Chapter 6

Technology balance of payments: a renewed perspective

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1. Introduction

The central idea that structures this chapter is a profile of the technological relations between Brazil and the rest of the world. It includes indicators for the flows of merchandise, services and intellectual property rights. As in all other chapters, the data and analysis are designed to focus on the participation of São Paulo State within the Brazilian context.

The chapter on this subject in the second edition of this publication (FAPESP, 2005) took the discussion forward while altering its scope compared with the first (FAPESP, 2002). For example, it analyzed international trade, enriching the discussion by situating Brazil in the global flow of technology. At the same time, however, while the 2002 edition investigated the technology balance of payments (TBP) and intellectual property (IP) in conjunction, the 2005 edition analyzed these two topics separately and in greater depth in two chapters, one on IP (Chapter 6), more specifically patents and other rights relating to intangibles (a term that seeks to capture the immaterial dimension by opposition to physical goods), and the other on the TBP (Chapter 7).

An understanding of trade relations (tangible or intangible) from the standpoint of technology absorption and payment flows between countries helps clarify the position of each country, state or region in the global hierarchy and world trade system. Net exporters of IP assets display a TBP surplus. The correlation between receipts from the sale of knowledge and payments for purchases may show the extent to which a country is a creator and seller of, or a user of and dependent upon, industrial technology and scientific knowledge applied to industrial activities beyond its borders. This has traditionally been the most widely adopted interpretation of the TBP.

This is not the only sense in which an analysis of a country's external relations from the standpoint of technology can be useful. No country can produce all the knowledge, science or technology needed by its production system and society for material and immaterial consumption. This is true even for the United States, with its unique S&T system and vigorous performance in scientific research and technological development, and a fortiori for countries that contribute marginally to world S&T production. A country that produces 1%-2% of world science measured in terms of publications (see Chapter 4) needs to be able to acquire and make appropriate use of the other 98%-99%. Analogously, a production system must be capable of using the technology produced, whether locally or abroad, as and when such use is relevant to its competitive strategy and for market penetration. A high-performance production system can both deploy existing technologies wherever they may be found and produce or induce production of the technology deemed appropriate to its needs. In this context, the TBP should capture the flows of technology between a given economy and the rest of the world in order to identify the ways in which domestic and foreign capabilities interact.

This edition's chapter on the TBP sets out to take this understanding forward once again. Whether a TBP is negative or positive should not necessarily be interpreted in the same manner as a conventional balance-of-payments surplus or deficit, according to which a surplus represents advantages and a deficit represents disadvantages. In the case of technology, imports may reflect a country's efforts to bolster the vigor of its industrial system and achieve a higher position in the international division of labor, while a TBP deficit need not necessarily be considered undesirable. The observable relations of technological interdependency between countries suggest that a country that does not import technology probably does not develop or export advanced technology. Japan and South Korea have systematically imported technology, and this imported technology has always played a highly active role in the design and assembly of their industrial and technological systems (Amsden, 1989; Kim, 1997).

Developed countries participate actively in world technology trade. Germany is an outstanding example: its imports and exports of technology services account for 2.1% of GDP and are relatively balanced (1.0% for imports and 1.1% for exports). Mexico has a trade deficit in technology (0.08% for imports and 0.01% for exports), but more importantly the volume of its total transactions in this area is very small (less than 0.1% of GDP) even when the difference in the size of the two economies is accounted for (Chart 6.1).

Chart 6.1 highlights the stark differences in the situations of different countries. Technology flows account for far more than 1% of GDP in some cases, and for far less in others. Japan, for example, has a surplus in technology services today (as well as a huge surplus in merchandise trade), even though it has imported technology intensely since the 1950s. This also appears to be true of Ireland, whose payments for foreign technology services account for almost 10% of GDP. The variety of cases and combinations shows that technology flows play different roles in countries' development models and in the functioning of their national systems.

The analysis of international trade presented in this chapter uses a classification based on criteria for measuring disembodied technology and the technology embodied in the goods traded between countries. Standard statistics for embodied technology come

Chart 6.1
Technology service flows for selected OECD countries by intensity and balance – 2000s

Intensity of technology service flows Net result	(receipts & payments, in % GDP)	
	High	Low
Surplus	Sweden (2.68 & 1.98)	France (0.29 & 0.18)
	Belgium (1.77 & 1.46)	Japan (0.40 & 0.14)
	Denmark (1.72 & 1.31)	USA (0.46 & 0.20)
Balanced	Norway (0.78 & 0.75)	Italy (0.24 & 0.26)
	Germany (1.14 & 1.01)	Australia (0.22 & 0.23)
Deficit	Ireland (0.29 & 9.71)	Mexico (0.01 & 0.08)
	Switzerland (2.05 & 2.21)	Slovakia (0.14 & 0.31)
	Hungary (1.43 & 2.21)	Poland (0.12 & 0.53)

Source: OECD (2007)

Note: 1. The original source used data for different years depending on availability.
2. Country classification: surpluses, deficits, balanced flows (i.e. surpluses or deficits close to zero) in technology service trade.
3. See Detailed Table 6.11.

from the Department of Trade (SECEX) at the Ministry of Development, Industry & Trade (MDIC) in the case of Brazil and São Paulo State, and from international organizations such as the United Nations Conference on Trade & Development (UNCTAD) for other countries.

Statistics for flows of payments and services relating to disembodied technology come from basic sources in Brazil, mainly the Central Bank and the National Industrial Property Institute (INPI). For international comparisons, the main data sources are the Organization for Economic Cooperation & Development (OECD) and various organizations that deal with intellectual property, such as the World Intellectual Property Organization (WIPO).

The analysis mentioned earlier uses data on the origins and destinations of merchandise trade and technology service flows, including technology transfer contracts, remittances and receipts both for Brazil and its trade partners and for São Paulo State. The focus again is on the relative positions of Brazil and São Paulo State with regard to international competitors and suppliers.

2. The TBP concept and some of its difficulties

The technology balance of payments (TBP) is analogous to the overall balance of payments inasmuch as both provide a systematic summary of economic transactions between an economy and the rest of the world. The TBP should quantify all transactions of a technological nature with other countries, as well as helping to understand the nature of the relations between countries based on their technological elements.

This apparently simple definition immediately raises conceptual and operational problems, starting with the restrictive qualification “of a technological nature”. A country trades with the rest of the world through flows of various types, several of which have significant technological dimensions. The most characteristic transaction in international trade relations of a technological nature is the purchase of knowledge, which when carried out by firms involves mainly specific and applied knowledge in the form of know-how. This is knowledge in intangible form, even when accompanied by explicit formalization, for example in the shape of manuals or plant and equipment.

Technological relations between a country and the rest of the world may also consist of contracts between firms, whether independent or part of larger business groups. Major corporations have foreign subsidiaries, and the relations established between parent companies and foreign branches involve technological transactions, which may be explicit and formalized or implicit and undeclared.

Foreign direct investment (FDI) may be in greenfield projects or via acquisitions. The former are usually associated with the transfer of specific knowledge and technological content. The latter may or may not have a significant technological dimension. Greenfield foreign investment may entail implementation and local adaptation of the investing firm's business model, but history shows that such adaptation is unlikely to make the local firm and its business autonomous with regard to the parent firm and all the intangibles transferred.

The foreign firm's business model determines how it deploys resources to achieve its objectives and often involves a specific use of technology. This includes its purchases of plants and equipment, physical inputs of all kinds, as well as brands, trademarks, licences and other intangibles usually transferred from the parent business. Thus FDI has a strong correlation with the TBP, even if the firms concerned do not literally invest in the items it tracks in accounting terms. FDI invariably entails exporting complete or partial technological packages. Firms also export and import goods and services, and like investments these vary in their technological dimensions. The goods and services in question may be high-technology or low-technology (or intermediate in terms of the intensity of their technology content). OECD defines categories of technology intensity based on R&D investment in proportion to sales, while the U.S. National Science Foundation (NSF) identifies key high-tech products and technologies, to take just two examples.

The second problem involves the operationalization of the concept, or restriction, comprised by the expression "of a technological nature". There is a gap between knowing what should be done and having the right statistics. In the not very distant past Brazil's system of accounts to book trade transactions with other countries sharply segregated its various components and strictly controlled these transactions, at least as far as the authorities' intentions were concerned. Payments could not be transferred between accounts that did not correspond to each of the transactions effectively performed. A firm's exports and imports of goods were booked to a merchandise trade account, whereas its service remittances and income had to be booked to a separate account specifically reserved for services. The authorities controlled these accounts and the related transactions strictly, or at least claimed to do so. Thus foreign firms were not allowed to pay royalties to their parent companies abroad for technology transfer, and to enforce this ban the law required all technology transfer agreements to be registered with and approved by INPI. Once this step was carried out, payments could be effected within certain limits and under Central Bank control.

However, firms could attempt to use their trade accounts to transfer payments pent up by INPI's and the Central Bank's coordinated controls, via underinvoicing of exports or overinvoicing of imports. SECEX (formerly known as CACEX) therefore set price floors for exports and price ceilings for imports. One control led to a need for more controls, in a process that seems impracticable today in external trade and financial relations, although it persists in other spheres, such as taxation. All these controls illustrate the perception that the various different accounts in the overall balance of payments and in the TBP are interconnected, and indeed substitutes for each other in several cases.

These controls were significantly relaxed in 1993, when the ministry issued Normative Act 120 (MDIC, 1993).[1] This measure was part of the process of liberalization of Brazil's trade, financial and technological relations with the rest of the world begun in the late 1980s and accelerated by the administration of President Fernando Collor de Mello. INPI now operates in a far less prescriptive manner, although officials say its efficacy has increased. Three years later Congress passed Law 9279 (Brazil, 1996) to change the regulatory framework for IP and abolished the ban on remit-

1. Article 4 of this ordinance (Ato Normativo 120/93) (MDIC, 1993) redefined INPI's role as follows: "In the process of registration governed by this Normative Act, INPI shall limit its analysis to verification of the status of licensed trademarks and patents in compliance with articles 30 and 90 of the Industrial Property Code, and to the provision of information regarding the tax deduction limits applicable under the tax and foreign-exchange legislation in force for the purposes of calculating income tax on and the remittability of contractual payments in foreign currency.

§1. INPI shall neither analyze nor require provisions in the acts or contracts covered hereby that do not specifically relate to the points set out in the main body of this article, including those referring to price, payment terms, type and conditions of technology transfer, contractual deadlines, use limitations, overlapping contract scopes, applicable legislation and competent jurisdiction, among others.

§2. INPI may not deny registration on the grounds of an alleged breach of the law on unfair competition, antitrust legislation or the law regarding abuse of economic power, consumer protection etc., although INPI may alert the parties to pertinent legal aspects" (Barbosa, 2002).

tances between foreign firms and their parent companies, among others that had been in force since 1970. As a result, payments relating to each item in the balance of payments can be made without the need for subterfuges.

Besides these institutional and legal issues, there are intrinsic elements to the relations among the various accounts in the balance of payments that cannot be circumvented however sinuous the accounting procedures adopted may be. A firm can choose between buying a machine and buying the technology and after-sales services it needs to develop an alternative to that machine. It can also choose between importing high-tech inputs or components and buying the technology and/or equipment to produce locally. In all such cases, comparing the different solutions is a problem in the real world, not just for accountants, and a priori no firm has sufficient objective elements for decision making in this area without randomness and risk taking.[2]

This raises a highly relevant difficulty for the understanding of TBP flows. It has two dimensions. The first relates to the choices made by firms, as the protagonists of the technological scene. An increase in Brazilian exports of goods with any technology intensity may be linked to a prior increase in imports of equipment, components and inputs, as well as technology services at a later stage. The more technology-intensive the goods or services to be produced (and exported), the more likely it will be that technical knowledge has to be imported to furnish a complete package of required capabilities and competencies. This imported knowledge may be intangible (technical assistance, patent licences etc.) and/or physical (equipment, inputs etc.).

The second dimension relates to time lags. An investment decision by a firm is a long-term commitment. The useful life of a piece of equipment may last many years and cover many production periods. The choice of technology that underlies this investment decision entails other choices, trajectories and commitments. The technology intensity of the goods produced by firms does not always determine the technical services and processes they use. A firm that decides to invest in the production of a fertilizer input in Brazil, for example, may assume favorable prospects for its business activities based on the growth of Brazilian agriculture. A low-tech input may nevertheless relate to a technological process that entails significant learning. A firm may acquire a complete factory on a turnkey basis, while another may develop a new technological process to produce the same goods. Efforts of similar magnitude and intensity helped produce the Brazilian firm which is currently a world leader in aircraft manufacturing, on one hand, and negligible results in other sectors also considered high-tech (such as electronics and pharmaceuticals) and the object of industrial policy, on the other, showing the considerable complexity of this process.

3. Problems in defining high, medium and low technology in the TBP

3.1 Embodied technology intensity

One of the main problems with the conventional definition of technology intensity in the context of world trade is the assumption that it can be applied universally. In effect, OECD defined these categories on the basis of the typical reality in its member countries and its classification has been gradually adopted by other countries, often without appropriate precautions.

The different degrees or levels of technology intensity defined by OECD relate to R&D investment or expenditure by firms in specific industries. Thus, for example, all pharmaceuticals are high-tech goods because OECD statistics aggregate all pharmaceutical firms regardless of whether they produce sophisticated drugs in terms of the underlying research and clinical trials or others for which the patents have long expired and which are widely sold like any other chemical commodity.

The world's best-selling branded pharmaceutical by value is Lipitor, produced by Pfizer (USA) as a drug for preventing cardiovascular disease. Sales of this product totalled US$ 13.6 billion in 2006. Lipitor was developed by other firms (Warner-Lambert and Yamanouchi). The licence to market the drug was obtained by Pfizer.

The success of this drug reflects not just the initial research but above all the firm's sales efforts. The greater its commercial success, the smaller will be the

2. Richard Nelson, whose first paper on this topic dates from 1959 and can be considered the founding contribution to the economics of technology, is well-grounded in knowledge and experience to make the following point: "The winners and losers are determined in an actual contest. Many contemporary modellers ignore this, treating technical advance as if it proceeded with much more accurate ex-ante calculation and before the contest agreement on winners than is the case... [S]uch models not only oversimplify, but fundamentally misstate, how technical advance proceeds under capitalism ..." (Nelson, 1990).

R&D/sales ratio. To put it another way, this method of calculating technology intensity (R&D divided by sales) can lead to an interpretation according to which the greater a product's success, the lower its technology intensity, and this does not seem reasonable.

Analogously, at the opposite extreme the low-tech category is said to include all goods that originate in primary production (mining, extraction and agriculture), in the food and drink industry, steel, textiles, apparel and footwear, regardless of any other considerations. Although the textile, apparel and footwear industries are classified as low-tech, there are cases of systematic efforts by these industries to create products with sophisticated properties – cases involving significant investment in terms of capital, human resources and technology.

Merely for the sake of illustration, it is worth citing the case of Speedo sports swimsuits, launched in 2008. The products caused considerable controversy in the sports world. They cost the consumer as much as US$ 500. The launch of a similar product by Mizuno forced a reduction in prices, but these garments will continue to cost far more than their weight in consumer electronics or desktop computers, to take only two examples. Another instance of a high-tech product belonging to a family of products classified as low-tech is Goretex waterproof boots, which sell for retail prices in the range of US$ 200 to US$ 300. In this case the final stage can be considered labor-intensive, but the product's components and materials have high-tech characteristics.

Some firms develop relatively sophisticated products that are eventually disseminated and sold more cheaply in response to pressure from competitive forces and patterns of organization in the industries to which they belong. From the standpoint of technology intensity, this means the efforts of some firms enable an entire industry to migrate to a higher technological level while also benefiting consumers.

The technological effort required to develop a product resembles capital investment in some respects. To develop an automotive vehicle, for example, it is necessary to have a certain amount of resources. The success or failure of the product in the marketplace will depend on many other circumstances aside from this investment. Whether the initial R&D investment increases or decreases relates only partially to the product's final market results and is by no means the only determinant of its success.

3.2 Electronics

Let us focus for a moment on the case of electronics. Did the production of appliances and consumer electronics, the last stage of which is booked in the TBP as production of electronic goods, migrate to Southeast Asia because of the abundant supply of technology there or merely because of the supply of cheap workers with nimble fingers and sharp eyesight? The design of these products is high-tech but their production almost exclusively involves simple assembly on production lines that are both low-cost and highly versatile (not least geographically). Electronic goods do of course contain high-tech components, but when the end-products come off the assembly line and are exported, their total value is booked as high-tech for TBP purposes, even if the exporting country has performed nothing other than final assembly, using imported parts, components, subassemblies and systems. In this case, assuming (radically) that all components are high-tech and imported, and that all end-products are exported, the exporting country will have a trade surplus in high-tech goods equivalent to the value added in the final assembly stage, whereas strictly speaking it should have neither a surplus nor a deficit in this category. The surplus corresponding to the difference between the total value of the imported components, parts, subassemblies and systems and the exported finished goods should be booked under the category of labor-intensive rather than technology-intensive products.

