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BOOSTING INNOVATION PERFORMANCE IN BRAZIL

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ABSTRACT/RÉSUMÉ

Boosting innovation performance in Brazil

Brazil's main challenge in innovation policy is to encourage the business sector to engage in productivity-enhancing innovative activities. At 1% of GDP, R&D spending (both public and private) is comparatively low by OECD standards and is carried out predominantly by the government. Most scientists work in public universities and research institutions, rather than in the business sector. Output indicators, such as the number of patents held abroad, suggest that there is much scope for improvement. Academic patenting effort is being stepped up and should be facilitated by the easing of restrictions on the transfer and sharing of proceeds of intellectual property rights between businesses and public universities and research institutions. Innovation policy is beginning to focus on the potential synergies among science and technology promotion, R&D support and trade competitiveness. To be successful in boosting business innovation, these policies will need to be complemented by measures aimed at tackling the shortage of skills in the labour force; this shortage is among the most important deterrents to innovation in Brazil, particularly against the backdrop of a widening gap in tertiary educational attainment with respect to the OECD area.

This Working Paper relates to the 2006 *Economic Survey of Brazil* (www.oecd.org/eco/surveys/brazil).

JEL classification: O30, H25, I23

Key words: innovation, productivity, human capital

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Stimuler l'innovation en Brésil

En matière de politique d'innovation, le principal enjeu pour le Brésil est d'encourager le secteur des entreprises à s'engager dans des activités innovantes génératrices de gains de productivité. À 1% du PIB, les dépenses de R-D (publiques et privées) sont relativement faibles par comparaison avec les niveaux observés dans les pays de l'OCDE, et elles sont surtout imputables au secteur public. La plupart des chercheurs travaillent dans des universités et des établissements de recherche publics, et non dans le secteur des entreprises. Les indicateurs des résultats, tels que le nombre de brevets déposés à l'étranger, donnent à penser que la situation pourrait être sensiblement améliorée. Les universités déposent de plus en plus de brevets et il faudrait faciliter cette évolution en assouplissant les règles qui restreignent le transfert et le partage des recettes tirées des droits de propriété intellectuelle entre les entreprises et les universités et établissements de recherche publics. La politique d'innovation commence à mettre l'accent sur les synergies potentielles entre la promotion de la recherche scientifique et technologique, le soutien à la R-D et la compétitivité commerciale. Pour parvenir à stimuler l'innovation dans les entreprises, il faudra compléter ces politiques par des mesures destinées à remédier à la pénurie de qualifications dans la population active qui constitue l'un des principaux obstacles à l'innovation compte tenu notamment du retard de plus en plus sensible du Brésil vis-à-vis de la zone OCDE en matière d'enseignement supérieur.

Ce Document de travail se rapporte à l'*Étude économique du Brésil* 2006 (www.oecd.org/eco/etudes/bresil).

JEL classification : O30, H25, I23

Mots clés : innovation, productivité, capital humain

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Boosting innovation performance in Brazil

Carlos H. de Brito Cruz and Luiz de Mello¹

1. Introduction

Brazil's innovation performance is improving fast, but R&D intensity still lags far behind the OECD area. Brazilian scientists published 15 777 articles in indexed scientific journals in 2005 – about 1.7% of world production – almost three times as many as in the early 1990s, making the country the 17th largest producer of science in the world. Despite academic excellence in many niche areas, including photonics, materials science, biotechnology and tropical agriculture, other indicators point to the need for improvement, particularly in terms of converting knowledge into productivity gains in the business sector. At about 1% of GDP, total R&D intensity (public and private) is much lower than the OECD average of 2.2% of GDP. The number of triadic patents (*i.e.* patents filed in the world's three main patent offices) is comparatively low, as are payments of royalties and license fees to foreigners, partly reflecting the economy's relative inward-orientation and closedness to trade. Most published scientific research continues to be generated in public university laboratories, and the use of ICT technologies is somewhat less widespread than in countries with comparable income levels. Process, rather than product, innovations account for the bulk of innovative activities in the business sector. Some of the framework conditions for innovation are yet to be fulfilled, despite macroeconomic stabilisation since the mid-1990s: the cost of capital is high, GDP growth has been volatile, and some aspects of financial markets need to be liberalised further (OECD, 2005, 2006a).

The key elements of Brazil's innovation policy are spelled out in the 2002 *White Book on Innovation*. The current policy framework, known as PITCE (*Política Industrial, Tecnológica e de Comércio Exterior*), launched in late 2003, focuses on the promotion of R&D activities in the business sector, aiming at better integrating innovation into the government's industrial and foreign trade policies. Recent legislation, enacted in 2005, introduced new tax incentives for innovation as part of a broader package for reducing the tax burden on the business sector and facilitated the sharing of intellectual property rights (IPR) proceeds between businesses and public universities and research institutions. But, more generally, the current policy framework will need to be complemented by measures aimed at tackling the shortage of skills in the labour force, which is among the most important deterrents to innovation in Brazil, particularly against the background of a widening gap in tertiary educational attainment with

1. This paper is part of the *Economic Survey of Brazil*, published in November 2006 under the authority of the Secretary General of the OECD and discussed at the Economic and Development Review Committee (EDRC) on 10 October 2006. Luiz de Mello is Head of the Brazil/South America Desk of the Economics Department of the OECD and Carlos H. de Brito Cruz is Scientific Director of FAPESP, State of São Paulo Research Foundation. The authors want to thank, without implicating, Andrew Dean, Peter Jarrett, Val Koromzay and Diego Moccero, as well as Brazilian experts, especially Léa Contier, Ministry of Science and Technology; João A. de Negri, IPEA; and Rosana C. di Giorgio, Roberto Lotufo, Sérgio Queiroz and Sérgio Salles Filho, University of Campinas, for helpful comments and discussions. Special thanks are due to Anne Legendre for research assistance and Mee-Lan Frank for excellent technical assistance.

respect to the OECD area and a still considerable differential in quality-adjusted upper-secondary education attainment.

Against this background, this paper reviews the main elements of Brazil's innovation policy and discusses policy options for improving the country's innovation performance. The remainder of the paper is organised as follows. Section 2 compares and contrasts Brazil's innovation indicators with those of OECD and Latin American countries. Section 3 discusses the main government support instruments, including tax incentives for innovation. Section 4 briefly reviews the country's higher education system. The paper's main policy recommendations are discussed in Section 5 and summarised in Box 8.

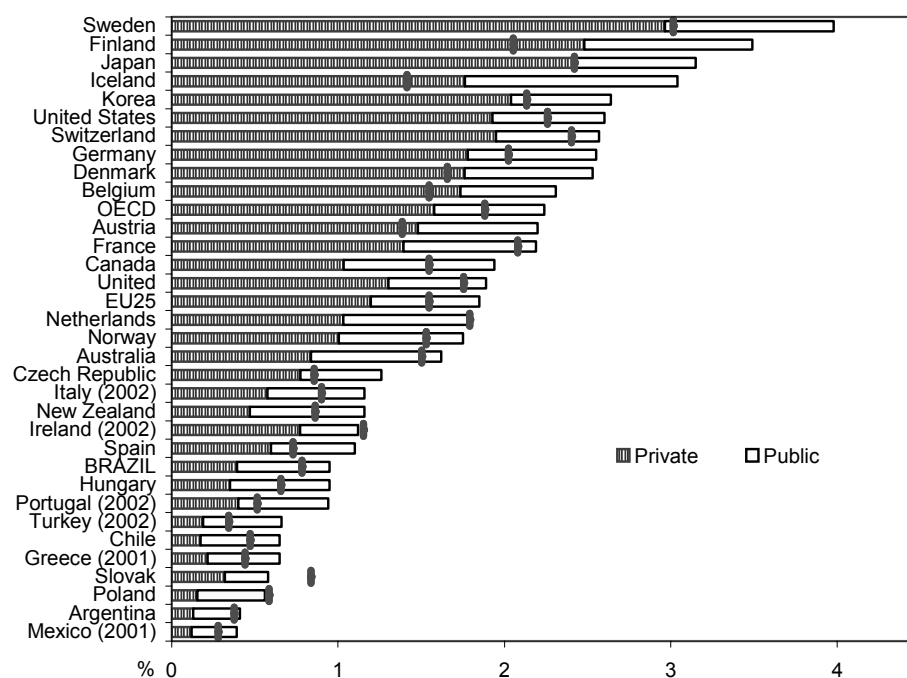
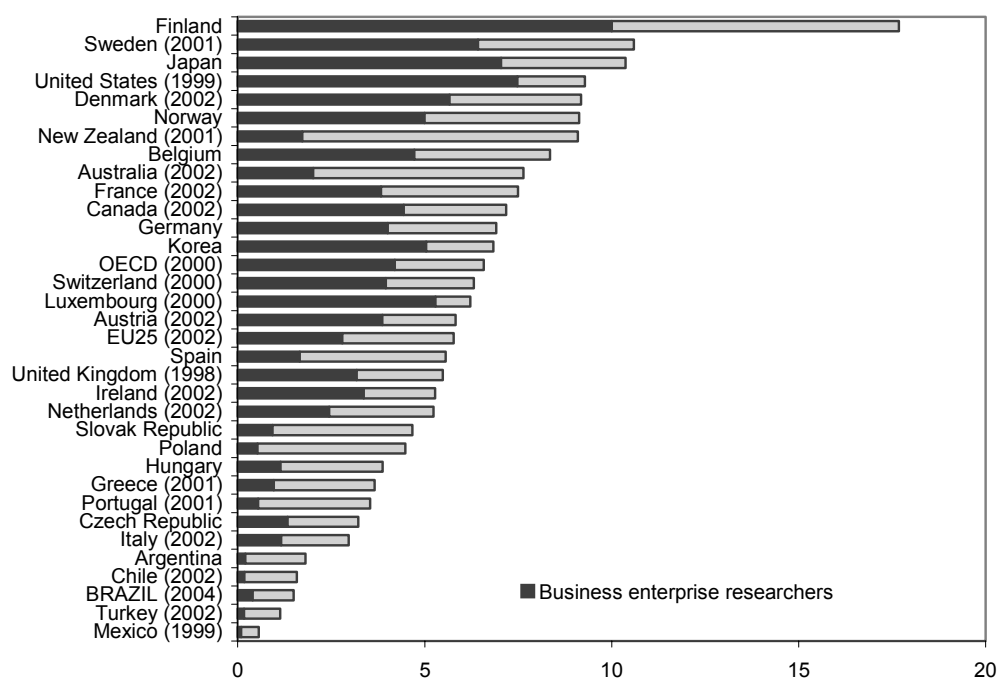
2. Background and main issues

