7, 2009.

Figure 7.28
Total economic impact of product innovations in manufacturing and mining as % of all firms' sales – Brazil & São Paulo State, 2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.1.

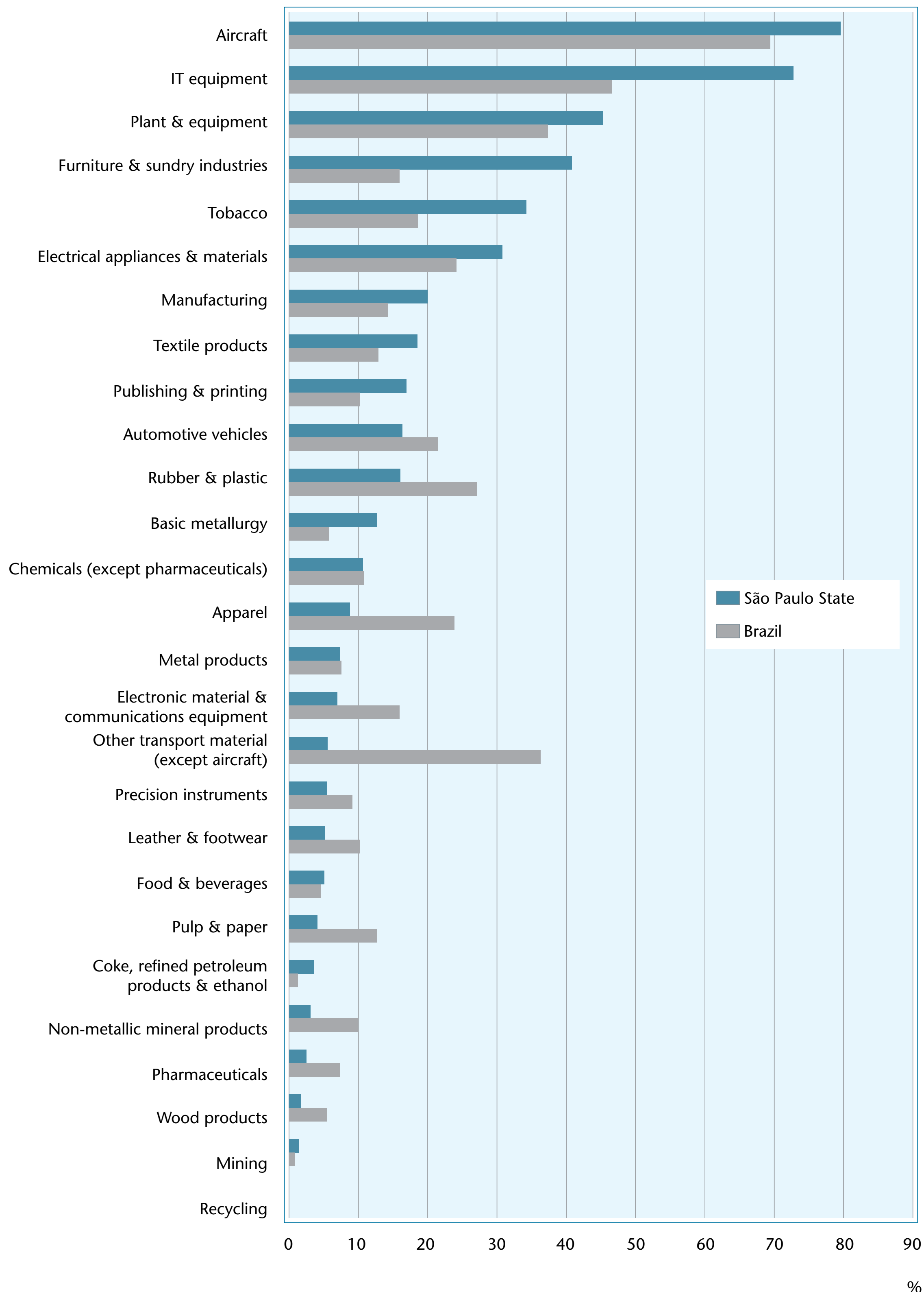
are global leaders. With the exception of Tobacco, the other industries that perform strongly in terms of the economic impact of product innovation are those that invest significantly in intramural R&D, especially Plant & equipment, IT equipment and Automotive vehicles.