A crucial point in this argument is the need to distinguish between the concepts of technology-intensive activities and high-technology products. OECD's classification based on sectors and products ignores this difference, which can be important to many countries, such as Brazil, and has become important in all production chains made up of stages located in different parts of the world. Statistics based on the OECD classification may not capture real results in terms of product technology content, as they underestimate more traditional sectors in which technology-intensive activities take place and overestimate sectors that export high-tech goods dependent upon imports of inputs with a high degree of technological density and do little local development (such as cases of simple assembly and mixtures). Thus the more finished the exported products, the more misleading may become the interpretation of the TBP with regard to the product or sector concerned.[3]

3. In a hypothetical example, if the value of imported components amounts to 80 and the value added in assembly is 20, the goods produced will be worth 100. If they are all exported, the export value booked as high-tech goods will be 100, versus imports of 80, leaving a surplus of 20. Strictly speaking, however, the assembly stage is not high-tech, and the value added thereby, corresponding to 20, should not be booked under high-tech exports. Moreover, the material contents of the exported end-products were not produced locally and should therefore be excluded from the value of high-tech exports booked in the TBP. Thus, whereas the statistics show a high-tech surplus of 20, the actual result should be equal to zero.

3.3 Implications of the internationalized production system

The problem of product classification would not be especially important if industrial production were integrated at the country level, with exports mainly consisting of basic raw materials and finished goods. On the contrary, however, production is increasingly internalized, with different stages of the process taking place in different countries and regions, so that countries specialize in production stages rather than products. The prevalence of this process is greatest in "nomadic" industries, whose components "travel well" at low cost. Electronics and pharmaceuticals – and indeed all goods whose average value by unit weight or volume is high – "travel well" (with relatively low unit transport costs), and hence many foreign trade transactions may occur until all inputs and materials are embodied in their final form. They are therefore perfectly suited to a global production process, with different stages taking place in different countries and even continents. As a rule, the last stage, involving different degrees of manufacturing, may occur close to the final consumer. The electronics and pharmaceuticals industries are the most important exceptions to this rule.

The immediate consequence of this contemporary phenomenon is the obscuring of merchandise trade statistics. Distortions have always been possible, but while production was verticalized within national borders the scope for such distortions was limited. The advent of a globalized system of production chains with multiple fractures and spatially separated processes leads to a proliferation of localized problems, although these do not have the same intensity in all sectors.

It is evident that this problem particularly affects countries like Brazil. Local production of medical drugs is substantial, for example, but it is largely confined to the "assembly" (mixing) and packaging of imported active constituents. Some of these are indeed high-tech substances, produced under patent protection by firms that invest hundreds of millions of dollars in R&D (in all its various stages, from the discovery and development of substances to clinical trials). Many others, however, are chemical commodities whose competitiveness is strongly determined by production cost, whose production processes have long been in the public domain, and which are purchased by firms in India or China, or transferred to these and similar countries by pharmaceutical firms with dominant positions in the market for end-products. These products originated from an intense technological effort but have since been trivialized to become commonplace and not at all high-tech drugs. In many cases they are produced in a few locations for worldwide distribution; however, this is due not to their technological attributes but to cost-based competition in accordance with certain manufacturing patterns.[4] Concretely, the effect of this process on TBP statistics is that products and exports continue to be classed as high-tech even after they have become "commoditized" and their production has been transferred to low-cost countries. This transfer may lead to the creation of a manufacturing base and capabilities favoring the development of a high-tech industry. For now, booking these goods under high-tech production and/or exports is no more than a statistical mistake. A deeper critique of the use of technology intensity categories relates to the effects of spatial separation (by country) of the manufacturing and technological development functions, a separation that involves many technology-intensive industries. This point, which is effectively critical, is significantly attenuated by the more rigorous requirements of competitive manufacturing in sectors such as electronics and pharmaceuticals.

3.4 United States: leadership in science, industrial deficiencies, trade fragilities

The U.S. produces a quarter of world science (see Chapter 4) and its firms lead the world in patenting. If there are countries whose industrial sectors can be considered intensive in S&T and R&D, the U.S. is certainly one of them. Despite the immense importance of the U.S. in world S&T and R&D, it has had a persistent and growing trade deficit for over 30 years. The U.S. deficit averaged about US$ 750 billion per annum (or more than half Brazil's GDP) in the period 2005-07. The relations between S&T and R&D on one hand and production and exports on the other are complex, indirect and sinuous.

The automotive industry is a clear example. The major U.S. automotive manufacturers invest more in R&D than their Japanese peers, but their financial performance is poor and their market shares are being steadily eroded by the advance of competitors from other countries, especially Japan. Electronics also illustrates the argument. The U.S. practically invented electronics as an industrial activity, starting with the transistor, invented by Bell Labs in 1947. The U.S. is

4. According to Magalhães *et al.* (2003), "383 drugs accounted for US$1.2 billion of Brazil's imports of pharmaceuticals in 1997 (Silva, 1999, p. 37). Most had been patented in the second half of the 1960s. Most of the active constituents on the essential drugs list (Rename) had even older patents. It is worth noting that 83% of the total F.O.B. value of imported drugs in 1998 had original patents prior to 1977, and 47% were prior to 1962 (Silva, 1999, p. 49)."

the home of IBM, Microsoft, Dell and Google, and created all the other foundational elements of the world's electronics complex. Nevertheless, the U.S. electronics complex is in deficit.

Scientific relevance and even technological primacy may be only tenuously reflected by a country's trade figures. Conversely, countries with leading positions in world trade have not necessarily achieved such leadership solely or even chiefly by investing massively in technology. Just as Japan's cars and consumer electronics goods depend on a combination of technological factors and others of a more industrial and commercial nature, investment in technology may serve to bolster pre-existing advantages in agriculture for example (see Chapter 10).

3.5 The electronics industry in Brazil and its fragilities

The electronics complex is one of Brazil's most hotly debated industrial weaknesses. For historical reasons associated with policies to protect the domestic market and foster the development of a local industry in the 1980s, the topic remains highly controversial. Can the Brazilian electronics complex develop without manufacturing the basic components and inputs, such as chips? Is a semiconductor industry indispensable? Or would one be useful, but no more than that? In either case, would the cost of attracting such an industry be offset by the benefits? All these questions have been repeatedly raised in the debate during recent years, especially when the administration of President Lula introduced its first industrial policy.

The argument can be summarized as follows. An electronic components industry in Brazil requires two key drivers if it is to contribute to the nation's industrial development. One is widespread use of electronic components in many electronic and non-electronic products. To take an obvious example, cars have electronic components but are not classified as electronic products. The other is the elasticity of demand for electronic components, given that there are growing numbers of electronic products and products with electronic content, and that consumer goods and production processes generally require increasing amounts of electronics.

The Brazilian electronic components industry displays evident fragilities, which are synthesized in its trade balance. But do these fragilities extend to the industrial system, to the economy, to the public sector and to all other users of its products and services? The absence of a microelectronic components industry has not prevented the flourishing of products, solutions and business organizations with industrial and commercial capabilities in the field of electronics. The electronic voting machine is an example of a product/service that has generated economic, social and public benefits. A simple comparison with some countries that still use primitive voting systems in their elections, with extended, highly contested procedures for ballot counting, evidences these benefits intuitively. The same goes for many other products and services of social interest, such as the national health card and online filing of digital income tax returns. In the private sector and business world, the fragility of the basic structures of the electronics complex has not prevented the emergence of robust industrial and commercial automation processes led by domestic firms with high-tech capabilities and innovative products.

Software is now more important than hardware in electronics: "Most of the equipment used in this segment [bank automation] comprises computer networks that have become commodities. Software is the heart and soul of bank automation, although it goes practically unnoticed by users of the financial system. New programs and applications can be installed in terminals in operation and drive the sector without requiring significant hardware changes. According to a study by SOFTEX (2006), 'the emphasis in banking automation has shifted from hardware to software, although the development of both is complementary'".

In contrast with the pharmaceutical industry, where innovation is a core dimension and occurs well before active constituents are produced on an industrial scale, electronic and digital products and services are increasingly a basic support for the development of innovative solutions.

Indeed, it is curious that the aircraft industry, which accounts for most of Brazil's exports of high-tech goods, is not universally perceived as an example that local production of the inputs for high-tech industries is indispensable so that these goods can be produced competitively. Are not the aircraft Brazil exports themselves a demonstration that it is possible to constitute and permanently develop the technological intelligence and capacity to innovate in a product or product group based on the last link in the chain without necessarily demanding local production of every single component? Embraer, the most frequently cited example of a Brazilian high-tech industry, exports aircraft that it designs and assembles using imported components, parts, modules and systems. In 2007 its exports totalled US$ 4.7 billion, surpassing imports of US$ 2.9 billion (ranking second close behind Petrobras). Does this reduce its importance? Most analysts would agree there is no alternative, and many would even say the strategic partners who develop and manufacture aircraft modules are a key ingredient in the recipe for Embraer's success. In other words, Embraer's imports represent a major constituent of its industrial model and its competitive position in the global marketplace.

Why does the principle that applies to Embraer not apply to the electronics industry? Indeed, why cannot all of Brazil's industry and services, including service providers dedicated to mining and agriculture as well as manufacturing, develop technologically vigorous and affirmatively innovative solutions, above all with intelligent design, and equally making use of imported inputs and components?

An indigenous electronics industry could be advantageous for the Brazilian trade balance and an important driver of the development of competencies and qualifications, as well as sowing richer solutions in the already fertile soil of local S&T and the productive system generally, although pursuing such an ambitious goal without adequate means would be imprudently costly.

3.6 Oil & gas

At the other end of the technology spectrum, the oil & gas sector is considered "medium-low tech": the top global companies in the sector invest only 0.3% of sales in R&D (DTI, 2006). Some oil companies, of course, are also manufacturers of petrochemicals and invest more significantly in this downstream segment of the supply chain, but the oil industry proper, as correctly delimited, is considered medium-low tech by the OECD. By extension, and for the sake of immediate comparability, our statistics follow the OECD classification.

Petrobras explores for and produces oil under very special conditions. Persevering despite scepticism, it found oil in the ocean and at greater depths than other countries that had the good fortune to find it onshore or at lesser depths offshore. The geological accident became actual wealth only because of heavy investment made over a very long period starting in the 1970s and intensifying in the 1990s. Now that Petrobras produces millions of barrels per day, the company's past and present technological investments can be considered modest given the volume produced (the ratio of R&D investment to sales is low because the numerator created in the past is small in relation to the currently large denominator); hence its classification as medium-low tech. On the other hand, its R&D investment is more than three times that of the world's other oil majors in proportion to GDP (EC, 2007). Its workforce includes several thousand engineers and technicians with university degrees, some dedicated to research proper, others to development. According to its website, its Research Center has some 1,500 researchers, of whom 300 have a master's degree or PhD. By comparison, it is worth noting that no Brazilian pharmaceutical company, and very likely no Brazilian electronics company, has such a large well-qualified workforce.

This has important consequences for the technological relations between Brazil and the rest of the world. The merchandise trade dimension of the technology balance of payments (TBP), which reflects imports and exports of goods, consists mainly of low-tech commodities in the case of oil. The reality is different, however. Strictly speaking, it can be argued that Brazil imports a commodity called petroleum and exports a product whose production process required the development and deployment of technological content extracted from the depths of the ocean. In terms of engineer-hours and knowledge, the content of this product that Brazil uses and exports is far greater than that of the products it imports in the sector. Nature has made Brazilian oil difficult to extract and hence relatively costly. Productivity in the oil sector is much lower in Brazil than in the really oil-rich countries, but thanks to this deficiency many related activities and knowledge areas have had to be developed. This is why oil, which elsewhere may be sterile, has fertilized the production system and proved a source of wealth in Brazil.

3.7 Technology intensity of an economy, a sector, a company

Two elements determine the total technology content of an economy's output. One is the intensity of the technology used in each economic sector. The other is the overall composition of the economy's output, i.e. the variety of sectors and the weight of each one in total GDP. Switzerland's pharmaceutical industry is highly qualified in terms of S&T strongly competitive on a global scale. Its weight in GDP is considerable, and this communicates with the technology intensity of the Swiss economy in two ways – via the intensity of pharmaceutical R&D and via the industry's overall importance to the national economy. The Japanese electronics industry is also of great significance to the economy and is made up of several companies that invest heavily in R&D. Thus the above formulation for Switzerland also applies to Japan. Both exemplify specialization with two mutually reinforcing connotations that determine an important contribution to total R&D investment in the respective economies, via the strong presence of high-tech sectors that account for a large proportion of GDP and the presence within these sectors of firms with a significant share of national R&D investment.

The Swiss pharmaceutical industry and the Japanese electronics industry enjoy major competitive advantages and also display significant fragilities in many countries, including Brazil. These two manufacturing industries' contribution to the technology intensity of the Brazilian economy is relatively small, despite the efforts made by various policies under several administrations. Can this situation be changed? Evidently it can, but only in the long run, by many governments, and depending more on the development of competencies in the design and creation of new products and processes than mere internalization of the production of inputs, components and parts. For now, the contribution of these industries to the economy's technology intensity is modest compared with the same industries' contribution to the economies of other countries. In light of this observation, the classification based on the OECD's official statistics can be relativized by saying that most products and firms in the electronics and pharmaceutical industries in Brazil are medium-low tech. In the case of electronics, the same applies to product assembly operations in many Asian countries.

This does not mean the industries concerned cannot or do not contribute effectively to Brazilian development and to the technological evolution of the industrial system. Brazil can hardly compete in the world market for innovative mass-market consumer electronics products, such as the iPod or digital camera. It has the capabilities to develop innovative products with the potential for global commercialization – the electronic voting machine is the best-known example of such opportunities (in this case now lost). But the main opportunity offered by an industry like electronics to Brazilian development is linked to the design and production of solutions appropriate to Brazilian needs, in terms of the typically Brazilian pattern of consumption and above all those defined by the articulation of the demands of the country's production and social systems. Onboard electronics in Brazilian satellites, retail sales and financial automation, automation systems in process industries of all kinds – these are some of the contributions made by Brazilian electronics to national development, albeit without overcoming the limitation of not having an electronics base analogous to that of industrial mechanical systems, endowed with diversity, articulation and integration.

Can the lack of an integrated electronics or pharmaceutical industry in Brazil, including intangible foundations and tangible production, be offset by technological and innovative dynamism in other activities? The answer involves a clear distinction between technology efforts and technology intensity, i.e. between the total volume of the efforts expended and the relative intensity of these efforts compared with the basis for their application.

Technology efforts, like any investment, yield deferred returns. The lag between expenditure and results varies, but in pharmaceuticals it can be as long as ten years for a genuinely innovative substance, while the electronics industry launches a new chip every three years, typically requiring construction of a dedicated plant. Long cycles, such as those noted for pharmaceuticals, are also typical for many primary products. For example, the development of a new variety of sugarcane takes about ten years.

The higher the research investment required by an industry, firm or product, the greater both the risk involved and the possibility of achieving superior results. Moreover, the greater the production base to dilute and amortize a given research effort, the greater the potential profit and the smaller the relative effort. Thus when two pharmaceutical companies merge and "rationalize" their research efforts by eliminating overlaps, they can become more efficient and effective in their development and innovation activities with relatively less effort.

What matters most is results rather than effort in terms of the impact on expansion and competitiveness in an economy driven by technological development and innovation. Any technology effort is associated with the creation of competencies, the use of skilled labor, the renewal of capabilities and the deployment of development and innovation capacity in more advanced positions on the knowledge frontier. However, in absolute terms the larger the amortization base (i.e. the lower the intensity) the more profitable will be the effort that mobilizes all these elements. Two firms that make the same effort in the sense of devoting the same amount of resources to technological activities in absolute terms may achieve different results if one can produce and market on a global scale while the other can do so only domestically or regionally.

3.8 Technology efforts in Brazil

Technology efforts are significant in only a few Brazilian industries, as evidenced by the discussion in Chapters 3, 5 and 7 of this publication. Few large firms have numerous and consistent research teams. Most small and medium firms display little or no interest in R&D. This applies even to industries in which R&D intensity is typically intense, such as electronics and pharmaceuticals (Table 6.1). Electronics firms have specific incentives and institutional apparatuses that enable them to maintain a certain level of R&D, whereas even the largest pharmaceutical firms in Brazil do very little local R&D, which is mostly based on project-specific or sporadic cooperation with universities.