An overview of input indicators

R&D intensity is comparatively low by OECD standards and overly reliant on government, as is common in countries with relatively low R&D intensity. At about 1% of GDP since 2002, total (public and private) spending on R&D lags well behind the OECD average of about 2.2% of GDP, although it is the highest in Latin America (Figure 1). About 60% of R&D activity is carried out and financed by the government. The lion's share of government support (almost two-thirds of government spending on R&D) is directed to public universities and research institutions, with a small share devoted to businesses (Table 1). At the same time, co-operation between businesses and universities for joint R&D projects is rare. By contrast, about 5% of funding for R&D carried out by universities and research institutions comes from the business sector in the OECD area on average (about 7.5% in the United States) (OECD, 2005). Consistent with relatively low government-oriented R&D intensity, the number of scientists working in the business sector is below par in comparison with the OECD area. In addition, the use of ICT technologies – a pre-requisite for the development of a knowledge-based economy – is somewhat less widespread than in countries with comparable income levels (Figure 2).

In a decentralised federation such as Brazil, the states play an important role in financing R&D, although most support comes from the federal government, and in the design of science and technology (S&T) policies. Programmes aimed at fostering human capital accumulation and academic research accounted for over two-thirds of federal spending on R&D in 2002 (Table 2), including funding for the 52 federal higher-education institutions, CNPq and CAPES (the two federal post-graduate research support agencies), followed by transfers to EMBRAPA, the Brazilian Agricultural Research Corporation (Box 1). The states enjoy full autonomy to set their own S&T policies, and several have their own support agencies, as well as higher-education and research institutions. The Ministry of Science and Technology estimates that about 35% of government spending on S&T in 2003 was funded by the states.

The largest state-level R&D support system is that of the state of São Paulo, which is also the largest recipient of federal funds. Nevertheless, about two-thirds of public funding for R&D in the state of São Paulo comes from state sources, including funding for three state universities, 19 research institutions and FAPESP, the state's S&T support agency (FAPESP, 2004). The strong support by the state government makes the state of São Paulo the second largest investor in R&D in Latin America, ahead of Mexico and Argentina. But other states are also active in this area, including Rio de Janeiro, Minas Gerais and Rio Grande do Sul, although their S&T budgets are much smaller.

Figure 1. **R&D intensity and number of researchers: Argentina, Brazil, Chile and OECD countries, 2003****A. R&D intensity (in % of GDP)¹****B. Researchers (per thousand total employment)**

1. The dots identify the R&D intensity levels in 1995.

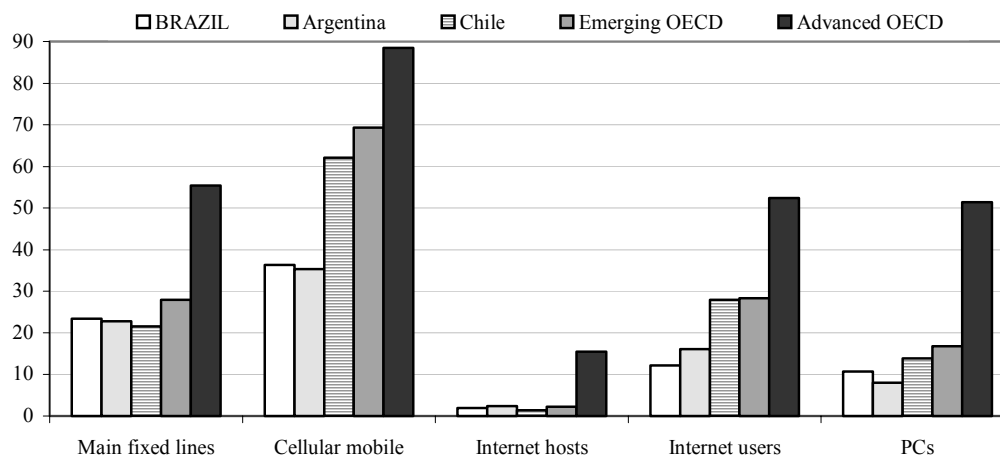
Source: Ministry of Science and Technology, Conicyt (for Chile), Ricyt (for Argentina and Mexico), OECD and STI database.

Table 1. **R&D intensity: Sources and use of funds, 2004**
In billions of BRL

Destination	Source			Total
	Government	Business	Universities	
Total	9.3	6.4	0.4	16.1
Government	3.4	3.4
Business	0.0	6.4	...	6.4
Universities	5.8	...	0.4	6.2

Source: Ministry of Science and Technology (*Indicadores Nacionais de Ciência e Tecnologia*).

Figure 2. **Penetration of information and communication technologies (ICT): Argentina, Brazil, Chile and OECD countries, 2004**
Units per 100 inhabitants



1. Unweighted averages. Emerging OECD refers to Czech Republic, Hungary, Mexico, Poland, Slovak Republic and Turkey. Advanced OECD refers to the remaining Member countries.

Source: International Telecommunications Union.

Table 2. **Federal R&D expenditure, 2002¹**
In millions of *reais*

Programmes	Total	Share of spending (per cent)	Ministry
Total outlays	4 549.1	100.0	
Higher education R&D	1 556.7	34.2	Education
EMBRAPA	600.9	13.2	Agriculture
CNPq	525.5	11.6	Science and Technology
CAPES	460.7	10.1	Education
Ministry of Science and Technology	331.8	7.3	Science and Technology
FIOCRUZ	331.0	7.3	Health
FNDCT	326.7	7.2	Science and Technology
National Foundation for Health	164.5	3.6	Health
National Health Fund	164.4	3.6	Health
Ministry of Education	20.6	0.5	Education
Navy	16.2	0.4	Defence
Air force	14.9	0.3	Defence
Nuclear Energy Commission (CNEN)	13.4	0.3	Science and Technology
Brazilian Space Agency (AEB)	11.0	0.2	Science and Technology
Ministry of Environmental Affairs	10.8	0.2	Environment

1. Compiled from http://www.mct.gov.br/estat/ascavpp/portugues/2_Recursos_Aplicados/tabelas/tab2_5_2.htm and http://www.mct.gov.br/estat/ascavpp/portugues/2_Recursos_Aplicados/tabelas/tab2_5_2.htm (for higher education).

Source: Ministry of Science and Technology.

Box 1. **EMBRAPA: The Brazilian Agricultural Research Corporation**

EMBRAPA was created in 1973 to “develop solutions for the sustainable development of the country’s rural areas, focusing on agribusiness through the generation, adaptation and transfer of knowledge and technologies to benefit Brazilian society”. It has 37 research centres (including 3 service units and 11 central divisions) and 2 221 researchers, 53% of whom hold a PhD or other doctoral degree.

Most research centres carry out commodity-specific research, while others are involved in thematic research (e.g. environment, genetic resources and biotechnology, agro-biology, among others) and/or regional issues. The corporation also has two overseas laboratories, in France and the United States. EMBRAPA focuses on technological upgrading in farming by developing techniques for biological and integrated control of harmful biological agents. It also coordinates the National System of Agricultural R&D, including federal and state-level R&D institutions, universities and businesses, which, in a co-operative manner, develop R&D projects relevant to different regions of the country.