São Paulo State does not differ from the rest of Brazil to a significant extent. Firms in the state attribute 21% of net sales to product innovation (Detailed Table 7.1); this is slightly higher than the national average. Differences between industries in the economic impact of innovation are similar to the differences in intramural R&D intensity. Sectors such as Other transport materials, Refined petroleum products and Tobacco, whose innovative activities are located outside the state, also report lower impact. The sole exception is the automotive industry, which concentrates innovation efforts in São Paulo State yet reports lower innovation impact on sales, probably because the oldest firms in this industry are located in the state. These firms have well-established markets and focus on introducing modifications to existing product lines. New entrants into the market for automotive vehicles, as well as auto parts suppliers based in other states, need more frequent product launches in order to compete with the incumbents. Thus there is not necessarily a direct correlation between intramural R&D intensity and product innovation, since all the new technology can be imported.

The impact of product innovation on exports behaves similarly, although it is proportionally smaller. Technologically new products account for only 14% of the value of the goods exported by manufacturers in Brazil (Detailed Table 7.1). These exports are actually of a conservative kind and mostly low-tech, although the percentages vary considerably across sectors. The top performers are relatively technology-intensive industries (Figure 7.29). Aircraft manufacturing comes first, with technologically new products accounting for almost 70% of exports, followed by IT equipment and Plant & equipment. Other less significant sectors such as Rubber & plastic and Apparel outperform the automotive industry in this measure. In the automotive industry, 21.3% of exports are high-tech. The percentages are even lower in high-tech sectors such as Electronic material & communications equipment (15.6%), and in Precision instruments (9%), where the pace of technological change is very fast. In these cases Brazilian industry's share of international markets is evidently due mainly to products that are obsolescent in those markets.

The impact of innovation on exports by industry in São Paulo State is almost 20%, well above the national average (Detailed Table 7.1), reflecting an entirely different situation. Almost all sectors in the state display a higher capacity to export technologically new products; the exceptions are those in which intramural R&D activities are mostly conducted outside the state, such as Other transport equipment except aircraft, and Apparel. However, once again it is clear from the data that important industries with substantial innovation efforts perform well below the national average in terms of the impact of innovation on efforts, especially Automotive vehicles, Electronic material & communications equipment, Precision instruments, and Rubber & plastic. These findings reflect the conservative bias of exports by these industries in São Paulo State.

Figure 7.29
Impact of product innovation on exports in manufacturing and mining as % of export revenue for all firms – Brazil & São Paulo State, 2005



Source: IBGE. PINTEC 2005.

Note: See Detailed Table 7.1.

7. Conclusions

The broad spectrum of technological innovation indicators discussed in this chapter provide a comprehensive overview of the performance of firms in manufacturing and some knowledge-intensive segments of the service sector in Brazil and São Paulo State.

IBGE's PINTEC innovation surveys have undoubtedly contributed to a far clearer and more precise understanding of the nature and dimensions of innovation activities in the various branches of the manufacturing industry and, with the 2005 edition of PINTEC, in knowledge-intensive services. The most important point is that the survey findings are produced in accordance with internationally accepted statistical and methodological principles, enabling comparisons to be made with other countries.

The chapter shows that the innovation rate for Brazilian industry, in the broad sense of new product and process technologies, is similar to those observed in certain developed countries. Nevertheless, it is very low in the case of products and processes that are new to the home market, suggesting that innovative firms in Brazil are mainly followers. According to this narrow definition, the Brazilian innovation rate lags far behind the European average.

The national average for Brazil, however, conceals sharp differences depending on firm size: the larger the firm, the higher the probability that it is innovative. The gap between large and small firms is clearer still when the criterion is innovation for the national market. In addition, large firms make much more use of patenting as a protection mechanism. These indicators show that technological innovation is a key factor for firms to remain market leaders.

The innovation rate for São Paulo State does not diverge significantly from the national average. However, the use of this indicator may mask some important differences that place industry in São Paulo more in evidence in the national context. The innovation rate surpasses the national average when the criterion for defining innovation is the home market. The same applies to the proportion of firms that use patenting to protect innovation and also when the indicator used is the intensity of intramural R&D. These elements point to a greater commitment by firms in São Paulo State to innovation efforts and their leadership of the innovation process on a national scale.