A comparison between these two high-tech industries and low- or medium-low tech sectors such as mining or agriculture, for example, highlights interesting points that help define the contours of the problem. In absolute terms, the technology effort of the farming and livestock sectors in Brazil is much greater than that of the pharmaceutical industry. In terms of the number of people employed by pharmaceutical firms in in-house R&D, the industry ranks well below many of those clas-

Table 6.1
In-house R&D staffing at innovative firms in high-tech industries (1) by level of qualification – Brazil, 2005

Level of qualification High-tech industries	Total		Post-graduate degrees		Undergraduate degrees	
	No. of people	%	No. of people	%	No. of people	%
Manufacturing	**27,425**	**100.0**	**4,280**	**100.0**	**23,145**	**100.0**
Total all five industries	**5,793**	**21.1**	**719**	**16.8**	**5,074**	**21.9**
Pharmaceuticals	950	3.5	172	4.0	778	3.4
Office machinery & computer equipment	1,007	3.7	83	1.9	924	4.0
Electronics material & communications equip.	1,918	7.0	232	5.4	1,686	7.3
Basic electronics material	209	0.8	8	0.2	201	0.9
Communications equipment & apparatus	1,709	6.2	224	5.2	1,485	6.4
Other transport equipment (aircraft)	2,312	8.4	290	6.8	2,023	8.7

Source: IBGE. PINTEC 2005.

(1) According to the OECD classification.

sified as low-tech. There are as many employees with post-graduate degrees in basic steel manufacturing R&D as in pharmaceuticals R&D, for example.

4. Trade in goods with embodied technology: concept and measurement

This section begins with an analysis of the international trade statistics from the angle of embodied technology and moves on to discuss the results for Brazil and São Paulo State between 2003[5] and 2007. The focus is on continuity with previous series (FAPESP, 2002, 2005), while at the same time emphasising the new perspective proposed in this chapter. São Paulo State is highlighted both because of its role as the rationale for this publication and because the state contributes significantly to Brazil's performance. The dynamism of São Paulo's production chains and their integration with Brazil's help explain the behavior of several of the variables observed.

The statistics for the Brazilian and São Paulo State trade balances are presented in accordance with the technology content classification[6] used in the previous two editions of this publication (FAPESP, 2002, 2005), which adopted a commodity trade pattern (CTP) based on Pavitt's taxonomy (Pavitt, 1984). Products are grouped into three categories according to technology content using this classification and the concept of "average value" defined as dollar value divided by weight in kilograms, a reasonably good proxy for embodied technology.[7] Products were typified as

5. The year 2003 may not be a good basis for comparison with the results for 2007 because the values associated with the former are lower than for the latter. However, base year 2003 is important to assure continuity with the series analyzed in previous editions of this publication.

6. Primary agricultural goods (PAG); Primary mineral goods (PMG); Primary energy goods (PEG); Agrifood industry (AI); Industry intensive in other agricultural resources (IIOAR); Mineral-intensive industry (MII); Energy-intensive industry (EII); Labor-intensive industry (LII); Scale-intensive industry (SII); Specialist suppliers (SS); R&D-intensive industry (R&DII); Not classified (NC).

7. Average value can be an adequate indicator of technology content or embodied technology, but it may be problematical in the case of goods that have high unit values but relatively little weight without this necessarily relating to value added or technology content. Traditionally this issue is exemplified by precious stones, but it also applies to parts or other items across a range of different production chains (e.g. some kinds of metal and articles of apparel such as hosiery). The idea is that the higher the average value, the greater the value added per kilo, suggesting a correspondence with goods that have higher technology content. This concept was discussed at length in previous editions (FAPESP, 2002, 2005).

high-tech, medium-tech and low-tech on this basis as a first step in the analysis of trade flows for Brazil and São Paulo State with groups of partner countries selected according to the degree of development. More details of this procedure are given in the Methodological Annex.

The findings presented below accord with international technology classification standards and thus may not always match the actual level of technology intensity in the Brazilian case. The reader is strongly advised to take into account the comments made in the initial sections of this chapter for a more critical interpretation.

5. Overview of international trade in goods with embodied technology

All countries play a role in international trade, some adding substantial value to the goods they produce, others occupying marginal positions as suppliers of abundant cheap labor for use in labor-intensive production or merely exporting natural resources. Is this all the less developed countries (LDCs) contribute or do they have more to offer the world? One of the central arguments presented in this chapter is that trade classifications should be revised so as more accurately to distinguish between low-tech, medium-tech and high-tech goods by taking into account the technology effort underlying their production.

This section summarizes the embodied technology trade statistics for selected countries in the recent past, both as a counterpoint to the analysis of trade by Brazil and São Paulo State and as an aid in understanding the increasingly conspicuous role of LDCs. More such statistics are provided in the Detailed Tables for this chapter.

The technology question has always been very much bound up with the discussion of exports by LDCs in the last two decades. Historically speaking, LDCs have been mainly exporters of primary goods and importers of value-added goods produced or traded by developed countries (DCs).

World economic changes in the last quarter of the 20th century led to different trade dynamics for some LDCs, heightening the importance of technology content. The patterns of international distribution and the "centralized dispersion"[8] of industrial activities in some countries and regions around the world have contributed to this process.

Whereas in the past DCs accounted for most of the manufactured goods produced worldwide, the pendulum has increasingly swung towards LDCs. Thus in the new geography of production, the countries and regions that used to lie outside the high value-added or high-tech production circuit now have their own space shaped in accordance with global restructuring and production rationalization strategies.

Empirical evidence for this argument can be found in the global export statistics for DCs and LDCs[9] broken down by level of skill and technology intensity (Figure 6.1). The percentage of exports by LDCs traditionally classified as primary goods with low technology intensity can be seen to have decreased compared with exports that embody more technology. This rise in the technology intensity of LDC exports has taken place concurrently with a fall in the share of DCs in these segments, where the latter historically predominated.

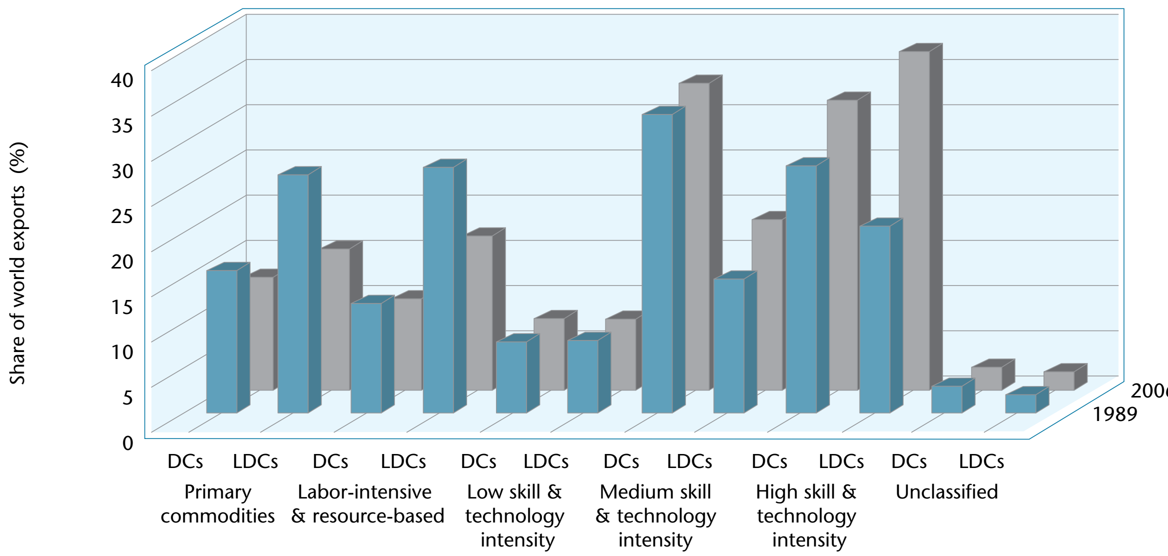
DCs that played an important foundational role in industrial development, such as the U.S., France and the U.K., have growing trade deficits, while South Korea, Indonesia and China have large and growing annual surpluses. This in itself helps explain some of the above observations on the changing profile of international trade.

An analysis of product shares in exports and imports based on technology content shows that the U.S. has a deficit in all such categories. Nevertheless, high-tech products account for a larger proportion of its exports than of its imports. The same applies to the U.K., and to France, Germany and Japan with regard to medium-tech goods as well. On the other hand, high-tech imports by Spain and Canada account

8. Ernst (1999) uses the concept of "concentrated dispersion" to show that technological activities have crossed the borders, the geography, of the triad (the U.S., E.U. and Japan). They have moved above all to Southeast Asia, which points to a process of "selective integration" into global production networks. International integration has increased and become more complex but in an uneven and asymmetric manner.

9. DCs include members of NAFTA, the E.U., Japan, Hong Kong, and the Asian newly industrialized countries (NICs) South Korea, Taiwan and Singapore. The rest of the world, divided into six other groups of countries, includes the following LDCs: Mercosur, Latin America & Caribbean, Rest of Europe, Rest of Asia, Africa, and Middle East. Although China is classified as Rest of Asia, it features individually in the tables because of its increasing importance in international economic relations.

Figure 6.1
World exports by level of skill and technology intensity – developed countries (DCs) and less developed countries (LDCs), 1989 & 2006



Source: Rodrigues (2008), based on UNCTAD aggregation (Comtrade).

Note: See Detailed Table 6.1.

for a larger proportion of the total than high-tech exports (Table 6.2).

China, India, Mexico and Brazil all have high-tech deficits. This reinforces the comments made above on the restructuring of international production, the changes in production in DCs and the impacts of all this on the pattern of world trade relations.

The fact that Mexico has a surplus only in the low-tech category, for example, points to its low capacity to respond to technological issues. But how far does this kind of statistical finding genuinely represent a country's capabilities in terms of the technology used or embodied in exports? Is China's success a reflection only of the technology created and developed in China or is it also the outcome of broader and more complex international relations with regard to the acquisition and capacity to use knowledge and technology?

High-tech exports by the U.S. rose US$ 83.5 billion between 2002 and 2005, while its high-tech imports rose US$ 124 billion. At the same time, China's high-tech exports rose US$ 194.4 billion, while its high-tech imports rose US$ 178.7 billion (Detailed Tables 6.2 and 6.3). These numbers reflect the differences between two economic superpowers in high-tech trade. To date, however, China's growing importance as a leading global supplier of high-tech goods and America's persistent deficit has not dislodged the U.S. from pole position among the world's major centers of S&T.

In the case of Brazil, medium-tech exports increased US$ 37.3 billion in 2002-05, while medium-tech imports increased US$ 10.6 billion, evidencing the importance of this technology category (which includes primary agricultural and agroindustrial goods) to the significant growth of Brazilian exports in recent years.[10]

Furthermore, differences in the level of technology embodied in products are typically analyzed in terms of average value or price per unit weight, as a proxy for technology content. The above findings for U.S. imports can be confirmed using this method, which shows that the average value of U.S. high-tech imports is consistently far higher than that of its high-tech exports (Table 6.3). Thus the question is again raised as to whether

10. Of course, the rise in international commodity prices seen in the 2000s contributed to this strong performance by Brazilian exports.

Table 6.2
Merchandise trade balance by level of technology content – Brazil & selected countries, 2002-2005

Level of technology content	Merchandise trade balance by country (US$ billion)	
	2002	2005
USA	**-511.1**	**-827.6**
High technology	-17.2	-57.7
Medium technology	-375.7	-492.0
Low technology	-118.2	-277.9
U.K.	**-62.5**	**-131.5**
High technology	10.3	6.3
Medium technology	-80.0	-128.6
Low technology	7.2	-9.2
Spain	**-40.1**	**-96.9**
High technology	-18.2	-32.4
Medium technology	-6.4	-30.1
Low technology	-15.5	-34.4
France	**-5.1**	**-49.7**
High technology	20.4	22.2
Medium technology	-4.0	-24.4
Low technology	-21.5	-47.5
India	**-8.8**	**-46.5**
High technology	-6.9	-22.6
Medium technology	12.8	8.9
Low technology	-14.7	-32.8
Poland	**-14.9**	**-12.2**
High technology	-9.4	-11.9
Medium technology	-2.1	7.4
Low technology	-3.4	-7.7
Mexico	**-8.0**	**-7.8**
High technology	-11.8	-19.5
Medium technology	-5.5	-7.6
Low technology	9.3	19.3
Italy	**7.6**	**1.1**
High technology	17.9	30.7
Medium technology	9.1	6.1
Low technology	-19.4	-35.7

(CONTINUED ON NEXT PAGE)

Table 6.2 (continued)
Merchandise trade balance by level of technology content – Brazil & selected countries, 2002-2005

Level of technology content	Merchandise trade balance by country (US$ billion)	
	2002	2005
Argentina	**16.8**	**11.3**
High technology	-1.3	-7.9
Medium technology	13.9	13.9
Low technology	4.2	5.3
South Korea	**10.2**	**23.1**
High technology	10.0	30.1
Medium technology	29.0	51.1
Low technology	-28.8	-58.1
Indonesia	**25.9**	**27.9**
High technology	-0.1	-2.5
Medium technology	17.2	20.5
Low technology	8.8	9.9
Brazil	**10.7**	**39.7**
High technology	-9.6	-9.4
Medium technology	21.6	48.3
Low technology	-1.3	0.8
Canada	**30.2**	**45.6**
High technology	-29.9	-39.4
Medium technology	38.3	38.1
Low technology	21.8	46.9
Japan	**79.1**	**79.0**
High technology	92.5	133.3
Medium technology	59.6	91.6
Low technology	-73.0	-145.9
China	**30.5**	**102.0**
High technology	-39.1	-23.4
Medium technology	85.6	201.3
Low technology	-16.0	-75.9
Germany	**117.7**	**200.2**
High technology	70.0	130.9
Medium technology	81.5	140.0
Low technology	-33.8	-70.7

Source: ITC, PC-TAS 2001-2005.

Note: 1. Trade balances are calculated as the difference between exports and imports by level of technology content and trade partner for the period concerned.
2. See Detailed Tables 6.2 and 6.3.

Table 6.3
Average value of merchandise exports and imports by level of technology content – Brazil & selected countries, 2002 & 2005

Level of technology content	Average value by country (US$)			
	Exports		Imports	
	2002	2005	2002	2005
USA				
High technology	43.17	26.08	66.78	33.28
Medium technology	1.26	1.34	2.84	0.80
Low technology	0.39	0.17	0.24	0.23
U.K.				
High technology	18.46	18.19	13.75	14.76
Medium technology	2.35	3.17	1.93	3.02
Low technology	0.22	0.44	0.20	0.35
Spain				
High technology	5.57	8.33	9.76	13.44
Medium technology	1.59	2.12	1.08	1.54
Low technology	0.16	0.31	0.14	0.28
France				
High technology	13.53	17.17	11.22	14.51
Medium technology	1.32	1.76	1.52	2.03
Low technology	0.23	0.14	0.18	0.27
India				
High technology	1.96	8.15	0.04	28.32
Medium technology	0.99	1.41	0.77	1.20
Low technology	0.15	0.57	0.21	0.35
Poland				
High technology	4.41	6.05	6.66	9.33
Medium technology	1.00	1.56	1.16	1.43
Low technology	0.06	0.11	0.13	0.26
Mexico				
High technology	0.74	11.71	0.10	11.77
Medium technology	0.45	1.51	0.08	0.70
Low technology	0.14	0.26	0.11	0.27
Italy				
High technology	8.64	11.11	12.13	15.23
Medium technology	2.12	2.79	1.33	1.74
Low technology	0.18	0.38	0.15	0.28

(CONTINUED ON NEXT PAGE)

Table 6.3 (continued)
Average value of merchandise exports and imports by level of technology content – Brazil & selected countries, 2002 & 2005

	Average value by country (US$)			
	Exports		Imports	
	2002	2005	2002	2005
Argentina				
High technology	4.59	4.24	8.26	10.53
Medium technology	0.31	0.37	1.02	1.62
Low technology	0.18	0.35	0.09	0.16
South Korea				
High technology	14.74	20.70	19.15	24.62
Medium technology	1.44	2.00	0.68	0.99
Low technology	0.21	0.43	0.13	0.25
Indonesia				
High technology	4.86	4.57	4.72	5.93
Medium technology	0.75	0.92	0.50	0.69
Low technology	0.09	0.14	0.19	0.42
Brazil				
High technology	6.9	14.9	15.2	21.0
Medium technology	0.5	1.1	0.6	1.1
Low technology	0.0	0.2	0.1	0.4
Canada				
High technology	47.70	19.58	37.56	21.36
Medium technology	1.30	1.32	2.50	1.82
Low technology	0.20	0.27	0.14	0.19
Japan				
High technology	23.42	26.18	13.94	10.81
Medium technology	2.32	0.69	1.35	1.30
Low technology	0.14	0.15	0.12	0.08
China				
High technology	11.30	15.67	18.89	26.14
Medium technology	0.07	0.19	0.10	0.20
Low technology	0.00	0.00	0.04	0.12
Germany				
High technology	11.99	16.29	13.02	18.20
Medium technology	1.74	2.56	1.58	2.37
Low technology	0.13	0.24	0.13	0.27

Source: ITC, PC-TAS 2001-2005.

the U.S. can remain a major power in the technology arena while importing goods at higher average prices than those of its exports.