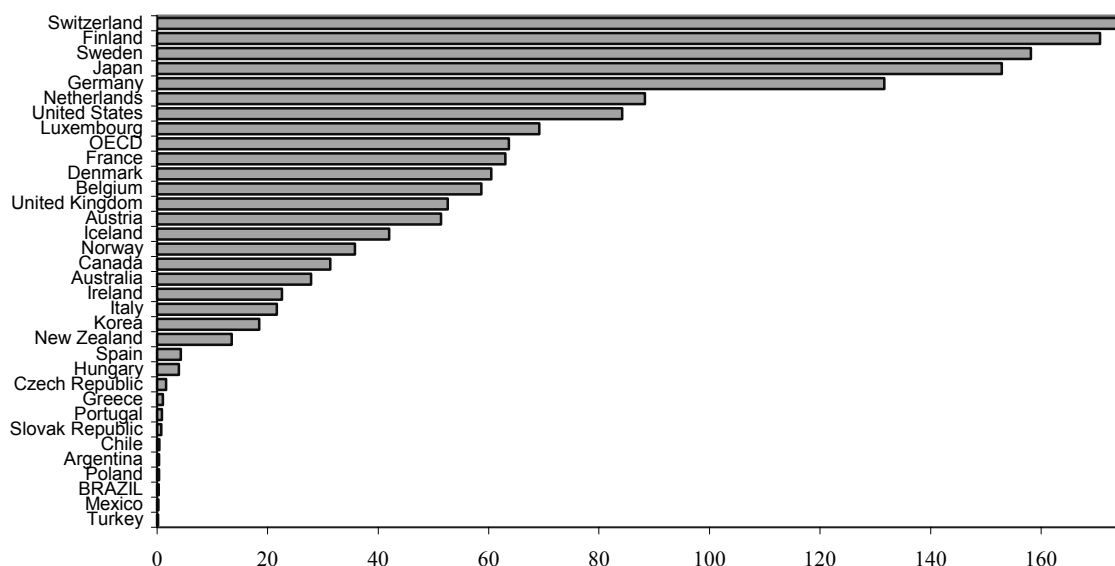
EMBRAPA and its sister institutions at the state level are reputed to play a key role in agricultural R&D, which has helped Brazil to become one of the world’s largest agricultural producers and a competitive, low-cost exporter of such commodities as soybeans, sugar, coffee, oranges and meat. Agricultural exports totalled around USD 30 billion in 2004, or almost one-third of Brazil’s total merchandise export revenue.

An overview of output indicators

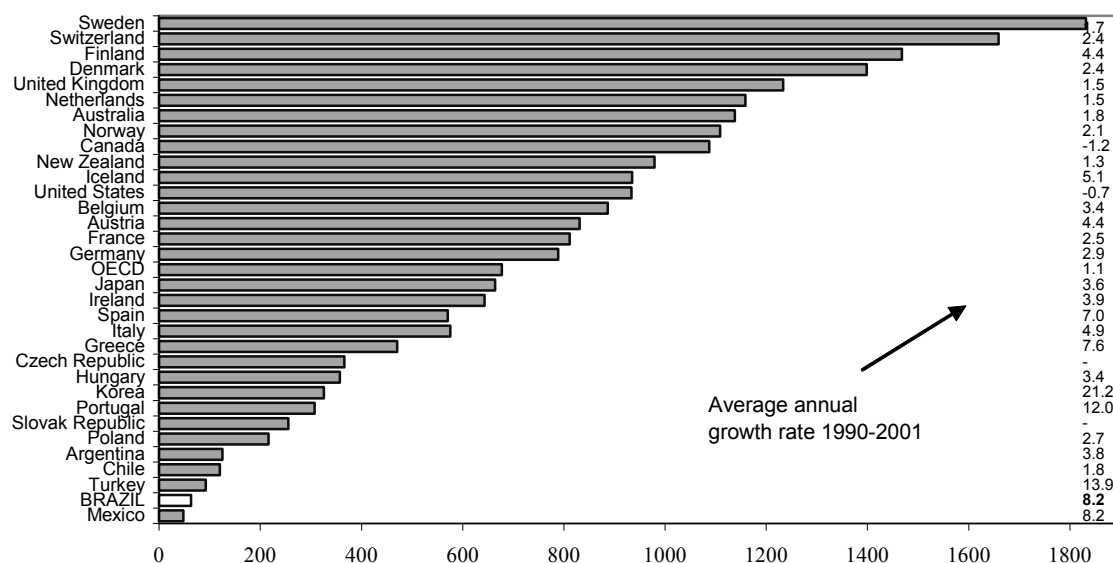
The number of scientific publications originated in Brazil – a usual indicator of R&D output – has been growing steadily over time (Figure 3), reaching 1.7% of the world total in 2004, against 0.4% in 1981. Publication performance is higher than average in the fields of agronomy and veterinary

Figure 3. **Triadic patents and scientific publications: Argentina, Brazil, Chile and OECD countries**
Per million of working-age population

A. Triadic patents, 2002¹



B. Publications in science and engineering, 2001



1. Patents are reported by inventor's country of residence and priority date, using fractional counting procedures.

Source: OECD (Patent Database, January 2006), Institute for Scientific Information, Science Citation Index and Social Science Citation Index: CHI Research, Inc., Science Indicators database and National Science Foundation.

medicine (3.1%), physics (2.0%), astronomy and space science (1.9%), microbiology (1.9%), and plant and animal sciences (1.8%). Information for 2000 shows that 50% of the academic articles published then were in the field of life sciences, 33% in physical sciences, 13% in engineering, technology and mathematics, and 3% in social and behavioural sciences. This distribution is similar to the OECD average (OECD, 2003). The number of citations of Brazilian scientific publications also rose over time, from 1 056 per

article published in 1981 to 1 862 per article published in 1998 (Leta and Brito Cruz, 2003).² As expected, the increase in the number of scientific publications follows closely the rise in the number of PhDs awarded every year, from 554 in 1981 to 8 856 in 2004. Notwithstanding this trend, the country still faces a shortage of higher-education graduates, especially in engineering and science. As discussed below, attainment in higher education is also below the OECD average, and the gap is widening.

A growing scientific community has allowed for the development of collaborative research programmes that require a large number of researchers. Recent experience in this area is promising and has the potential for engaging the business sector in commercially-oriented research. For example, the Genome Project, set up in São Paulo in partnership with the Citrus Producers' Association (Fundecitrus), resulted in the DNA sequencing of a phyto-pathogenic bacterium, the *Xylella Fastidiosa*, which allowed Fundecitrus researchers to devise ways to protect orange trees from a disease (*citrus variegated clorosis*, CVC) that had been associated with considerable economic loss in the past. The joint venture also generated at least two spin-off companies in the field of genomics and bioinformatics. Another example is the Biota Research Programme, a conservation and sustainable development-oriented biodiversity research effort to study and map biodiversity in the state of São Paulo (Box 2).

Notwithstanding these achievements, and considering the size of the Brazilian economy and its scientific production, the number of triadic patents held by residents is comparatively low. This relatively poor performance certainly arises from the low R&D intensity in the business sector, which reflects at least

Box 2. The Biota Research Programme: Innovation and sustainable development

BIOTA, a "Virtual Institute of Biodiversity", has been studying and mapping the biodiversity of the state of São Paulo since 1999, aiming at conservation and sustainable development. Participating researchers, including approximately 400 PhDs and 500 graduate students, are affiliated with 16 research institutions. Participation is open, subject to the approval of research projects in a peer-review process carried out by FAPESP. There are 80 collaborators from other Brazilian states and approximately 50 from abroad.

With an annual budget of approximately USD 2.5 million, the Biota/FAPESP programme has sponsored 75 major research projects since its creation in 1999. It has trained 150 MSc and 90 PhD students, produced/stored information about approximately 10 000 species and made data available from 35 major biological collections. This research effort is summarised in 464 articles published in 161 scientific journals. The programme has published 16 books and 2 atlases.

An open-access electronic peer-reviewed journal, *Biota Neotropica* (<http://www.biotaneotropica.org.br>), was launched in 2001 to disseminate original research on biodiversity in neotropical regions. The journal is becoming an international reference in its area. A new venture called *Bioprospecta* (<http://www.bioprospecta.org.br>) was launched in 2002 to search for new compounds for pharmaceutical or cosmetic use. As a result of this initiative, patent applications have been filed for three new drugs.

The international scientific advisory board that evaluates the Biota/FAPESP programme considered that "science in most BIOTA projects is of high quality equivalent to, or exceeding, that in other countries; in several projects, it is of outstanding quality at the cutting edge of international efforts. In many respects the BIOTA program provides an example and sets standards that many countries would be happy to follow".