It can also be seen, however, that relatively few firms use patenting as a mechanism to protect intellectual property. Trademarks are by far the most frequently used protection mechanism, reflecting low technological content for most of the innovations introduced by business organizations.

The inclusion of knowledge-intensive services, mainly in telecommunications and IT, is an important advance, extending the coverage of innovation by business in PINTEC 2005. The information presented in this chapter shows that the behavior of these sectors closely resembles that of high-tech industries in terms of innovation rates and innovation effort. The most relevant distinguishing feature is perhaps greater propensity to cooperate and lower patenting rates in these sectors compared with the overall average for industry.

Multinational corporations are leaders of industrial R&D in Brazil, accounting for more than 44%, one of the highest proportions in the world. Their contribution is even higher in São Paulo State, exceeding 56%.

The relatively passive stance of industrial firms can be inferred from the low level of importance attributed by most firms to R&D in the innovation process. Few firms establish cooperative links with other firms or with universities and research institutions. The proportion is far smaller than in European countries. Acquisition of machinery is still the main innovation effort for firms in Brazil and São Paulo State, in contrast with firms in Europe, where these resources are concentrated in intramural R&D.

The indicator that best illustrates the structural differences between Brazilian industry and industry in the developed countries is the intensity of intramural R&D, measured in terms of the ratio of intramural R&D spending to value added. This is 1.5% for Brazilian industry and 2.1% for industry in São Paulo State, well below the OECD average, which is 7.7%. An analysis of sectoral R&D intensity rates shows that high-tech sectors lag furthest behind the developed-country average for these same sectors. The exception is the aircraft industry, where the Brazilian and OECD averages are roughly equivalent.

An analysis of the structure of intramural R&D spending by industry shows that the automotive industry is by far the leader, accounting for almost a quarter of industrial R&D in Brazil. The industry's contribution is even larger in São Paulo State, exceeding 30%. Three sectors are in fact responsible for almost half of all industrial research in Brazil: Automotive vehicles, Coke, refined petroleum products & ethanol, and Aircraft. Another noteworthy finding, which points to São Paulo State's leadership nationwide, is the concentration in this state of 54.8% of total industrial R&D spending.

Government support for innovation activity is still very limited in Brazil. The vast majority of business R&D activities are internally funded by firms themselves. In São Paulo State, the public sector accounts for only 2.8% of R&D funding. This limited presence of the public sector is reflected in relatively infrequent university-business cooperation.

Recent federal and state initiatives have helped create a more favorable environment for business innovation in Brazil. Laws were passed to stimulate innovation in 2004 and 2005 (Law 10973, known as Lei da Inovação, and Law 11196, known as Lei do Bem). The new legal framework includes federal grants for business R&D, as is already commonplace in the developed countries. The main missing element is the structuring of these resources through large-scale technological programs to channel innovation activities in industry around important national objectives determined by mutual agreement between business and society.

The new legal framework established by Law 10973 (Lei de Inovação) did not extend innovation development mechanisms to large S&T procurement programs, both civilian and military. Public-sector procurement continues to be governed by Law 8666 (1993), known as Lei de Licitações, which regulates government procurement at the federal, state and municipal levels and severely limits the capacity of the state to induce learning processes in firms with significant technological potential. In the developed countries, procurement policy is the main mechanism for the state to fund industrial R&D without obliging business organizations to become heavily indebted.

By furnishing a variety of data on business innovation, the PINTEC surveys represent an important instrument to support the formulation and enhancement of ST&I policy, including the mechanisms mentioned above. Extension to the service sector is an important advance. In the developed countries, the service sector's share of intramural R&D spending by private enterprise is growing. Coverage of knowledge-intensive services is only a first step towards more comprehensive data collection in the sector. On the other hand, it would be worthwhile in forthcoming rounds of PINTEC for IBGE to include only business organizations not covered by federal and state surveys of R&D spending. This precaution would avoid doubling counting in official R&D statistics and increase the relevance of these statistics in the study of business innovation.

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