For Japan, France and the U.K., the average price of high-tech exports is higher than that of imports in each case, in contrast with Germany, Italy, China, South Korea, Poland, Spain and Brazil, as well as India and Indonesia in 2005.

Lastly, an analysis of the trade statistics for these countries based on the classifications used may be insufficient for an accurate understanding of the factors that influence each country's performance, particularly the terms of trade and the distribution of production activities around the globe. Nevertheless, and indeed perhaps precisely for this reason, it helps draw attention to the underlying issues relating to technology, marketing and other variables that add value to exported goods.

The above discussion of a small but significant set of countries points to a number of possible errors and traps into which analysts may fall when examining trade statistics in isolation. The trade statistics for Brazil and São Paulo State presented in what follows comply with the classification of technology content used throughout this chapter but should be analyzed in light of the questions and considerations expounded above.

6. Patterns of trade in goods with embodied technology by Brazil and São Paulo State

The statistical analysis presented in this chapter takes into consideration the level of technology embodied in exports and imports, but this cannot be dissociated from the economic reality in which trade is transacted, since international merchandise trade statistics also indicate or even reflect the behavior of domestic productive structures. Without doubt Brazil's trade performance is strongly influenced by the global structure of production and trade.

The Brazilian economy underwent highly significant changes in the first decade of the new millennium. It has consistently produced a merchandise trade surplus since 2001, with a lag following currency devaluation in 1999. Between 2011 and 2007, exports grew 18.4% per year while imports rose 13.8% per year. This shows the importance of the period for Brazil's growing participation in international trade and the integration of its economy with the rest of the world.

The trade surplus reached US$ 25 billion in 2003, almost double the 2002 value, and US$ 46 billion in 2006: this is the largest surplus for the period analyzed here (Detailed Tables 6.5, 6.6 and 6.7). This strong growth realigned Brazil's trade pattern and strengthened its exporters, owing to rising international demand and commodity prices, a favorable exchange rate, and growing global integration, as already mentioned.

Analyzing international trade from the perspective of embodied technology can contribute to more precise conclusions on the direction taken by Brazil and São Paulo State in this context. The trade indicators presented in this section highlight the results obtained for the period 2003-07.

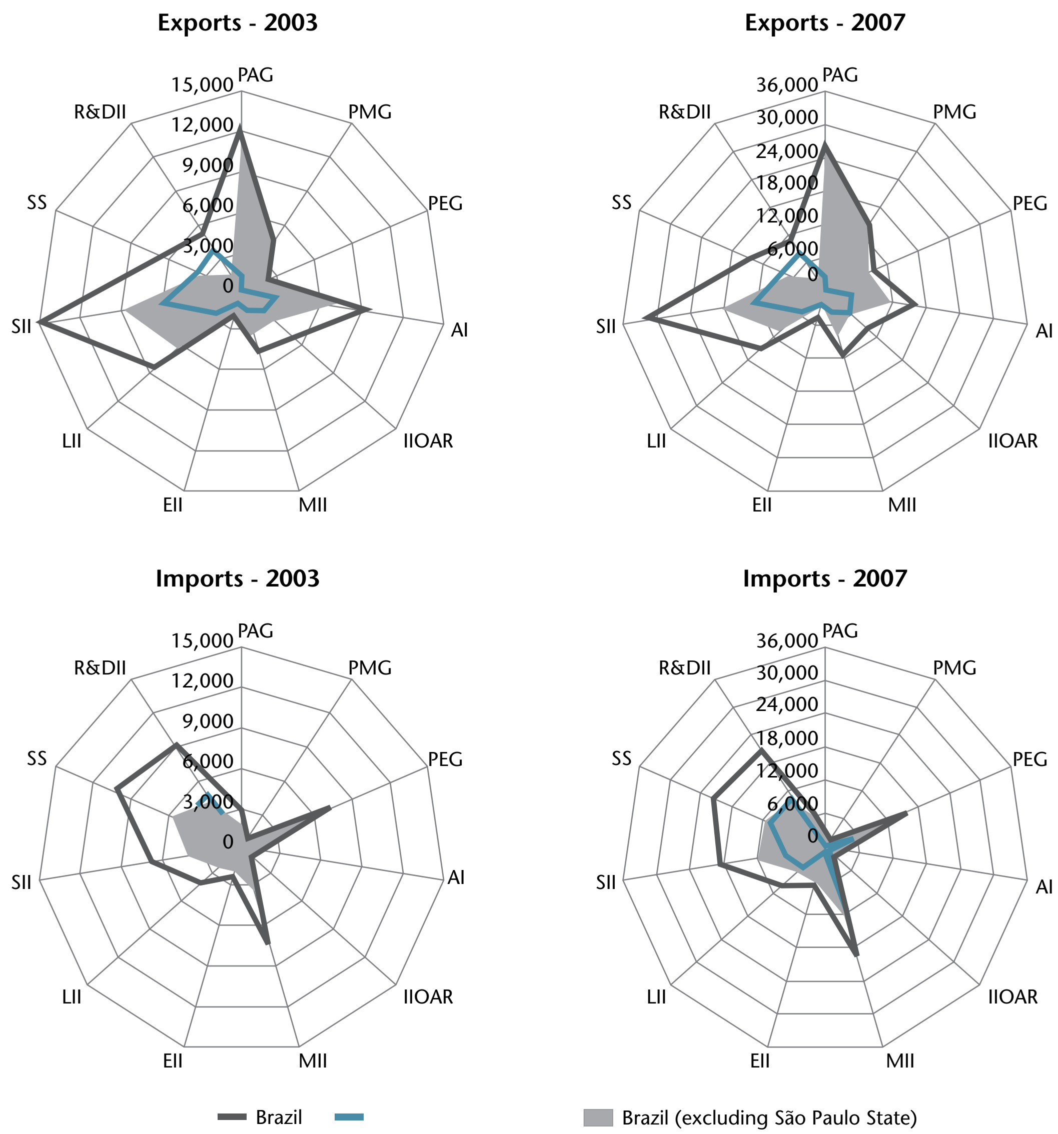
Figure 6.2, which plots exports and imports by Brazil, São Paulo State and Brazil excluding São Paulo, shows the direction taken in terms of embodied technology and São Paulo's significance in this context.

Exports by São Paulo accounted for a large proportion of the national total, approximately 32%, in 2003 and 2007 (Figure 6.2). This was particularly the case for the product categories Specialist suppliers (SS) and R&D-intensive industry (R&DII), which make up the group of items classified as a high-tech (see Table M6.1 of the Methodological Annex). In 2007 exports of these product categories amounted to US$ 8 billion and US$ 8.5 billion respectively in the case of São Paulo State, and to US$ 14 billion and US$ 10.6 billion for Brazil.

Although São Paulo's exports rose strongly in the period (from US$ 23 billion in 2003 to US$ 51.7 billion in 2007), its share of the national total did not rise because exports by other states also increased significantly. The difference in trade patterns between São Paulo and the other states of Brazil can clearly be seen from Figure 6.3. While São Paulo's exports advanced above all in the categories R&D-intensive industry (R&DII), Specialist suppliers (SS), Scale-intensive industry (SII) and Labor-intensive industry (LII), exports by other states (Brazil excluding São Paulo) grew most strongly in Primary agricultural, mineral and energy goods (PAG, PMG, PEG), Agrifood industry (AI) and Scale-intensive industry (SII). The only coincidence is SII, mainly reflecting decentralization of the automotive industry.

Thus São Paulo State reaffirmed its significant contribution to the above segments and led the growth in their exports. It is worth noting that the patterns seen in 2003 repeated in 2007 with much more intensity and clarity, underscoring the important role played by São Paulo in exports of goods classified as high-tech. At the same time, other states made a far from negligible contribution to fast growth in exports of agricultural, mineral and energy goods, essential to Brazil's persistent trade surplus and themselves often embodiments

Figure 6.2
Trade patterns by CTP product category – Brazil, São Paulo State & Brazil excluding São Paulo, 2003 & 2007

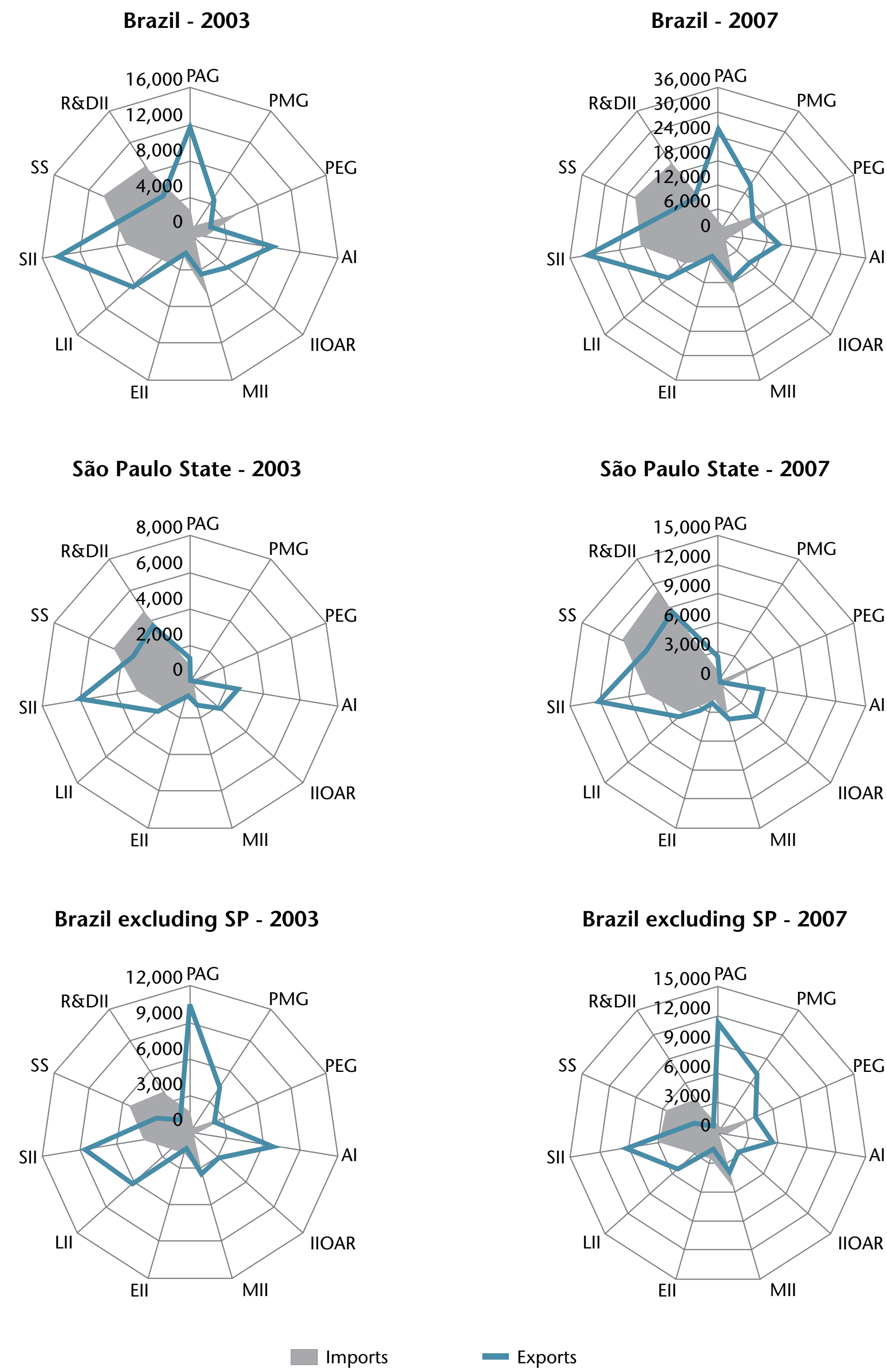


Source: MDIC, SECEX.

Note: See Detailed Table 6.4.

Key: Primary agricultural goods (PAG); Primary mineral goods (PMG); Primary energy goods (PEG); Agrifood industry (AI); Industry intensive in other agricultural resources (IIOAR); Mineral-intensive industry (MII); Energy-intensive industry (EII); Labor-intensive industry (LII); Scale-intensive industry (SII); Specialist suppliers (SS); R&D-intensive industry (R&DII); Not classified (NC).

Figure 6.3
Exports and imports by CTP product category – Brazil, São Paulo State & Brazil excluding São Paulo, 2003 & 2007



Source: MDIC. SECEX.

Note: See Detailed Table 6.5 and 6.6.

Key: 1. Primary agricultural goods (PAG); Primary mineral goods (PMG); Primary energy goods (PEG); Agrifood industry (AI); Industry intensive in other agricultural resources (IIOAR); Mineral-intensive industry (MII); Energy-intensive industry (EII); Labor-intensive industry (LII); Scale-intensive industry (SII); SpecAllist suppliers (SS); R&D-intensive industry (R&DII); Not classified (NC).

of substantial technology content. It is also important to note the significant contribution of the EII category to the exports of Brazil excluding São Paulo.

In addition to exports of goods classified in the categories R&DII and SS, São Paulo also accounted for a significant share of exports in the AI and IIOAR categories: in 2007 the state exported US$ 4.4 billion in AI and US$ 4.9 billion in IIOAR, or 29% and 50% of the national total in these categories (Detailed Table 6.4). In the PAG category, however, it exported US$ 2.7 billion or some 10% of the total. Despite this smaller share of primary goods, the state is also a major exporter of more intensely processed or industrialized agricultural goods.

São Paulo's imports grew at about the same pace as Brazil's, amounting in 2007 to US$ 48.4 billion, or 40% of the national total, which was US$ 120.5 billion (Detailed Table 6.4). In aggregate, R&DII, SS and EII accounted for US$ 29.0 billion or 60% of the state's imports. It is clear from Figure 6.3 that São Paulo's imports are strongly driven by high-tech goods, which grew between 2003 and 2007.

Another interesting point is São Paulo's share of 2007 total imports in the IIOAR category,[11] which was 56% (US$ 811 million out of US$ 1.4 billion) (Detailed Table 6.4). Its share was greater in this category than in R&DII and SS, which it traditionally dominates. Its contributions to imports in these categories in 2007 were US$ 11.2 billion and US$ 10.7 billion respectively, or 54% and 48% of the national total.

A breakdown of the trade balances for Brazil and São Paulo State by CTP product category shows unchanged trade patterns in 2003 compared with 2007 (Figure 6.4), with same signs in both years for most products evidencing a trend.

The largest deficit in 2007 for São Paulo State was in PEG (US$ 4.9 billion), and for Brazil in R&DII (US$ 10.3 billion).[12] São Paulo accounted for 28.7% of Brazil's US$ 18.4 billion deficit in goods classified as high-tech (R&DII and SS – see Detailed Table 6.4). This share and that of the rest of Brazil were practically the same as in 2003 despite the growth in high-tech imports in absolute terms.

The largest surpluses for São Paulo in 2007, as in 2003, were in SII, AI and IIOAR.[13] The largest contributions to Brazil's trade surplus in 2007 were in PAG, PMG, AI and SII, which in aggregate accounted for a surplus of US$ 49 billion (Detailed Table 6.4). This pattern can also be found in the 2003 statistics, but between then and 2007 the surplus in PMG tripled from US$ 4.1 billion to US$ 12.5 billion. The categories concerned cover a wide array of products, from soybeans and iron ore to tractors, chassis and cars.

It is important to highlight these findings and to ask what it means for Brazil and São Paulo State to produce significant trade surpluses in categories that include both manufactures (such as cars) and agricultural commodities (such as soybeans and byproducts, orange juice etc). Technology is embodied in all these products to a greater or lesser extent. We are not dealing with recently won advantages here. On the contrary, the strong performance observed in these categories correlates closely with the local development of S&T competencies and capabilities.

The above findings are confirmed by an analysis of São Paulo's and Brazil's trade statistics in more aggregate groups formed by regrouping the CTP categories into high, medium and low technology. Figure 6.5 presents trade patterns for Brazil and São Paulo in high, medium and low tech for the years 2003 and 2007 in accordance with the same technological classification as that adopted for the TBP chapter in the first edition of this publication (FAPESP, 2002).

Medium-tech goods accounted for the lion's share of trade flows for both years in percentage terms. Exports of these goods grew significantly between 2003 and 2007 for Brazil as well as São Paulo. It is important to note that the indicators used here, based on this classification by technology level, display a trade deficit in both high-tech and low-tech for São Paulo but not for Brazil overall.[14] Brazil had a deficit only in high-tech goods.