2. The number of ISI (Institute for Scientific Information) publications underestimates scientific production because it excludes publications in local outlets. In order to enhance the visibility of Brazilian scientific production, in 1999 FAPESP and the Latin American and Caribbean Centre for Health Sciences Information organised an open-access web portal, *SciELO* (Scientific Electronic Library Online, www.scielo.org), offering access to more than 150 peer-reviewed journals. See Alonso and Fernández-Juricic (2002) for more information.

in part the dearth of scientists working in private enterprises. In Korea and the United States, for example, close to 80% of scientists work in the business sector, against only 26% in Brazil. Other countries have a much stronger patenting performance with a comparable number of researchers. For instance, Spain has approximately the same number of researchers working in the business sector as Brazil (roughly 20 thousand) and holds almost three times more patents. This discrepancy might follow from a gap between the two countries in skills, given that only 8.7% of the scientists working in the business sector (including non-profit enterprises) in Brazil hold at least a post-graduate degree (according to IBGE/PINTEC), as well as in the quality of inputs, such as machinery and equipment. But it also reflects the fact that the Brazilian economy is more closed to foreign trade. Brazilian enterprises are therefore relatively less exposed to competition in foreign markets and invest less abroad, which weakens the incentives for having their IPR protected in foreign markets. As an attempt to tackle this problem, in 2005 the authorities introduced a deductibility of 50% of spending on salaries paid to scientists from the corporate income tax. Because this measure is recent, it is too early to assess its cost-effectiveness.

Another consideration is that patenting activity is dominated by the government. Petrobras, the government-controlled oil company, is Brazil's most important holder of triadic patents. Nevertheless, academic patenting is gaining momentum, which is a positive development. Successful examples include the University of Campinas (Unicamp) and the Federal University of Minas Gerais (UFMG), in addition to FAPESP in the state of São Paulo. Unicamp has a long tradition in patenting in Brazil and is the nation's largest holder of domestic patents, followed by Petrobras. The university created an innovation agency, *Inova*, in 2002, which has focused on licensing and is generating revenue for the university from its IPR proceeds (Box 3). Most of the licenses are exclusive, since the licensee takes part in the development of intellectual property through co-operative R&D agreements with the university. In any case, it is important

Box 3. Academic patenting: The case of *Inova*

The University of Campinas's Agency for Innovation – *Inova* – was created in 2002 to foster university-industry co-operative ventures in R&D, consulting and intellectual property licensing.¹ With a staff of 49, *Inova* has already filed 40 patents and 3 non-proprietary technologies in 21 contracts. Prior to *Inova*'s foundation, Unicamp, one of the country's most renowned centres for science and technology, held only 8 filed patents. Unicamp also created a Technology Transfer Office in 2002 in support of its patenting effort.

During 2004-05, *Inova* intermediated 87 licensing contracts with businesses, which increased Unicamp's revenue from intellectual property licensing by 60% and the number of patent applications submitted to INPI (*Instituto Nacional de Propriedade Industrial*) by one-third to 66 applications in 2005. Licensing contracts included mainly pharmaceuticals and phyto-therapeutic agents, food processing and nanotechnology-incorporated products. The first product to be licensed (May 2004) was *Aglycon Soy*, a soy-derived phyto-therapeutic agent to be used in hormone replacement therapy, launched commercially in March 2006. *Inova* executives estimate the product will generate BRL 12 million per year in royalties from 2008.

The licensing of Biphor™ to *Bunge Alimentos* is *Inova*'s most important endeavour. Biphor™ is a new nanotechnology-based, environmentally-friendly white pigment for paint, coatings and allied products, jointly developed by *Bunge Alimentos* and Unicamp's Chemistry Institute. *Bunge*'s Brazilian subsidiary, the largest South American manufacturer of fertilisers, built a state-of-the-art, large-scale pilot plant, which is already producing Biphor™ samples. *Bunge* estimates its white pigment could have a 10% world market share by 2010, resulting in annual royalty payments to *Unicamp* in the neighbourhood of USD 45 million over the next decade.

Inova is also working closely with 100 spin-off companies, coordinating studies for the implementation of a technology park adjoining *Unicamp*.

1. See www.inova.unicamp.br for more information.

to note that, although it is widely used, the number of patent holdings is an imperfect measure of innovation output, because, among other reasons, it fails to gauge the outcome of innovation in firms that prefer to exercise property rights through trademarks and copyrights. Firms may also prefer to keep commercially sensitive information secret for fear of having their intellectual property leaked to competitors in the process of patent registration.

Recent R&D initiatives have a strong focus on sustainable development. This is the case of the use of ethanol to replace fossil fuels. About three-quarters of the new automobiles currently sold in Brazil are of the flex-fuel type (as of January 2006), and ethanol has traditionally been added to gasoline (at a maximum rate of 25%) to reduce emissions. Brazil is the largest ethanol producer in the world, and R&D joint ventures among industry, government and universities are focusing on developing better sugar cane varieties, and more efficient planting, harvesting and refining methods to reduce production costs further, although they are already low by international comparison. The *Pro-Álcool* programme implemented in the 1970s was a precursor to the current innovative efforts in this area.

Innovation in the business sector

Brazilian firms tend to engage predominantly in process, rather than product, innovations. According to the Innovation Survey (PINTEC) conducted by IBGE, the National Statistics Bureau, about one-third of Brazilian firms with at least 10 employees engaged in innovative activities during 2001-03, but only 6% of businesses reported to have engaged in innovative activities aiming exclusively at product innovations over the same period (Table 3).³ This 6% ratio remained fairly stable since 1998-2000. Comparison with the European Innovation Survey (EIS) is informative. Brazil's overall innovation rate is comparable to that of Spain in the OECD area, but lower than the European average of about one-half. Consistent with emphasis on process innovations in the business sector, the acquisition of machinery and equipment, which embody technologies developed elsewhere, is reported as being the main source of innovation by Brazilian firms. Costs, economic risk and a lack of external financing are deemed the main obstacles to innovation. The increase, from an already relatively high base, in the share of respondents that identified a scarcity of skilled labour and difficulty in adopting standards is noticeable from the earlier to the more recent period.

Small enterprises are becoming more innovative, especially for the development of new products. As a general trend, firms that innovate in products also tend to innovate in processes, but process innovations are often aimed at reducing costs through the diffusion of better existing technologies, rather than at pushing out the technological frontier. Although the sectors that tend to be dominated by large enterprises still account for the bulk of spending on R&D, the innovation rate has been rising faster in the sectors that are more closely associated with a prevalence of smaller enterprises. For example, the motor vehicle and transport equipment sectors accounted for, respectively, 26% and 13% of total R&D expenditure in 2003 (Figure 4). The innovation rate in the clothing and wood product sectors rose, respectively, from about 26% to 32% and from just over 14% to 31% between 1998-2000 and 2001-03. The increase in the sectoral innovation rates appears to be conducive to labour productivity gains (Figure 5), although this channel of causality would need to be examined more thoroughly, taking account of additional determinants of labour productivity growth.

Competition fosters innovation in the business sector. Recent empirical evidence shows that Brazilian firms' innovation effort depends strongly on the market share of foreign affiliates in the sectors where they operate (Araújo, 2005; de Negri *et al.*, 2005). This suggests that competition encourages

3. PINTEC surveys a sample of over 84 000 enterprises accounting for total turnover of about USD 850 billion (at a PPP exchange rate) and reported R&D expenditures of USD 4.5 billion (PPP).

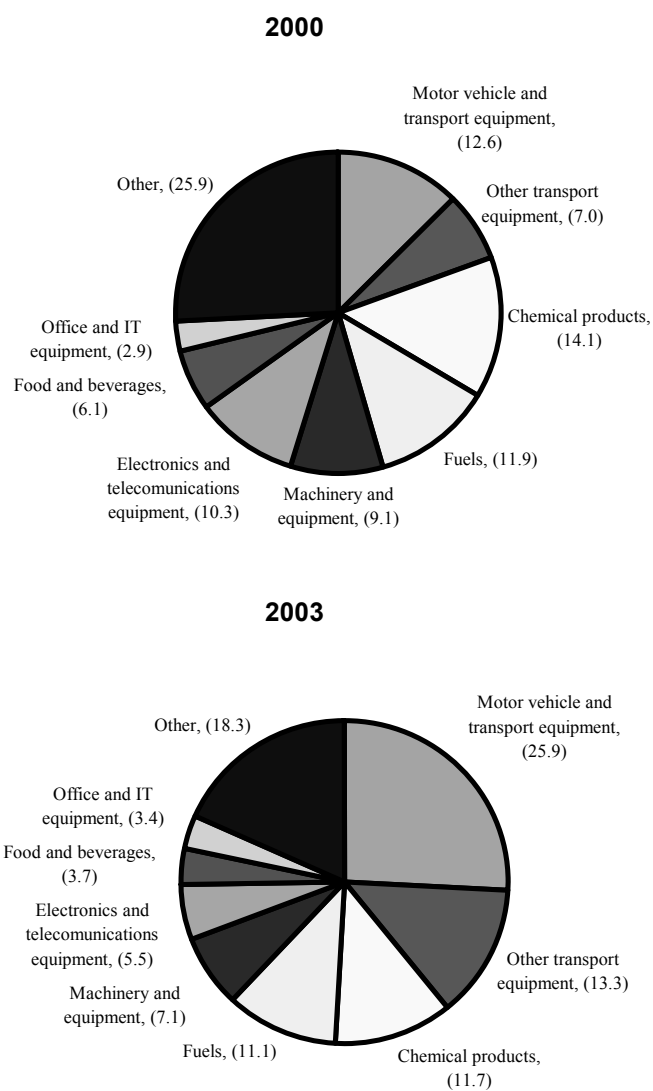
Table 3. Business innovation indicators: 1998-2000 and 2001-03
In per cent of firms with at least 10 employees

	1998-2000	2001-03
Innovation rate		
Product	6.3	6.4
Process	13.9	12.9
Product and process	11.3	14.0
Any type of innovation	31.5	33.3
<i>Memorandum items:</i>		
Product innovation rate		
Small firms (10-49 employees)	14.1	19.3
Large firms (+500 employees)	59.4	54.3
Process innovation rate		
Small firms (10-49 employees)	21.0	24.8
Large firms (+500 employees)	68.0	64.4
Source of innovation		
Acquisition of machinery and equipment	76.6	80.3
Labour training	59.1	54.2
In-house R&D	34.1	20.7
Main obstacles to innovation		
Costs	82.8	79.7
Economic risk	76.4	74.5
Scarcity of financing	62.1	56.6
Shortage of skilled labour	45.6	47.5
Lack of information	36.6	35.8
Difficulty to adopt standards	25.1	32.9

Source: IBGE (Innovation Survey, PINTEC) and OECD calculations.

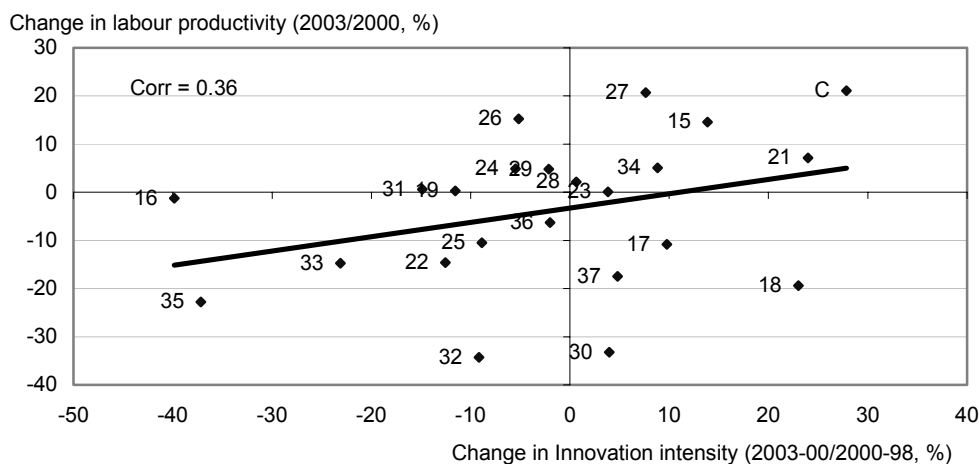
innovation as a means of catching up with the efficiency level of foreign affiliates. Nevertheless, according to PINTEC, foreign affiliates innovate less than Brazilian firms, at least on the basis of reported R&D spending in relation to turnover. This is likely due to the fact that foreign affiliates already have access to best-practice technologies developed by parent companies located overseas. These firms may also be present in less technology-intensive sectors, such as the exploitation of natural resources. At the same time, Brazilian firms with operations overseas tend to engage more in product innovations at home, to demand more skilled labour and to spend more on labour training than their counterparts that do not have operations abroad. This suggests that exposure to competition in foreign markets, as well as the need to adapt to foreign demands, creates an innovation spillover effect at home. This evidence is consistent with the positive effect of trade openness on labour productivity, discussed in OECD (2006a), Chapter 1, and with the evidence available for OECD countries that competition in product markets encourages innovation.

Figure 4. **Composition of in-house R&D intensity by manufacturing sector: 2000 and 2003¹**
In per cent of total



1. The numbers in parentheses are the sector's percent share in total spending.

Source: IBGE (Innovation Survey, PINTEC) and OECD calculations.

Figure 5. Innovation and labour productivity by sector¹

National sectoral classification system (CNAE):

C Mining and quarrying

D Manufacturing:

15 Food and beverages

16 Tobacco

17 Textile products

18 Wearing apparel and accessories

19 Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear

21 Cellulose, paper and paper products

22 Printing and publishing

23 Fuels

24 Chemical products

25 Rubber and plastics products

26 Non-metallic mineral products

27 Basic metal industries

28 Fabricated metal products, except machinery and equipment

29 Machinery and equipment

30 Office and IT equipment

31 Electrical machinery and apparatus n.e.c.

32 Electronics and telecommunications equipment

33 Medical and optical equipment

34 Motor vehicle and transport equipment

35 Other transport equipment

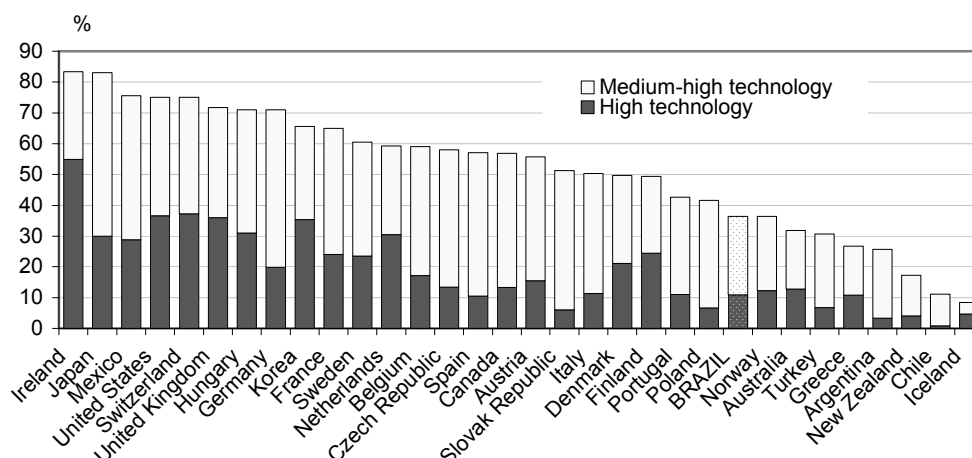
36 Furniture and other manufacturing industries

37 Recycling

1. Excludes manufacturing of wood products. Labour productivity is defined as value added per employee.

Source: IBGE (Innovation Survey, PINTEC; and Annual Industrial Survey, PIA) and OECD calculations.

Innovation and scale efficiency are powerful determinants of Brazilian firms' propensity to export. In the case of manufacturing, exporting firms tend to be more scale-efficient, in the sense of being closer to their respective sector's technological frontier, and to have a better educated labour force than non-exporting firms (de Negri and Freitas, 2004). This is regardless of the sector in which the firm operates. The innovation intensity of competing firms, measured by their R&D spending, is also associated with firms' export propensity (Kupfer and Rocha, 2005). The existence of an association between a firm's innovation rate and its propensity to export is important for Brazil to exploit comparative advantages and therefore to increase the technological content of its exports (Figure 6). It also underscores the logic of the increasing policy effort to integrate, and maximise synergies, among policies in the areas of innovation and trade competitiveness.

Figure 6. Technological content of exports: Argentina, Brazil, Chile and OECD countries, 2000-04 averages¹

1. Exports with high technological content refer to ISIC Rev 3 codes 353, 2423, 30, 32, and 33; and exports with medium-high technological content refer to ISIC Rev 3 codes 31, 34, 24 (except 2423), 352, 359, and 29.