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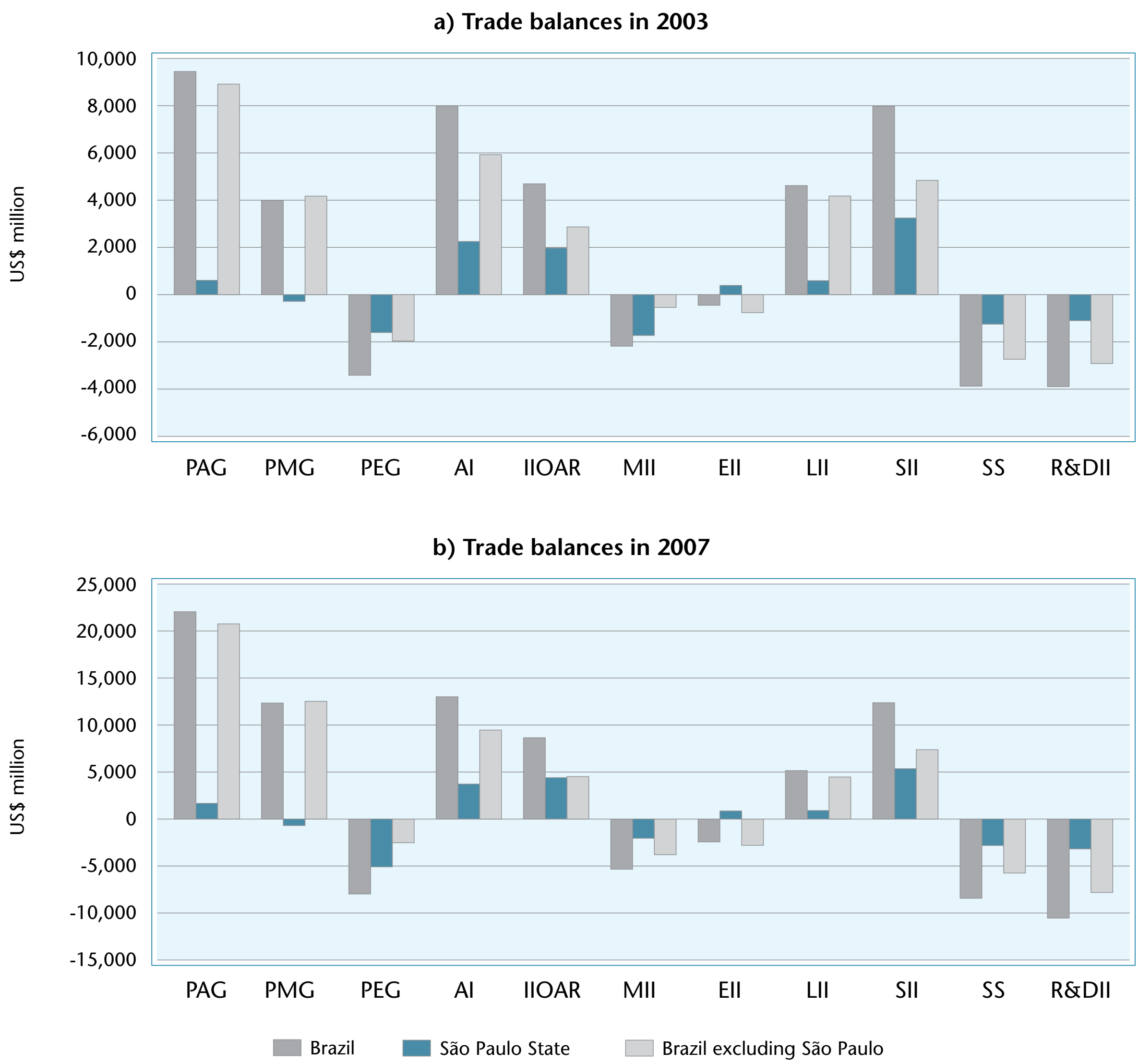
11. Comprising the following product groups: newsprint (reels or sheets); other types of writing paper and card; dried fish, salted fish, fish in brine; other dried fish; chemical wood pulp.

12. São Paulo's deficit in PEG in 2007 was concentrated in the following products: crude petroleum oils, crude oils obtained from bituminous minerals; coal, briquettes, ovoids; petroleum gases and other gaseous hydrocarbons, natural gas, propane; coke and semicoke of coal, lignite, peat. Brazil's deficit in R&DII was concentrated in the following products: other electrical apparatus for line telephony or line telegraphy; other drugs and medicines; other electronic integrated circuits and microassemblies; other devices, appliances and instruments; other types of electronic integrated circuits.

13. São Paulo's surplus in SII in 2007 was concentrated in the following products: vehicles with other types of piston engines; tractors; chassis fitted with engines for motor vehicles; goods vehicles with piston engines. In AI the main surpluses were in: fruit juices; oilcake (bagasse) and other solid residues, whether or not ground; other prepared or preserved meat and offal; extracts, essences and concentrates; cotton, not carded or combed. In IIOAR the main surpluses were in: cane and beet sugar; chemical wood pulp, soda or sulphate; other paper and paperboard weighing $40g/m^2$ or more; other paper and paperboard, coated.

14. The 2007 trade deficit in high-tech goods was concentrated in the following product groups: aeronautical, electronic appliances and apparatus, antisera and binders, turbojets, printed circuits, and static converters. In the low-tech category the largest deficits were for: other petroleum or bituminous mineral oils; sulphur, except sublimed sulphur; crude petroleum oils, crude oils obtained from bituminous minerals.

Figure 6.4
Trade balances by CTP product category – Brazil, São Paulo State & Brazil excluding São Paulo, 2003 & 2007



Source: MDIC. SECEX.

Notes: 1. Trade balances are calculated as the difference between exports and imports by CTP category for the period concerned.
2. See Detailed Table 6.7.

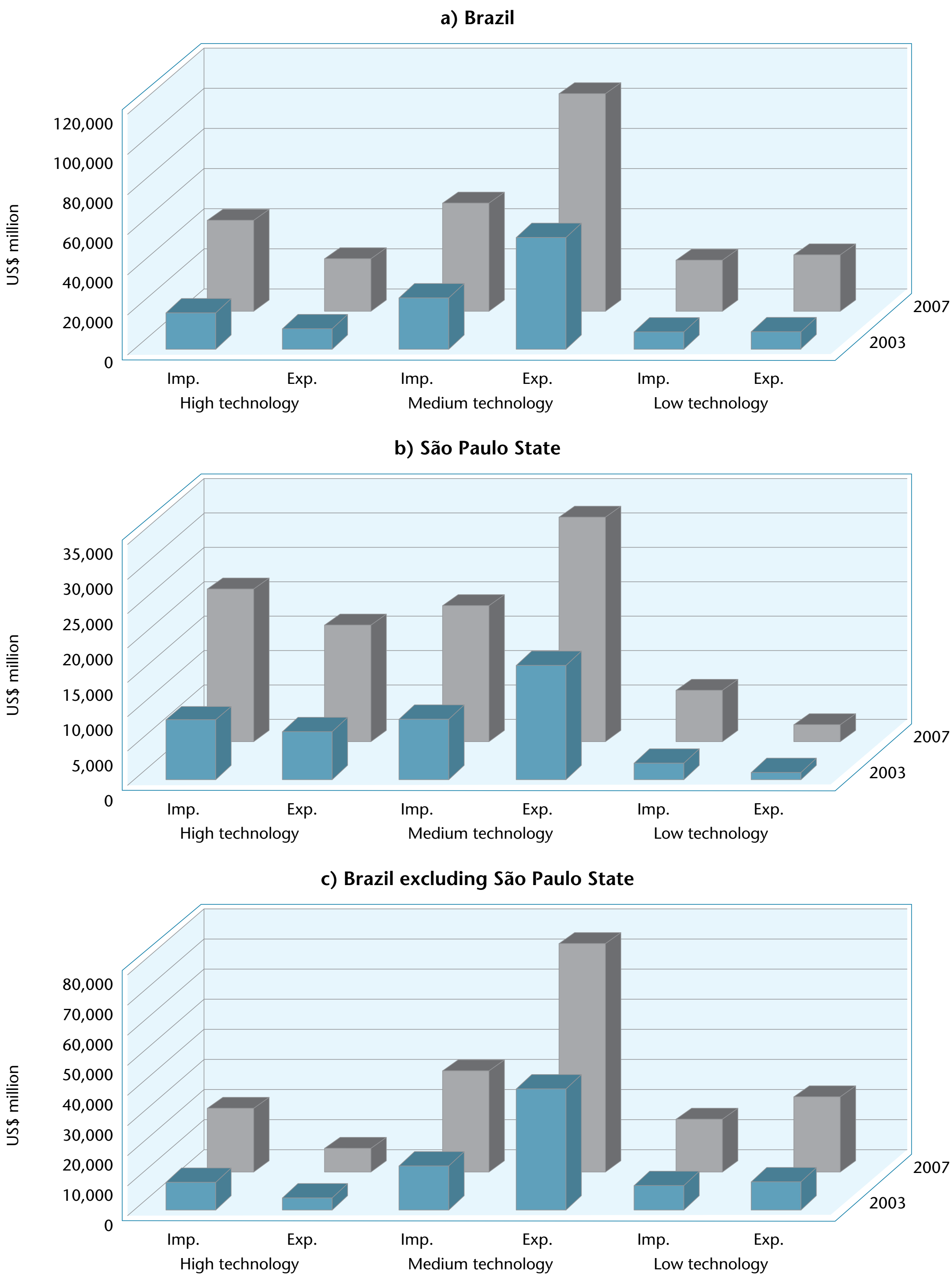
Key: Primary agricultural goods (PAG); Primary mineral goods (PMG); Primary energy goods (PEG); Agrifood industry (AI); Industry intensive in other agricultural resources (IIOAR); Mineral-intensive industry (MII); Energy-intensive industry (EII); Labour-intensive industry (LII); Scale-intensive industry (SII); Specialist suppliers (SS); R&D-intensive industry (R&DII); Not classified (NC).

The high-tech deficit persisted in 2007 but was of a different size compared with 2003. In 2007 Brazil's high-tech imports exceeded its high-tech exports by US$ 18.4 billion. For São Paulo State the deficit was US$ 5.3 billion (Detailed Table 6.8).

A rapid examination of these numbers may lead to inaccurate conclusions regarding the significance of the trade balance in goods classified as high-tech. A more appropriate interpretation requires more detailed analysis of the deficits. There are cases in which the apparently higher-level technology content actually refers to standardized items that affect only assembly-line processes. Many electronic goods now classified as high-tech have less technology content than goods classified as low-tech.

Agricultural goods, and even industrialized goods, serve as a good example of this problem. The areas in which these goods are classified interrelate and over-

Figure 6.5
Exports and imports by level of technology content – Brazil, São Paulo State & Brazil excluding São Paulo, 2003 & 2007



Source: MDIC, SECEX.

Note: See Detailed Table 6.8.

lap, making the analysis still more complex. Inputs and components of various types are classified as high-tech and used in the manufacturing of end-products classified as medium-tech or low-tech. In pharmaceuticals, for example, veterinary products are typically classified as high-tech when imported and are important inputs for agroindustry, among other sectors. The end-product commercialized in the marketplace, in this case, is classified as low-tech despite the complexity of the activities involved in its production.

São Paulo State has deficits in low-tech goods owing to lack of natural or industrial supplies of items included in this category, such as certain kinds of crude oils and gases (energy base). Thus it is not a matter of being more or less dynamic in these areas. In segments classified as low-tech as well as high-tech there are gaps or geographical, physical and human deficiencies, some of which are irreparable while others may become more dynamic depending on the use of locally and nationally generated productive and knowledge bases.

7. Evolution of Brazil's & São Paulo's trade flows: classification by level of technology content & partner country development

Despite the above criticisms regarding the possible imperfections deriving from the classifications used in the main international technology balance of payments studies, analyzing trade flows in terms of technology content and trading partner country development contributes to an understanding of Brazil's role in the global division of production.

To facilitate temporal and geographic comparisons, the methodology used is the same as for the corresponding chapters in previous editions of the series (FAPESP, 2002, 2005). The world is divided into ten country blocs, which in turn are grouped into two broad categories: developed countries (DCs)and less developed countries (LDCs). The DCs are the European Union (E.U.), North American Free Trade Area (NAFTA), Japan, and Asian newly industrialized countries (NICs).[15] The LDCs comprise the remaining selected countries.

The rationale for this procedure is the importance of the correlations among goods with less or more embodied technology, as well as origins and destinations, and the implications of such correlations for domestic production systems on a national and local scale.

7.1 Exports

An analysis of Brazilian exports from the standpoint of the degree of development of the partner countries that buy Brazilian goods shows an important recent change compared with past trends. The DCs have always been the main importers of Brazilian goods and this remains the case. However, countries other than those traditionally classified as the most developed have steadily increased their share. As can be seen from Figure 6.6, in 2003 Brazilian exports were more or less equally split among DCs and LDCs, while in 2007 LDCs accounted for 58.3% of the total (Detailed Table 6.9). Since then the shares of both groups have risen at roughly the same pace, reflecting an increase in the importance of Asian partners (still classified as developing nations), especially China. These changes are due to both rising international commodity prices and growth in export volumes.

Exports of goods classified as medium-tech still account for most (67.4%) of Brazil's exports by value (Figure 6.6), but this share has fallen since 2003, when it accounted for 72.9%. Most medium-tech exports go to LDCs, whose share of total exports has risen largely for this reason (Detailed Table 6.9).

The shares of DCs and LDCs in low-tech exports have also changed. DCs accounted for 53.2% in 2003, while LDCs accounted for 56.8% in 2007. Similarly, DCs accounted for 58.4% of high-tech exports in 2003 and for 17 percentage points less in 2007, when LDCs accounted for 58.3%.

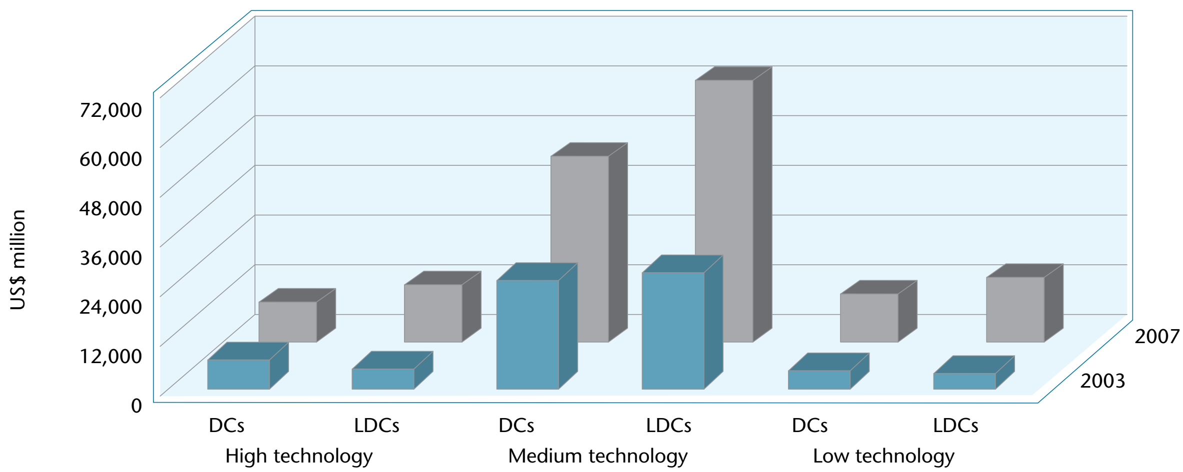
In 2003 exports from both Brazil and São Paulo State were fairly evenly split between DCs and LDCs (Detailed Table 6.9), but by 2007 the share of LDCs had increased significantly in all three technology intensity groups, to the detriment of DCs. LDCs accounted for 58.1% of Brazilian exports and 66.2% of the state's exports in the period. China's share of low-tech exports rose 6.3%, more than that of any other country.[16]

15. Japan is considered individually. Asian NICs: South Korea, Taiwan, Hong Kong, Singapore.

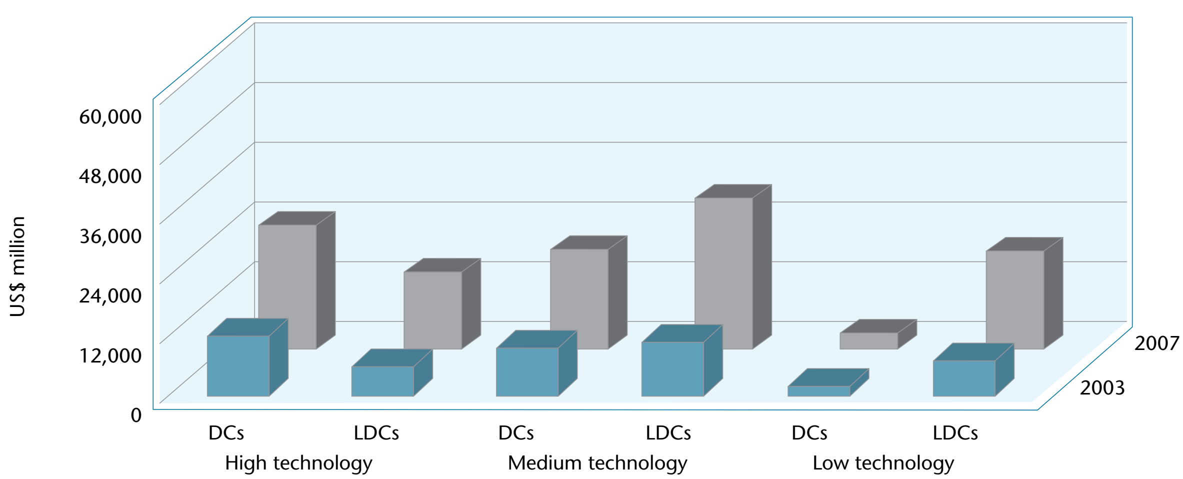
16. The main products classified as low-tech among exports to the Rest of Asia in 2007 were: inflight catering material, types of asbestos, crude petroleum oils, crude oils obtained from bituminous minerals.