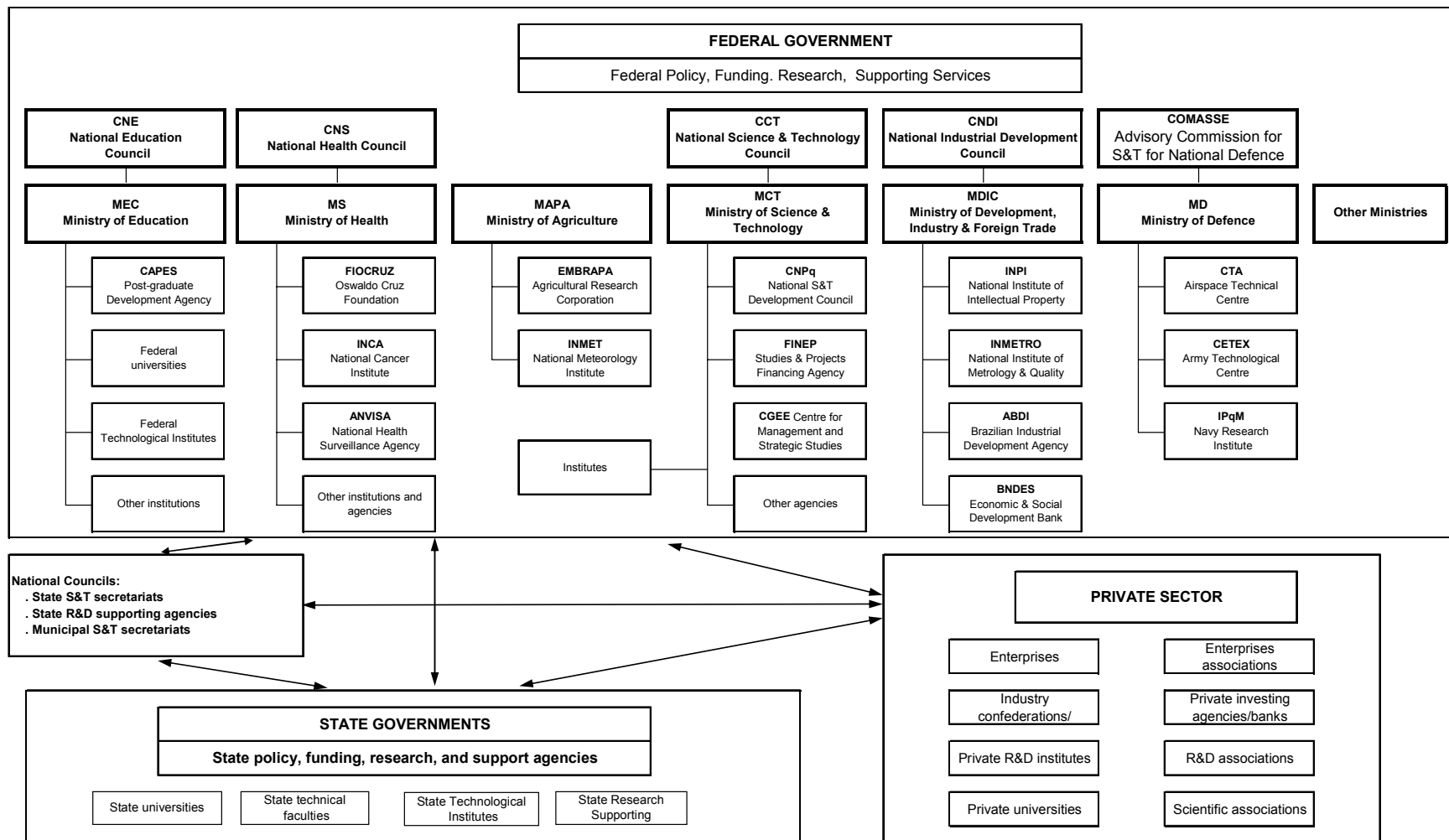
Source: OECD (STAN database), UN Commodity Trade Statistics database (UN Comtrade) and OECD calculations.

Brazilian manufacturing firms seldom engage in co-operative ventures for innovation. Based on the indicators available from PINTEC and the EIS, only about 11% of innovative enterprises in Brazil co-operate with other firms or universities/research institutions, against 17% in the European Union (Cassiolato *et al.*, 2005). The most important sources of innovation are internal in both Brazil and the EU countries covered by the EIS. Also, Brazilian firms tend to rely more on clients and suppliers as a source of knowledge than their European counterparts, possibly reflecting the importance of *learning by using* in process innovations, which account for the bulk of innovation in the business sector. Brazilian firms also rely on information from competitors as a source of knowledge, which is probably due to the importance of *learning by imitating* in innovation in the business sector. Scale effects also matter, with large firms having a higher propensity to co-operate.

The National Innovation System

Brazil's National Innovation System (NIS) is complex (Figure 7), but co-ordination between federal and state-level S&T agencies is being fostered. State and federal support initiatives are designed and implemented separately, which may lead to overlapping institutional settings and fragmentation in funding and policy design. However, efforts are being stepped up to promote inter-governmental coordination through the National Council of State Secretaries for Science, Technology and Innovation (CONSECTI) and the National Council of State Research Agencies (CONFAP) in many policy fora, especially in the National Council of Science and Technology (CCT). At the federal level, CCT, an advisory body to the Presidency, is entrusted with a policy coordination role, while the Ministry of Science and Technology (MCT) acts as an executive body with the assistance of FINEP (MCT's financial support agency), CNPq (*Conselho Nacional de Desenvolvimento Científico e Tecnológico*) and CGEE (*Centro de Gestão e Estudos Estratégicos*). On the other hand, industrial policy is formulated by the Ministry of Development, Industry and Trade (MDIC) through CNDI (*Conselho Nacional de Desenvolvimento Industrial*) and ABDI (*Agência Brasileira de Desenvolvimento Industrial*). Coordination among these agencies is promoted by representation of MCT and MDIC in both CCT and CNDI. The sectoral funds (discussed below) are governed by MCT, with the assistance of a technical secretariat. Each fund has a management committee and coordination is fostered through regular meetings that bring together the presidents of these committees under the purview of the Minister of Science and Technology.

Figure 7. National Innovation System



Source: Ministry of Science and Technology.

3. The mix of incentive instruments

Direct government support

The mix of instruments to foster innovation is tilted towards direct government support (excluding non-research transfers to universities and research institutions), rather than tax incentives, when gauged by the volume of budgetary resources mobilised and tax revenue foregone. Federal support for innovation is financed through a fund, FNDCT (*Fundo Nacional de Desenvolvimento Científico e Tecnológico*), managed by FINEP (Ministry of Science and Technology). FNDCT was created in 1969 to support scientific research in universities and research institutions. An important shift in policy took place in 2000-02 with the creation of the sectoral funds within FNDCT, when direct support began to focus on fostering sector-specific co-operative ventures between business and universities/research institutions, financed essentially through the earmarking of revenue from specific taxes and contributions (Box 4).

Impact assessment is not carried out systematically, despite the growing importance of the sectoral funds as a vehicle for direct government support for innovation. However, according to recent empirical evidence, the creation of the support funds, including FNDCT, appears to be associated with an increase in patent registration by beneficiary enterprises (de Negri *et al.*, 2006a and 2006b). But evidence is inconclusive as to their impact on productivity. This is in part due to the funds' emphasis on encouraging R&D rather than productivity gains *per se*. It takes time for a sustained emphasis on support for innovation *via* collaborative ventures to deliver durable productivity enhancement. Another consideration is that beneficiary firms often already have above-average productivity; they tend to be large enterprises that actively engage in R&D, to have a better educated labour force and to be exposed to competition in foreign markets through exports. In this regard, the deadweight losses associated with this support instrument may be large. The sectoral funds' ability to foster innovation in firms that would otherwise not innovate, and hence have lower productivity, therefore needs to be assessed more thoroughly. Support for innovation financed through BNDES also tends to focus predominantly on large, more productive enterprises, which underscores the policy objective of extending support to those enterprises that would otherwise not innovate. As an initial step towards meeting this challenge, in February 2006 BNDES announced the creation of credit lines in support of innovation activities in small and medium-sized enterprises, including university start-ups.

Public procurement is not used as an explicit support instrument for innovation. There has been continued pressure from the private sector for the government to adopt a more pro-innovation stance in its procurement policy. But Brazilian legislation does not provide for special treatment in public procurement depending on the technological content of purchases, even in the areas of defence and health care. The authorities are nevertheless considering policy options in this area, although so far little progress has been made. Notwithstanding these considerations, there are successful examples related to government procurement and technological development, including the establishment of the aeronautics industry at EMBRAER, the development of ethanol as an alternative fuel with the *Pro-Álcool* programme and the development of a competitive agribusiness sector under the stewardship of EMBRAPA. In any case, it should be noted that innovative procurement, as opposed to purchases of standardised goods, poses challenges.³ It calls for policy effort on several fronts, including the identification of requirements and specifications that could lead to a successful design of the goods or services to be commissioned, as well as the qualification of suppliers and the design of the tendering process itself. Abidance by international regulations is important. So is the need to ensure a balanced sharing of risk between the government and the supplier in the course of projects and subsequently to allocate intellectual property rights between the government and the supplier once projects have come to fruition.

3. See Fraunhofer Institute for Systems and Innovation Research (2006) for more information and analysis of case studies for selected European countries.

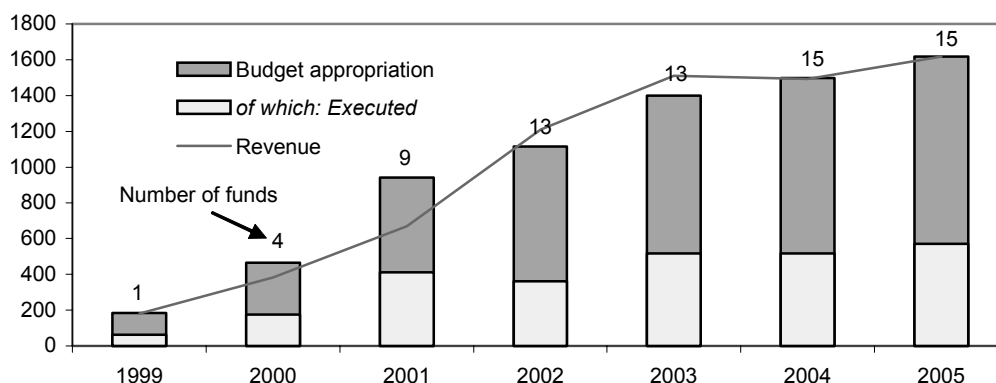
Box 4. Direct government support: The “sectoral funds”

The sectoral funds have become the most important instrument for delivering direct government support for innovation. There are currently 16 such funds in operation, including the Telecommunications Fund (FUNTEL), which is administered by the Ministry of Telecommunications.

Most sectoral funds are primarily financed by levies on enterprise turnover in the network industries that were privatised in the 1990s, including energy and telecommunications. The introduction of these sector-specific levies was justified as a means of preserving innovation intensity after privatisation, given that the former State-owned enterprises that had hitherto dominated the network industries were active R&D investors. Other sources of finance for the sectoral funds are the earmarking of revenue and a 10% levy on payments to non-residents for technical assistance and royalties. Due to the introduction of the sector-specific levies, financing for innovation rose in tandem with the increase in utility prices after privatisation. The composition of revenue sources varies across the sectoral funds.

The additional flow of revenue into FNDCT associated with the creation of the sectoral funds was estimated in 2000 at BRL 1.1 billion per year during 2000-05. However, actual disbursements have failed to keep up with the increase in financing, partly due to the sequestration of budgetary appropriations (*contingenciamento*) in support of the government's fiscal retrenchment efforts (Figure 8).

Figure 8. Sectoral funds: Revenue and disbursements, 1999-2005¹
In millions of reais of 2005



1. Deflated by the GDP deflator. The number of funds in operation refers to those under FINEP's executive purview.

Source: Ministry of Science and Technology.

Each sectoral fund has a Steering Committee with members from academia, government and industry. These committees make all disbursement decisions, usually aiming at a balance between basic and applied science. Typically, the sectoral funds can finance projects only in their respective sector of activity, although 40% of their funding can be allocated to cross-sectoral activities, which pool resources from different funds. Support is directed predominantly to universities and research institutions, which may work alone or engage in joint ventures with the business sector. Support cannot be granted to enterprises directly. Nevertheless, on average approximately two-thirds of disbursements consist of joint ventures between businesses and research institutions, despite considerable variation across funds. In addition, there are regional targets for disbursement favouring the less developed regions. Only the two cross-sectoral funds – *Fundo Verde Amarelo* and *Fundo de Infra-Estrutura*¹ – currently use alternative support instruments, such as subsidised loans and participation in venture capital funds, which can be more geared to specific projects, especially business start-ups and spin-offs. Projects that require counterpart financing by the beneficiary enterprises are becoming more widespread, although they account for only about 20% of total FNDCT disbursements (Pereira, 2005).

1. *Fundo de Infra-Estrutura* is financed by a 20% contribution from each of the other funds (except *Fundo da Amazônia*) and focuses on developing academic R&D infrastructure. *Fundo Verde-Amarelo* is financed by 40% of revenue from special contributions (CIDE), in addition to 43% of the additional revenue accruing from the gradual reduction in tax incentives granted to the ICT industry (discussed below). *Fundo da Amazônia* is financed by at least 0.5% of gross revenue of enterprises located in the Manaus Free Trade Zone.

The supply of venture capital and private equity is expanding but remains relatively under-developed. The use of public innovation funds for venture capital is limited to *Fundo Verde-Amarelo* (discussed above in Box 4), but equity investment accounts for a very small share of disbursements. BNDES has been acting in this market segment since 1995, and in 2000 the Ministry of Science and Technology launched the *Inovar* programme, led by FINEP. The market responded well to this initiative, and several Venture Forums were organised to introduce projects to potential investors. More recently, in 2005, BNDES announced the creation of a fund of BRL 260 million directed towards providing start-up capital. The creation of venture capital funds by FINEP and *Banco do Brasil* in 2006 is likely to contribute to the development of this market segment, but it is too soon to evaluate the success of these policies in encouraging further private investment in venture capital. In any case, several other recent measures have made the supply of such financing more attractive. Capital gains on investments in venture capital funds by non-residents are now exempt from income taxation, and bank debits associated with IPOs negotiated outside the stock exchange are exempt from bank debit (CPMF) taxation.

Tax incentives

The revenue foregone through tax incentives for R&D is estimated at about BRL 1.6 billion in 2005, or approximately 0.1% of GDP. This sum is not included in the calculation of Brazil's R&D intensity. There are federal laws providing tax breaks for R&D activities (Table 4), but most of these incentives benefit the ICT industry (Laws no. 8 248/91, altered by Law no. 10 176/01) (Box 5). Support was subsequently extended to non-ICT firms (Law no. 8661/93, altered by Law 9532/97 and now revoked). Tax breaks are also granted (Laws no. 8 010/90 and 8 032/90) to universities and research

Table 4. **Tax incentives for R&D, 2000-2005**
In millions of *reais*

	2000	2001	2002	2003	2004	2005 (est.)	Scope
Total revenue foregone	1310.2	209.5	944.1	1239.7	1228.5	1637.7	
Law no. 8 010/90	60.3	118.4	111.9	152.0	155.9	117.8	Research materials for academic institutions
Law no. 8 032/90	10.5	6.3	6.5	8.2	11.4	8.2	Research materials for academic institutions
Laws no. 8 248/91 and 10 176/01	1 203.7	...	732.9	961.7	934.6	1369.1	R&D in ICT companies
Laws no. 8 661/93 and 9 532/97	22.3	22.4	15.2	19.7	37.1	46.1	R&D in non-ICT companies
Law no. 8 387/91	13.4	62.4	77.6	98.1	89.5	96.5	R&D in ICT companies in the Manaus Free Trade Zone

Source: Ministry of Science and Technology (Secretaria de Política de Informática, Secretaria de Política Tecnológica Empresarial and Conselho Nacional de Desenvolvimento Científico e Tecnológico) and Ministry of Development, Industry and Commerce (Superintendência da Zona Franca de Manaus).

Box 5. The ICT sector: From protection to promotion

The Brazilian ICT sector was shielded from foreign competition during 1977-1992. Bureaucratic impediments created barriers to entry in the electronics industry at large, and upstream activities were protected through stringent national input-content requirements. Support for protection waned in the late 1980s as a result of a large price differential with respect to equipment produced abroad, and on the grounds that it was holding back productivity gains in export-oriented sectors. Quotas were eliminated in 1992, and a 30% import tariff was introduced with a schedule for gradual reduction over time, together with tax incentives for local production. Productivity rose at a fast clip with liberalisation, and prices fell considerably.

Empirical evidence shows that the Brazilian personal computer (PC) industry evolved rapidly after liberalisation.¹ Technological progress did occur during protection but failed to deliver competitive prices. A lack of competition in upstream sectors and impediments to entry throughout the production chain are considered the main culprits for the maintenance of high prices during protection. The gain in consumer surplus associated with the fall in prices after liberalisation is therefore estimated to have been high.

It was feared that the liberalisation of the ICT sector in the 1990s would adversely affect the banking industry. Brazil's banking automation industry, which remains dominated by bank-owned firms, not only survived liberalisation but is also considered among the most efficient in the world, especially in software development and services technology. Banking automation is a key downstream user of ICT. It requires significant R&D effort and contributes to the diffusion of ICT adapted to local needs. The combination of high inflation in the 1980s, the country's size and culture of using banks for payments created strong demand for ICT as a means of expediting back-office activities and payment processing.

In addition to banking automation, certain applications of ICT have been very successful: the filing of income-tax returns has been carried out almost exclusively through the internet for more than five years. Electronic ballot boxes have been used since 1996 for national and regional elections.