Figure 6.6
Exports and imports by level of technology content and partner country development – Brazil, São Paulo State & Brazil excluding São Paulo, 2003 & 2007

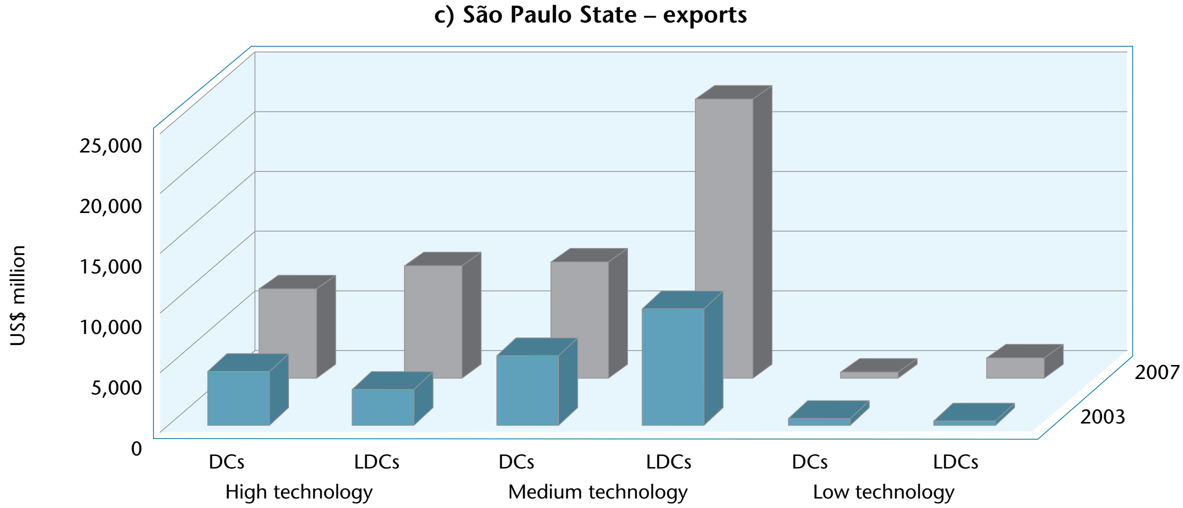
a) Brazil – exports



b) Brazil – imports



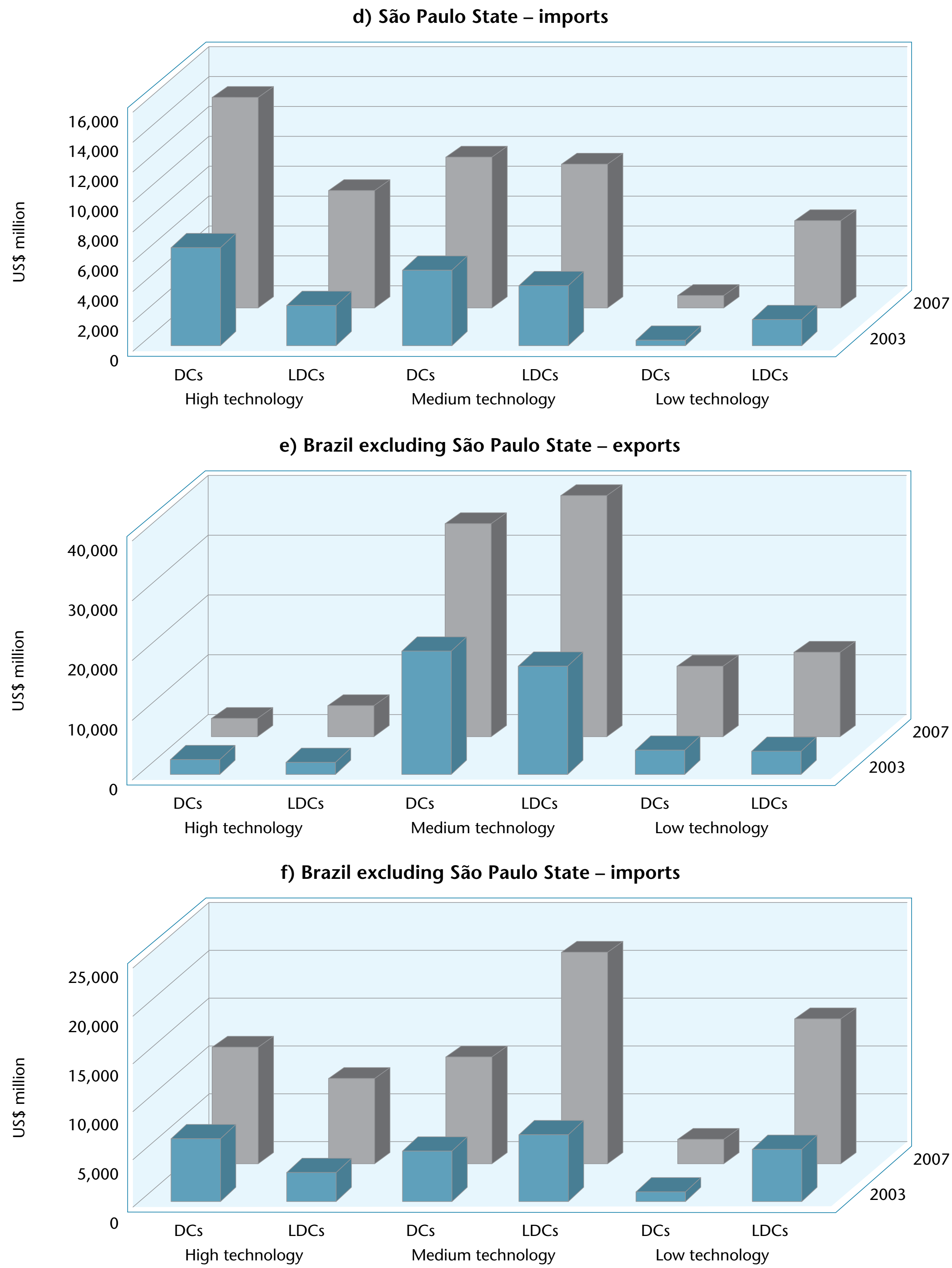
c) São Paulo State – exports



Fonte: MDIC. SECEX.

Nota: See Detailed Table 6.9.

Figure 6.6
Exports and imports by level of technology content and partner country development – Brazil, São Paulo State & Brazil excluding São Paulo, 2003 & 2007



Source: MDIC. SECEX.

Note: See Detailed Table 6.9.

The shift in favour of LDCs shows that Brazil and São Paulo have intensified trade with new partners, including other BRICs (Detailed Table 6.10).

7.2 Imports

The first key point evidenced by an analysis of Brazilian imports from the standpoint of partner country development is once again that the share of LDCs has increased (Detailed Table 6.9). Between 2003 and 2007, in fact, it rose 8 percentage points (R$ 46 billion), from 49.3% to 57.6% of total Brazilian imports.

Imports to both groups of countries rose in all three technology content categories between 2003 and 2007 (Figure 6.6). However, in contrast with the trend observed for exports, the shares of DCs and LDCs remained practically unchanged in the case of low-tech imports. In high-tech imports, the value of goods imported by Brazil from LDCs grew almost threefold (Detailed Table 6.9). In medium-tech imports, Brazil also purchased more from LDCs: in 2007 the group accounted for 59.7% of total medium-tech imports, for an increase of 8 percentage points compared with 2003. Moreover, medium-tech imports accounted for the largest proportion of Brazilian imports in both 2003 and 2007 (44%).

The profile of imports to São Paulo State differs from the overall profile of Brazilian imports as regards the shares of DCs and LDCs. While that of LDCs grew similarly in all three technology categories for both Brazil and São Paulo, in 2007 their contribution to the Brazilian total was much higher, whereas DCs and LDCs accounted for roughly the same proportion of the total imported to São Paulo (Detailed Tables 6.10 and 6.11).

High-tech imports to São Paulo from LDCs grew 190.1% between 2003 and 2007. In this case (as well as in that of medium-tech imports), the share of imports from the Rest of Asia group of countries also increased, led by the BRICs, especially China (Detailed Table 6.10).

7.3 Balance

An analysis of Brazil's trade statistics shows that a surplus was possible in 2003 and 2007 only because of positive balances in the medium-tech category (Figure 6.7). A breakdown of the trade balance by level of partner country development evidences similar contributions from DCs and LDCs in 2003 and significant growth of the surplus with LDCs in 2007, which exceeded the surplus with DCs by R$ 7.6 billion (Detailed Table 6.10).

A further aspect of trade in high-tech goods is worth noting. The surplus with BRICs fell 51% between 2003 and 2007 (Detailed Table 6.10), indicating that import growth accounted more than export growth for the intensity of trade with other BRICs. This observation is confirmed by the fact that the deficit in high-tech trade with BRICs, led by China, grew 8.7 times between 2003 and 2007, with the deficit reaching R$ 6.2 billion in the latter year.

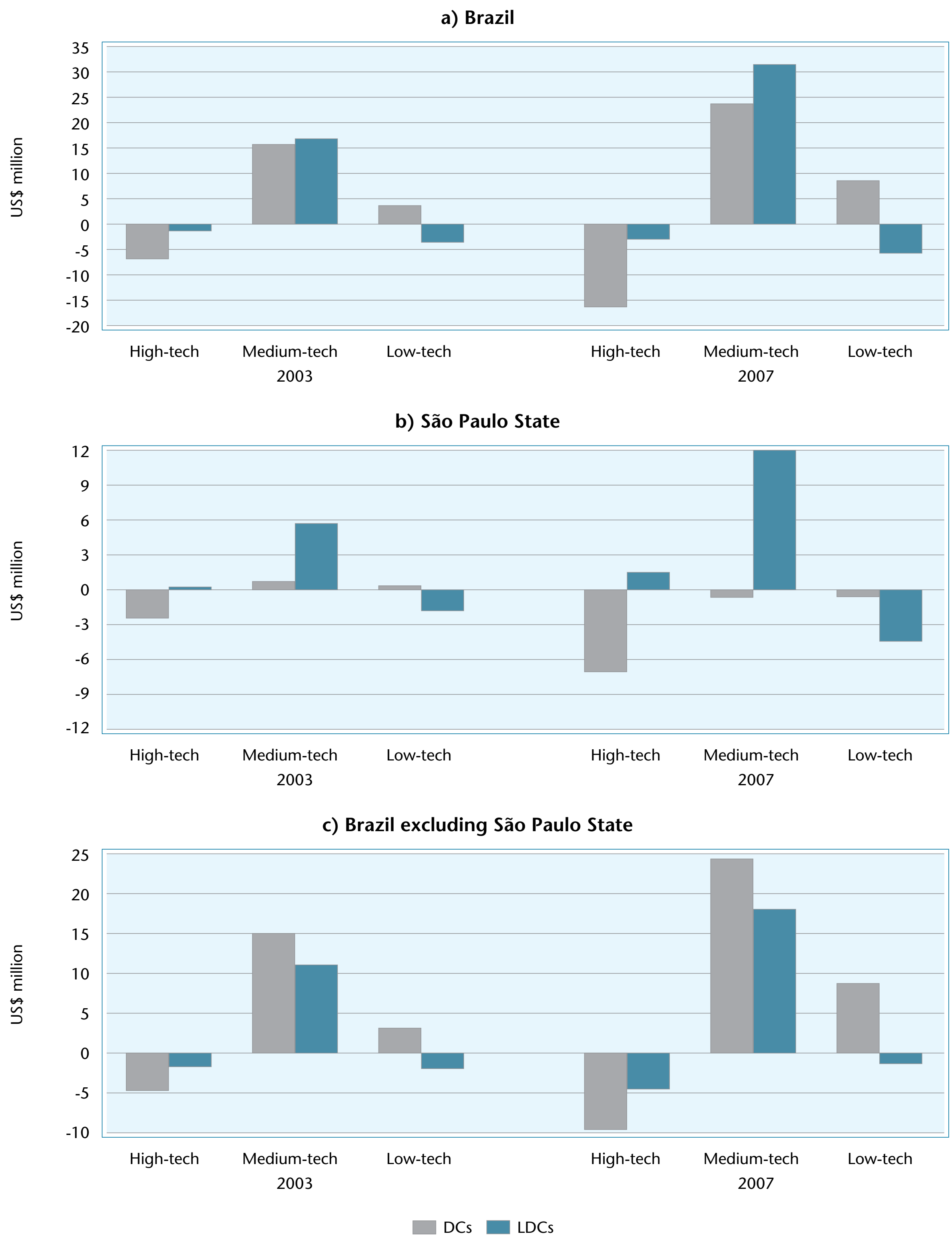
Brazil had a deficit in high-tech goods with both DCs and LDCs (Detailed Table 6.10), but it was much smaller with the latter. DCs sold Brazil far more than they bought from it in this category. So much so that the deficit was six times greater for trade with DCs than LDCs in 2007, having risen by US$ 9.4 billion between 2003 and 2007.

In low-tech goods, Brazil had a deficit with LDCs and a surplus of US$ 8.4 billion with DCs (Detailed Table 6.10).

São Paulo State accounted for a significant share of Brazil's deficit in high-tech goods (28.2% and 28.7% in 2003 and 2007 respectively, as can be seen from Detailed Table 6.10). This deficit was due mainly to transactions with DCs. A surplus of US$ 1.4 billion with LDCs was more than offset by a deficit of US$ 2.7 billion with the rest of the BRICs.

Both São Paulo and the other states of Brazil posted a trade surplus in 2007. Once again this surplus was due to trade in medium-tech goods. In the case of São Paulo, the standout is the contribution of trade with LDCs, which produced a surplus of US$ 13.5 billion in 2007 (Detailed Table 6.10). It is worth noting that São Paulo's surplus in medium-tech goods rose US$ 6.8 billion in this short period (2003-07). Despite this surprising growth, however, the final balance of trade for São Paulo was positive by only US$ 3.3 billion in 2007 owing to a large deficit in high-tech goods (US$ 5.3 billion).

Figure 6.7
Trade balances by level of technology content and partner country development – Brazil, São Paulo State & Brazil excluding São Paulo, 2003 & 2007



Source: MDIC. SECEX.

Notes: 1. Trade balances are calculated as the difference between exports and imports by level of technology for the period concerned.
2. See Detailed Table 6.10.

8. Technological services

Services are the second-largest category in the current account of the balance of payments in terms of value, after merchandise trade, and involve activities that are increasingly important in international trade flows.

The technological services purchased by firms may involve both embodied technology, in the form of people and/or equipment, and disembodied technology, in the form of knowledge created by innovative firms (patent licensing, technical assistance, engineering and R&D services, know-how contracts). Together with in-house efforts, imported services of both types make up the stockpile of technologies and capabilities available for their use. The choices made by each firm and later actions taken evidently determine distinct technological trajectories.

The acquisition of embodied technology entails buying external knowledge and technology without necessarily requiring any involvement with the seller of these assets (OECD, 2005). In this case knowledge is embodied in the acquired plant and equipment. However, when firms trade in disembodied technology, such as new knowledge, know-how, patents, licenses, registered trademarks and software, sellers and buyers perform transactions via technology transfer agreements, and such transactions comprise the technology balance of payments in the narrow sense.

International financial payments and remittances relating to technology transfer are part of the routine transactions performed by virtually all economies. The magnitude and composition of international knowledge flows are worth analyzing in light of at least two global trends that particularly affect LDCs.

Concern over the effects of variations in business R&D intensity (as a percentage of sales and in absolute terms) has fuelled the creation of systems designed to monitor such investment in a wide array of industries and in services, often controlling it very strictly. In addition, growing global economic integration via the subsidiaries of multinational corporations poses a number of different challenges for countries that seek more consistent development. This dimension is especially relevant in countries with internationalized firms that are capable of creating efficient mechanisms for interfirm and cross-border technology transfer, using different channels and subsidiaries with vital functions in the business group concerned.

Firms that are systematically involved in innovation activities face the huge challenge of establishing adequate strategies regarding the intensity and type of technology to develop within national borders and defining the technology to be captured from external sources for incorporation into their own production processes.

The acquisition of disembodied technology is typically associated with the absence of qualified personnel or in-house R&D labs. It may also be a means of obtaining technology and know-how more quickly. Here too, therefore, a trade surplus or deficit says little about national competencies. In static terms, deficits in technology flows point to a country's or firm's lack of capacity to internalize concepts, patterns of competitiveness and technology. In dynamic terms, deficits may reflect modernization and increasing integration with different suppliers of technology and know-how, alongside intense in-house efforts to absorb, read, interpret and assimilate distinct and growing options for the purchase and sale of intellectual and technological assets, while at the same time saving time and reducing the cost of in-house innovation.

A great deal of research has been done to try to measure the global dissemination of disembodied technology and assess the ways in which it may become autonomous.[17] Although the impact of technology on industrial and innovative structures is expected to differ case by case, it will typically be positive for the host country. The main reasons for which technology flows benefit importing countries are as follows:

- Productivity may rise as a result of the use of superior technology;
- Domestic competition tends to intensify when more advanced technology is adopted by some firms (demonstration effect);
- Competencies and learning processes are taken on board in the medium term by local firms that imitate acquirers of technology, so that they can evolve and sustain autonomous investment in research teams and more robust internal structures, gradually reducing their dependency on external sources of technology.

8.1 International context

The U.S., Japan, Germany, France and the U.K. have historically been the leading suppliers of the technologies absorbed by the productive structures of a large

17. Dosi *et al.* (1990), for example, discuss how domestic investment associated with foreign patenting increased productivity in some countries in the 1970s.

number of less developed countries. This leadership reflects the capacity intrinsic to the firms, institutions and research centers of the countries mentioned to advance at the frontier of scientific knowledge, while at the same time converting this knowledge into technological applications for new industrial products and processes that extend beyond national and sectoral borders.

On the other hand, for countries that traditionally import technology more than they export it, including Brazil, the specificities and profile of their demands display discrepancies with regard to the typical local industrial structures. The different relationships involved when firms use and commercialize disembodied technology reflect, albeit with a certain time lag, the scope of the acquiring country's capacity to absorb intangible assets that are developed abroad but are useful for domestic production of goods.

In 2006 services accounted for 21.8% of Brazil's total exports of goods and services combined, and for 18.7% of total imports. The share of services would be larger if it were not for the inclusion of hotel services, industrial cleaning and other services that cannot be bought and sold separately from production. This requires service providers to establish local business operations so as to be closer to their customers.

Internationally speaking, services account for a relatively small share of international trade but make a significant contribution to total value added. Value added corresponds to 70% of total trade in services by all OECD countries (OECD, 2008). Exports and imports of some items within the service balance of payments have increased significantly in the past five years: they include financial services, information and computer services, and insurance-related services. Table 6.4 shows a regional breakdown of the international trade in services, including technological services.

As can be seen from Table 6.4, world exports of services grew 13% per year on average in the period 2001-06, while imports grew 11.7% per year. Exports by the group of countries known as BRICs[18] rose 24.7% per year and imports 19.8% per year on average in the same period. The highlight was India, whose service exports rose 34.2% per year on average, while imports rose 25.9%.

Table 6.4
Regional trends in international trade in services – Brazil, selected countries & groups of countries, 2001 & 2006

Economic bloc/Country	Exports			Imports		
	US$ billion		Annual change (%)	US$ billion		Annual change (%)
	2001	2006		2001	2006	
World	1,529	2,816	13.0	1,559	2,710	11.7
OECD	1,183	2,081	12.0	1,142	1,887	10.6
NAFTA	335	495	8.1	283	438	9.1
OECD Europe	732	1,381	13.5	698	1,209	11.6
OECD Asia Pacific	116	210	12.6	162	246	8.7
BRICs	76	230	24.7	102	253	19.8
China	33	92	22.5	39	101	20.8
India	17	75	34.2	20	64	25.9
Russia	11	31	22.1	21	45	16.9
Brazil	9	19	15.9	17	29	11.3
South Africa	5	12	19.9	5	14	22.3

Source: OECD (2008, p. 39).

18. Brazil, Russia, India, China, South Africa.

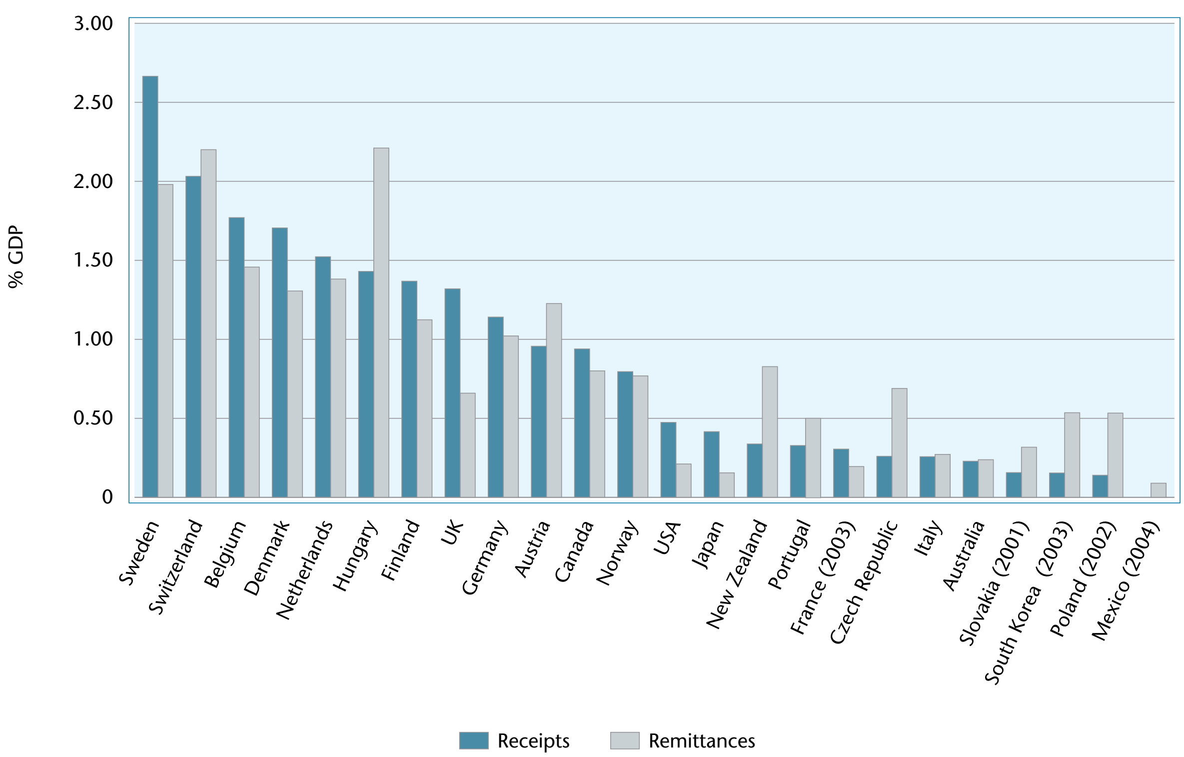
In aggregate terms only three OECD countries – Luxembourg, Sweden and Switzerland – had technology flow receipts and remittances that averaged more than 2% of gross domestic product (GDP). For most member countries the average was around 1.5% of GDP. As can be seen from Figure 6.8, trade in disembodied technology is not significant for some countries, such as Mexico, Poland, Slovakia, Australia and Italy. The magnitude of the data relating to remittances reported for Ireland is due largely to the strong presence of foreign corporations that import technology from their home countries (Detailed Table 6.11).

The U.S. remains the leader in net exports of disembodied technology. Japan has had a surplus and been a net exporter since the early 1990s.

The U.S. is recognized as one of the most successful countries in terms of policies to support business innovation. Nevertheless, it has a systematic deficit in technologically advanced products, which may appear paradoxical at first glance.

The U.S. deficit in high-tech goods was R$ 38.3 billion in 2006, down from R$ 44.4 billion in 2005 (Figure 6.9). The categories with the largest contributions to the deficit in that year were Information & Communications, and Life Sciences (US$ 93.2 bil-

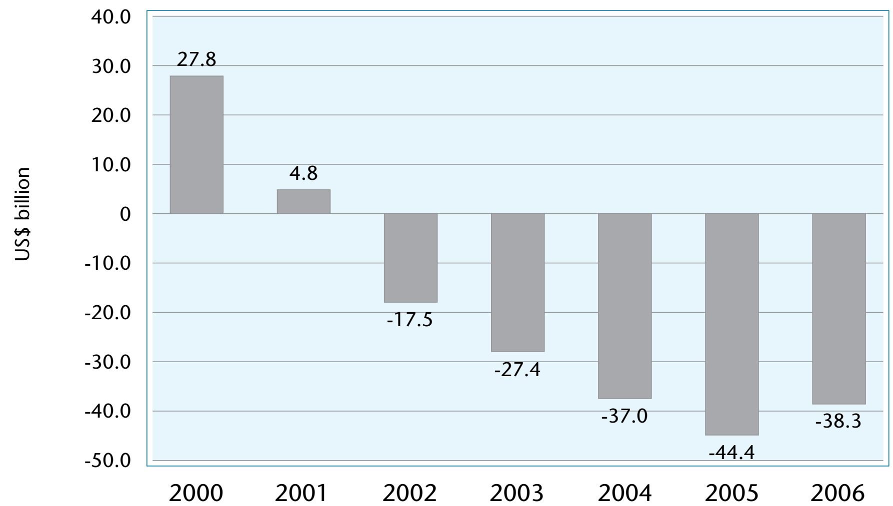
Figure 6.8
Receipts and remittances relating to technological services in proportion to GDP – OECD countries, 2005



Source: OECD (2007, p. 199).

Note: See Detailed Table 6.11.

Figure 6.9
Trade in high-tech goods – USA, 2000-2006



Source: NSB (2008), Appendix Table 6-20.

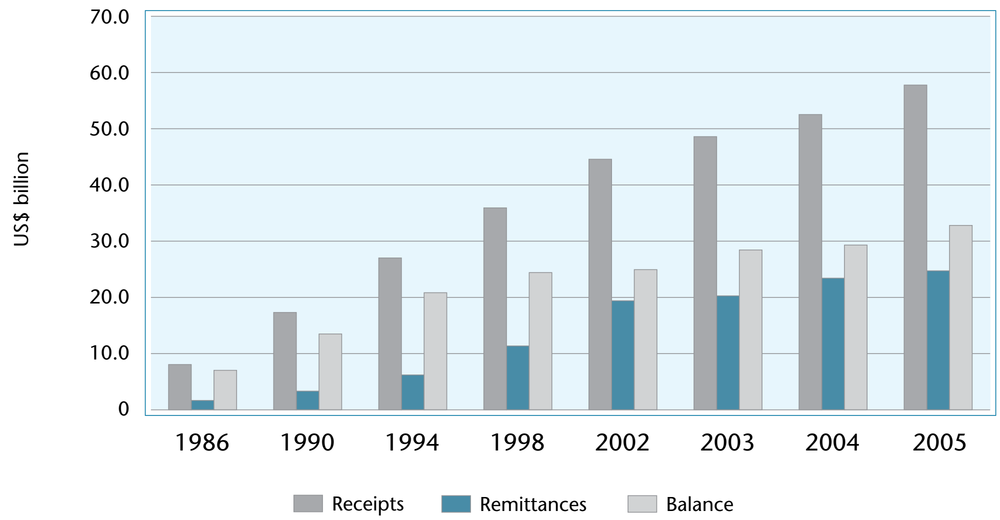
lion and US$ 15 billion respectively). These are precisely the areas pioneered by the U.S., so that it has defined the dominant innovation system. Its surplus of US$ 53.6 billion in aerospace technology in 2006 helped reduce the deficit. Asia was the main supplier of imports that produced the U.S. deficit in this type of product. The sophistication of products based on technology supplied by China led to a reduction in the pace of growth in the high-tech trade surpluses for all OECD countries.

The growing sophistication of China's exports leaves no room for doubt about China's capacity to influence the trade structures of several countries, both DCs and LDCs, despite its expanding deficit in services. The absorption of external technologies through channels of all kinds enables countries to play a role in the global technology arena without incurring a trade deficit that destabilizes the competencies that are increasingly incorporated locally. Brazilian efforts, albeit more modest and fragile compared with those of China recently, cannot be considered insufficient, nor should they suggest a single natural starting trajectory, i.e. that of dependency. On the contrary, there is scope for articulation and insertion, but the complexity and far from trivial nature of economic relations in the technology arena means that this process requires consistent oversight of choices and associated matching arrangements.

Although the U.S. has a deficit in high-tech trade, other important components of the trade balance that produce a surplus include intellectual property, licenses and royalties. These contribute to the country's performance as the leading net exporter of technology.

U.S. earnings from IP exports are significant. They have risen year by year, with the sole exception of 2001, and reached US$ 57.4 billion in 2005 (Figure 6.10),

Figure 6.10
Trade in intellectual property rights – USA, 1986-2005 (selected years)



Source: NSB (2008), Appendix Table 6-22.

Note: See Detailed Table 6.12.

producing a surplus of US$ 32.9 billion. About three-quarters of this surplus is estimated to derive from transactions between multinationals based in the U.S. and their foreign subsidiaries. This supports the argument that countries are increasingly interdependent in terms of both production and economics generally.

Table 6.5 shows the trade balance for royalties and trademark licensing for some countries. The U.S. outperforms all of them, including the U.K. and Japan, which have consistently achieved a surplus in this area. In 2006 the U.S. surplus amounted to over US$ 35 billion.

Table 6.5
Trade balance in royalties and licenses – Selected OECD countries, 1996-2006

Country	Trade balance (US$ million)										
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Germany	-2,507	-2,503	-2,298	-2,019	-2,676	-2,175	-1,459	-843	-341	-570	-1,961
Australia	-804	-776	-736	-905	-787	-685	-862	-1,058	-1,224	-1,453	-1,596
Austria	-513	-502	-712	-501	-407	-616	-938	-953	-1,069	-1,165	-785
Canada	-1,073	-1,165	-1,312	-1,793	-1,513	-1,369	-1,989	-2,784	-3,440	-4,019	-4,074
South Korea	-2,246	-2,162	-2,109	-2,206	-2,533	-2,129	-2,167	-2,259	-2,585	-2,652	-2,477
USA	24,633	24,067	24,391	26,563	26,765	24,158	25,155	27,955	31,216	34,777	35,946
Finland	-399	-409	-306	275	320	,53	-45	-114	39	83	-227
France	-768	-431	-383	-300	266	716	1,432	1,629	2,085	3,144	2,930
Netherlands	-516	-452	-509	-1,033	-404	-586	-649	561	2,275	1,658	2,318
Ireland	-3,313	-3,969	-6,026	-6,529	-7,412	-9,501	-10,728	-15,826	-18,485	-18,479	-19,753
Italy	-1,065	-415	-850	-819	-637	-864	-742	-1,184	-983	-795	-728
Japan	-3,150	-2,309	-1,564	-1,671	-778	-658	-585	1,286	2,062	2,984	4,607
Mexico	-238	-371	-315	-512	-364	-378	-672	-524	-714	-41	-332
U.K.	333	647	435	1,313	1,527	1,698	1,771	2,221	3,115	4,333	3,631
Czech Republic	-55	-43	-54	-95	-37	-56	-74	-124	-136	-445	-494
Sweden	43	79	186	258	367	630	620	1,051	2,030	1,983	2,311
Switzerland	1,195	1,582	1,572	595	916	-18	77	-264	-699	-869	-1,179

Source: OECD (2008, pp. 72-73).

8.2 Brazilian context

Since 2001 the Central Bank of Brazil (BACEN) has used the methodology recommended by the International Monetary Fund in its Balance of Payments Manual (IMF, 1993), in an attempt to comply with international standards for the compilation of statistics relating to both the balance of payments (BOP) and stocks of financial assets and liabilities. As a result, in addition to services relating to transport, international travel, insurance and government, the service account now also covers financial services, computer and information services, royalties and license fees, and equipment rental and leasing, all of which Brazil previously included under the rubric "sundry services".

It is important to note that despite successive attempts by BACEN to improve its procedures for capturing technology flows in the service account of the BOP, there are a number of limitations to the statistics it compiles. For example, it is difficult to identify origins and destinations, as well as specific types of technical services. Thus the data for individual states of Brazil may not be accurately extracted. While this publication focuses on São Paulo State, the limitations of the Brazilian system used to track receipts and remittances relating to technological services sometimes make it impossible to obtain consistent detailed information for São Paulo.

As stressed in an earlier edition (FAPESP, 2002), BACEN is the institution responsible for systematizing Brazil's technology balance of payments (TBP). However, in doing so it prioritizes foreign-exchange flows and does not detail the technological content of the transactions concerned.[19] Thus the TBP consists of inflows and outflows relating to registered foreign-exchange transactions. These flows are booked on the basis of declarations by the parties involved, registering payments effected or received for specialized technical services. They may or may not include strictly technological services; if they do, the respective contracts must be registered with the National Industrial Property Institute (INPI). The values reported by BACEN therefore tend to be larger than those reported by INPI. Despite the discrepancy, information on foreign-exchange transactions and registered technology transfer contracts are enough for a tentative understanding of the main tendencies and hence an approximate assessment of whether the receipts and remittances relating to international technology flows match up.

Figure 6.11 presents flows of payments in current dollars relating to technology transfers between 2005 and 2008. In this short period the amounts reported rose in absolute as well as relative terms. Between January and November 2008, the Brazilian deficit reached US$ 2.1 billion, almost 50% larger than that seen in 2005 (US$ 1.5 billion).

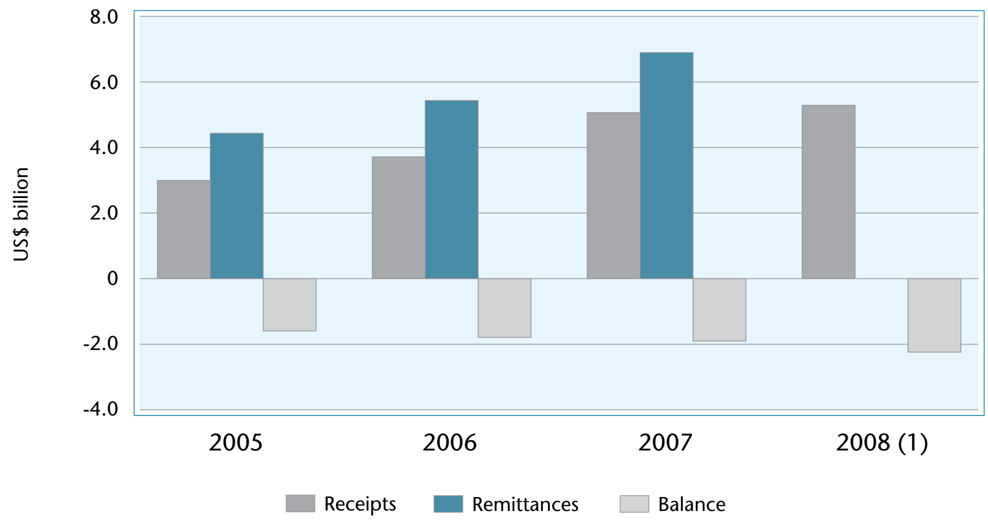
A breakdown of receipts by type of service shows that professional technical services are the main item exported by Brazil (Table 6.6). Although it fell between 2005 and 2008, this rubric accounted for 67.8% of receipts from exports of technological services by Brazil in 2008, or R$ 3.6 billion. Technical assistance, which accounted for about 1% of receipts in 2005, or some R$ 38 million, had reached 11% or R$ 558 million three years later and was the second-largest source of receipts from 2006 on. This jump reinforces the hypothesis that Brazilian statistics on technological services require enhancements and adjustments in order to discriminate technical and technological activities more accurately.

Patent and trademark licensing, as well as technology supply in general, accounted for a relatively small proportion of total receipts. On the other hand, these services contributed significantly to Brazilian remittances, as shown in Table 6.7.

With regard to spending on imported technological services, as can be seen from Table 6.7, acquisition of software and professional technical services accounted for about 60% of the total in all years of the period, amounting to more than US$ 4 billion in 2008. Here too it should be stressed that the wide array of possibilities for the use of software in production sys-

19. The chapter devoted to this topic in each of the previous editions of this series (FAPESP, 2002, 2005) outlines the difficulties faced by those who seek to collect statistics for Brazil and points out problems with the reliability of the data.

Figure 6.11
Receipts and remittances relating to technology flows – Brazil, 2005-2008



Source: Central Bank of Brazil (BACEN).

Note: See Detailed Table 6.13.

(1) January-November.

tems in Brazil requires more refined disaggregation of the different applications and the economic segments in which such software is used.

The third type of technological service most used in Brazil is acquisition of technology developed abroad, amounting in 2008 to US$ 1.2 billion, or about 17% of total remittances.

The data from BACEN shown in Tables 6.6 and 6.7 reflect receipts and remittances relating to foreign-exchange transactions for technology transfer agreements. This account includes capital remittances under agreements registered by INPI, the office responsible for registering and controlling technology contracts relating to patents, trademarks, licensing and franchising.

While on the one hand the data presented above show growth in technology flows, in terms of inflows and outflows of foreign exchange, on the other hand the number of agreements registered by INPI remained fairly stable in the period 1996-2006 (Table 6.8). The requirement to register agreements with INPI was established by article 140 of the Industrial Property Law (Brazil, 1996) and is intended to protect local firms with regard to guarantees when third parties are involved. Registered agreements stipulate remuneration and duration, among other terms and conditions. Thus Brazilian law requires INPI to register all contracts and agreements involving technology transfer between firms located abroad and local firms, or between foreign firms operating in Brazil. INPI is charged with verifying the legality of agreements for the use of patents, industrial designs, trademarks, technology, technical and scientific assistance, franchising, and R&D.

INPI registered 1,559 agreements in 2006. Most of them (929) were classified as relating to technical and scientific assistance. This category was the largest in every year of the period 1996-2006 (Table 6.8). Use of trademarks and technology supply came next, with 432 agreements in 2006.

A breakdown by origin and destination shows the U.S. and Germany as the main sources of technological services in the period, accounting for about 30% and 15% of the agreements respectively.

In aggregate, Brazil's technological service account has two dimensions that hinder public policy formulation and increased competitiveness on the part of Brazilian firms. The first relates to the nature of the statistics. There is no clarity regarding the methodologies used by the institutions that furnish the data. The available information is still excessively aggregated, allowing scant room for regionalization (data by state, for example) or disaggregation by industry, application etc.

Table 6.6
Receipts from technological services by type – Brazil, 2005-2008

Type of technological service	Receipts							
	2005		2006		2007		2008 (1)	
	US$ million	%	US$ million	%	US$ million	%	US$ million	%
Total	**2,949.7**	**100.0**	**3,723.4**	**100.0**	**5,041.9**	**100.0**	**5,265.2**	**100.0**
Specialized technical services – Other professional technical services	2,634.9	89.3	2,470.1	66.3	3,276.7	65.0	3,567.7	67.8
Marks & patents – Registration, application, maintenance	69.0	2.3	64.4	1.7	123.5	2.5	123.7	2.4
Software acquisition	50.4	1.7	61.1	1.6	112.4	2.2	125.8	2.4
Specialized technical services – Industrial designs, drawings & models	41.9	1.4	29.4	0.8	29.7	0.6	36.9	0.7
Specialized technical services – Equipment assembly	41.3	1.4	172.0	4.6	116.0	2.3	168.5	3.2
Technical assistance	38.1	1.3	685.8	18.4	901.5	17.9	558.1	10.6
Specialized technical services – Engineering designs, drawings & models	28.6	1.0	99.0	2.7	278.3	5.5	375.9	7.1
Copyright	23.3	0.8	45.1	1.2	45.9	0.9	54.2	1.0
Specialized technical services – Other custom assembly	8.0	0.3	22.7	0.6	16.6	0.3	21.6	0.4
Engineering project implementation & installation	7.4	0.3	41.3	1.1	64.5	1.3	79.5	1.5
Supply of services & complementary expenses	3.8	0.1	18.2	0.5	32.8	0.7	47.4	0.9
Technology supply	1.5	0.1	6.3	0.2	6.6	0.1	39.0	0.7
Trademark licensing	0.6	0.0	4.5	0.1	22.2	0.4	25.8	0.5
Technical-economic project implementation & installation	0.3	0.0	0.7	0.0	2.0	0.0	5.3	0.1
Franchising	0.0	0.0	0.4	0.0	0.5	0.0	0.5	0.0
Marks – Assignment	0.0	0.0	1.1	0.0	11.6	0.2	21.6	0.4
Patent licensing	0.0	0.0	1.5	0.0	1.5	0.0	12.6	0.2

Source: Central Bank of Brazil (BACEN).

(1) January-November.

Table 6.7
Remittances for technological services by type – Brazil, 2005-2008

Type of technological service	Remittances							
	2005		2006		2007		2008 (1)	
	US$ million	%	US$ million	%	US$ million	%	US$ million	%
Total	**4,444.6**	**100.0**	**5,413.1**	**100.0**	**6,884.8**	**100.0**	**7,418.6**	**100.0**
Software acquisition	1,523.6	34.3	1,866.9	34.5	2,124.0	30.9	2,369.8	31.9
Specialized technical services – Other professional technical services	1,179.8	26.5	1,518.1	28.0	2,010.6	29.2	2,056.9	27.7
Technology supply	646.3	14.5	640.9	11.8	1,055.1	15.3	1,246.9	16.8
Technical assistance	306.0	6.9	327.4	6.0	435.0	6.3	479.0	6.5
Copyright	299.6	6.7	471.0	8.7	403.7	5.9	412.9	5.6
Patent licensing	183.0	4.1	198.2	3.7	254.0	3.7	177.6	2.4
Supply of services & complementary expenses	173.4	3.9	183.8	3.4	298.9	4.3	337.8	4.6
Trademark licensing	64.9	1.5	118.6	2.2	175.1	2.5	145.4	2.0
Franchising	25.1	0.6	35.2	0.7	53.6	0.8	109.2	1.5
Specialized technical services – Equipment assembly	14.6	0.3	18.7	0.3	15.6	0.2	13.5	0.2
Marks & patents – Registration, application, maintenance	12.1	0.3	15.5	0.3	18.6	0.3	34.2	0.5
Specialized technical services – Industrial designs, drawings & models	6.6	0.1	5.4	0.1	10.0	0.1	6.8	0.1
Specialized technical services – Engineering designs, drawings & models	4.8	0.1	7.7	0.1	24.1	0.3	19.0	0.3
Engineering project implementation & installation	4.4	0.1	4.3	0.1	1.8	0.0	6.9	0.1
Marks – Assignment	0.4	0.0	1.1	0.0	4.5	0.1	2.2	0.0
Specialized technical services – Other custom assembly	0.0	0.0	0.1	0.0	0.2	0.0	0.3	0.0
Technical-economic project implementation & installation	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0

Source: Central Bank of Brazil (BACEN).

Note: January-November.

Table 6.8
INPI-registered technology agreements by category – Brazil, 1996-2006

Category	No. of INPI-registered agreements										
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total	**1,543**	**1,217**	**1,520**	**1,565**	**1,687**	**2,020**	**1,944**	**1,672**	**1,523**	**1,468**	**1,559**
Technical & scientific assistance	798	644	871	953	1,077	1,213	1,280	1,082	938	828	929
Use of brands	376	244	248	262	226	320	261	234	247	237	253
Technology supply	241	210	269	223	214	269	200	181	202	186	179
Franchising	54	65	68	41	51	72	52	41	27	73	79
Use of patents	43	27	25	37	34	39	39	39	31	53	45
Other	16	24	38	49	85	107	112	95	78	91	74
R&D	15	3	1	...	...	...	...	...	...	...	...

Source: INPI. DIRTEC.

The second dimension relates to the structure of Brazilian industry. In less than 20 years the Brazilian economy has undergone profound changes. Integration with other economies is now a necessity rather than an option. Integration has led to contact with different production practices and the absorption of technology. Countless possibilities for use reinforce the adoption of technologies that are less dependent on concrete physical structures and more centered on intangible assets. This has generated deficits in the flow of technology, which as stressed throughout this chapter cannot be seen as irreversible or a reflection of a widening gap between Brazil and more developed countries. Brazil's deficit can be understood as a foundation for the development of competencies hitherto lacking or insufficient on home soil.

The proposal advanced here to avoid hasty conclusions is that continuing deficits should be accompanied by a non-contingent but structured plan capable of mapping and involving the main actors in the technology absorption process. No country, however successful it may be in terms of technology endogenisation policy, is likely to be able to remain constantly at the forefront of and master all existing technological possibilities. The challenge lies precisely in the capacity of countries and firms to build consistent relationships between local, geographically delimited competencies, and the capabilities that develop globally in fertile knowledge areas. At first glance, Brazil still appears to be influenced by factors stronger than any systematic long-term planning for a policy to monitor business technological flows, given that firms are still at a stage where they are highly dependent on foreign technology and services.

9. Final considerations

The technology balance of payments is an instrument that helps understand an economy's relations with the rest of the world and at the same time reveals elements of its nature and the dynamics of its functioning. It can be valuable as a source of questions as to the economy's structure and how its principal technological dimensions work. It is an important tool that should be used regularly and continuously enhanced.

Developed economies are typically associated with very large stocks of knowledge and technology. They also have intense technological relationships, which are invariably two-way, i.e. they both sell and buy technology. Less developed economies have far smaller technology stocks and acquire less technology from other countries. Acquiring and needing are not the same thing, of course. A country may have immense and evident technological needs and yet remain outside the world's main technology flows. The most important technology flows occur precisely in areas where firms are developing more sophisticated or ambitious solutions, and where advances are associated with a combination of original elements not available or not existing in the firm or national economy. This is the case with intangibles, technology transfer agreements, formalized knowledge and technology embodied in plant, equipment and software. Germany, the U.S. and Japan all have substantial trade flows in these areas.

Technological relations contain complexities and implicit elements that are not always fully captured by the available statistics. Moreover, as economies develop these relations reveal the highly dynamic nature of the phenomena at the base of any economy – production, competition in markets, choices between local and foreign production, appropriation of local advantages and development of scale and scope economies, to mention only a few of the factors that influence the process. Thus the TBP has an important evolutionary element: the relations established develop into new relations in the present and serve as a basis for still more in the future.

One of the most significant items in the technology dimension of Brazil's balance of payments is exports by the aeronautics industry, which are classified as high-tech. This item, which appears in the trade balance as aircraft exports, relates to various others in the past as well as the present. First, aircraft are conceived and designed, so they require knowledge and intellectual property, both local and foreign. Both can be apprehended in the form of intense exchanges involving the scientific and technological communities, institutions, firms and suppliers. This is the world of high tech, a term summed up in the idea that designing and manufacturing a product involves a large quantity and variety of knowledge, which must be brought together in order to produce a successful result, and that some of this knowledge is original or used in an original manner. But the capacity to bring new and old knowledge together in products as complex and sophisticated as aircraft depends on a large and diversified set of pre-existing capabilities that must be mastered, well-developed, deep and regularly practiced. This process dates at least from the 1920s and 1930, when the Brazil aircraft industry began.

Brazilian agriculture makes and exports products that are classified as commodities, which are invariably considered low-tech, but this does not mean they do not contain or deploy technology, knowledge and science. Indeed, their scientific and technological content has ancient origins and local as well as foreign sources. An important part of this content originated at the Campinas Institute of Agronomy and its offshoots and complements, such as the state and federal universities that formed competencies and knowledge, and built extensive links between agriculture and science. Embrapa later played a significant role. Part of this knowledge has strong local roots while also benefiting from a vast international collaborative network of researchers and students. Another part is embodied in equipment and inputs that were of foreign origin but to be successful had to be adapted and developed here. Temperate agriculture had to undergo significant changes in order to become an effective instrument of development.

Some of the technology and knowledge flows between any economy and the rest of the world are explicit and formal, often involving contracts, but most of the relationships involved occur so as to link the formal and implicit at different moments in time. Aircraft exports presuppose imports of parts, components and systems, as well as exchanges of information, knowledge and technology. The advance of Brazilian farm and livestock production is related to exports of finished goods and imports of various technological elements, both tangible (such as inputs) and intangible (such as the technological and industrial knowledge embodied in the farm machinery produced in Brazil by foreign firms). In order to export, it is necessary to import. Combining both elements enables more advanced technological production systems to be created, and these in turn require new ingredients, components and solutions.

Some decisions determine trajectories that may contain strong elements of irreversibility. The choice of a trajectory based on knowledge, training and local technological development in sectors such as aeronautics and oil greatly delayed the start of production but eventually produced superior competitiveness and a degree of development not achieved by the automotive or chemical industries, where the gap between the model chosen and the results in production and internal availability was undoubtedly narrower. Each path has different consequences in terms of the resulting dynamics. Reality offers little scope for a change of direction or for new choices. But every choice, seen from a historical perspective and compared with others, can teach highly useful lessons for the formulation of strategies and policies for industrial organizations and emerging fields of technology.

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