1. See Luzio and Greenstein (1995) and Botelho *et al.* (1999) for more information.

institutions, exempting them from the payment of import duties on purchases of scientific equipment and materials. Another type of tax incentive (Law no. 8 387/91) benefits the ICT firms established in the Manaus Free Trade Zone through the exemption of federal indirect taxes on sales and import tariffs on inputs. The tax code was modified by Law no. 11 196/05, which simplifies the procedures for firms to take advantage of the existing tax breaks. This measure has been welcomed by the private sector. It is nevertheless too soon to assess the impact of these recent measures on innovation intensity in the business sector.

The existing tax incentives include: *i*) exemption from federal indirect taxes of sales of selected products and purchases of capital goods and intermediate inputs, *ii*) corporate income tax deductibility for spending on R&D and for payments of royalties for the use of trademarks/patents and technical/scientific assistance, and *iii*) accelerated depreciation and amortisation provisions. Since June 2005 (Decree no. 5 468), purchases of capital goods and intermediate inputs have been exempted from IPI taxation (the federal value added tax). Other measures were introduced in 2005 as part of a broad package to ease the tax burden on businesses (Law no. 11 196).⁴ These include: *i*) exemption from PIS/Pasep and COFINS (federal taxes on value added) of purchases of capital goods and intermediate inputs by exporters, defined as enterprises that export at least 80% of their output, including ICT goods and services;⁵ *ii*) exemption from PIS/Pasep and COFINS of retail sales of several types of lower-cost personal computers and peripheral equipment; *iii*) an increase in deductibility from the corporate income tax of spending on R&D to 200% of the value of purchases; *iv*) an allowance for remittances for the payment of

4. At the state level, there are initiatives based on the federal Innovation Law. In the state of São Paulo, for example, draft legislation has been submitted to the state legislature expanding the reach of the federal law to state-owned institutions.

5. The law created two tax regimes, respectively, for exporting firms (Regime Especial de Aquisição de Bens de Capital para Empresas Exportadoras, Recap) and for exporters of ICT services (Regime Especial de Tributação para a Plataforma de Exportação de Serviços de Tecnologia da Informação, Repes).

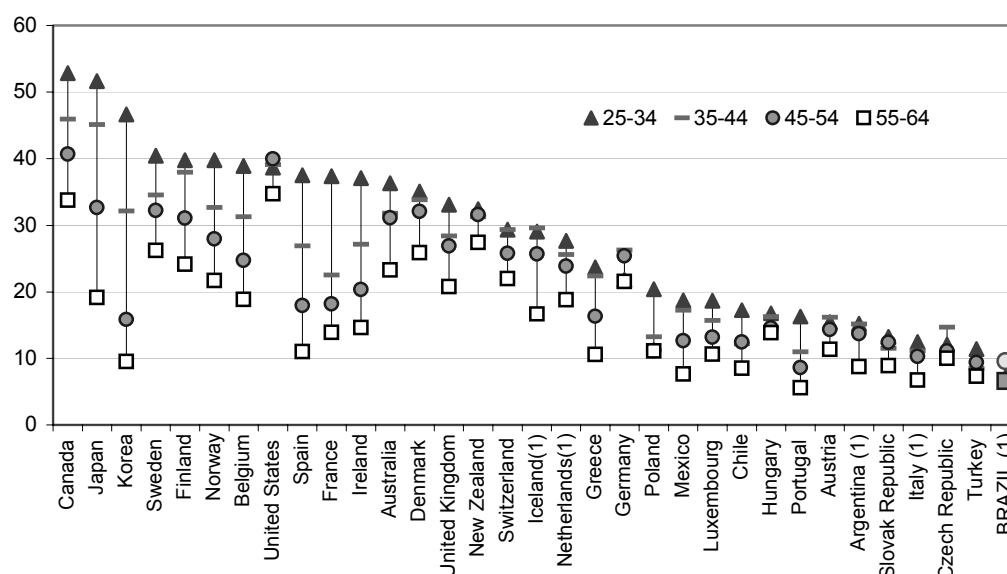
technical/scientific assistance fees to be creditable against the corporate income tax; v) exemption from corporate income taxation of remittances for the filing and maintenance of IPRs abroad (through patents, trademarks and cultivars); and vi) introduction of deductibility from the corporate income tax for up to 50% of the salaries paid to scientists working in the business sector.

4. Higher education

Brazil's poor record in educational attainment is among the key obstacles to the generation and diffusion of innovation. An increase in higher-education attainment is needed to improve R&D performance and should benefit from the rapid expansion in enrolment in upper-secondary education in recent years. Notwithstanding this positive development, Brazil lags far behind the best performers in the OECD area and even countries with comparable income levels. Policy initiatives have focused on the expansion of school enrolment for primary and lower-secondary education, which is now nearly universal, especially since the implementation of FUNDEF, discussed in the *2005 Survey*. Less emphasis has been placed on improving the quality of services. The performance gap in primary and lower-secondary education – measured on the basis of standardised tests, such as PISA – is wide relative to most OECD countries, suggesting that there is much room for improvement. In any case, it will take some time for current policies to bear fruit in terms of a sustained reduction in the performance gap, and follow-through is essential. Complementary measures, such as greater emphasis on the use of computers and access to the Internet at school, would contribute to building an education culture conducive to the development of a knowledge-based economy. The government's efforts to make computers available in all public schools are therefore welcome.

The attainment gap in higher education is widening relative to the OECD area, as well as Argentina and Chile (Figure 9), a trend that is likely to be reversed only in part by the increase in enrolment in upper-secondary education in recent years. The expansion of the university network in recent

Figure 9. Tertiary education: Attainment rates by cohort, 2003
In per cent



1. Refers to 2002.

Source: OECD (Education at a Glance, 2005).

Box 6. An overview of higher education

Background

There has been a substantial increase in the number of private higher-education institutions, which more than doubled during 1997-2003. These new institutions accounted for about 70% of the 3.9 million students registered in higher education in 2003. Some private universities are now among the largest in the country by number of students and have specialised in low-cost fields of study, such as management and social sciences.

The federal government finances about two-thirds of public spending on higher education, and about one-half of the public institutions are federal. The supply of higher-education institutions is tilted towards universities, and only 1.5% of higher-education students were enrolled in technological institutes (*escolas técnicas*) in 2003, a share that has nevertheless almost doubled since 1999.

Access to higher education is by examination, which is carried out in a decentralised manner. Public universities are free of charge, and there is little systematic information on tuition fees in the case of private universities. There are few student-loan schemes or much financial support for students from disadvantaged backgrounds. The introduction of quotas for non-white students in the federal universities is being debated, and a few institutions have set up such a quota system on a voluntary basis. Other universities have adopted affirmative-action initiatives to enhance the admission of graduates from the public high-school network.

The expansion of the public higher-education system has not kept pace with demand, as the ratio of applicants to accepted students rose from 6.6 to 8.4 during 1993-2003, whereas it fell from 2.4 to 1.5 for the private institutions. Despite the increase in enrolment, attainment remains low, even for the younger cohorts, because drop-out and failure rates are high. The graduation rate increased somewhat in the public universities, to 73% in 2003 from about 60% in 1993, but remains fairly stable at 55% in their private counterparts.

Quality assessment

Effort has been made to assess the quality of higher education through SINAES (*Sistema Nacional de Avaliação do Ensino Superior*). Since 2002, an assessment has been carried out by submitting a representative sample of first- and last-year students of different fields of study to an exam (ENADE, *Exame Nacional de Desempenho dos Estudantes*). ENADE's sample included 140 340 students in 2004, enrolled in 13 knowledge areas in public and private institutions. The performance of each student is assessed together with that of the institution to which he/she is affiliated and compared with that of fellow students in the same career and field of study.

There is a quality gap between private and public institutions. Based on the assessments carried out in 2004, students enrolled in federal universities had the highest scores both in general knowledge and career-specific tests. Input quality indicators also differ between private and public institutions. The student/teacher ratio, for example, rose slightly over time, from 12 to 15 during 1993-2003 and is higher for private than public institutions. The students placed outdated libraries, the structure of curricula and limited access to computers among the main weaknesses of their institutions.

years has been due essentially to the increase in the number of private institutions (Box 6), which focus for the most part on low-cost programmes in management and social sciences. In addition to raising quality issues for the higher-education sector as a whole, these developments do little to increase the supply of scientists and engineers, so as to strengthen the innovation potential of universities. The stock of engineers graduated per thousand population – 0.08 in Brazil, against 0.22 in the United States; 0.33 in France and Germany, and 0.8 in South Korea – illustrates the country's deficit in this area.

5. Policy recommendations

Brazil's key challenge is to encourage productivity-enhancing innovation in the business sector. Academic excellence in several niche areas is encouraging university patenting, but joint R&D efforts between universities and businesses remain nascent, partly due to legal impediments to the transfer and sharing of proceeds from intellectual property rights (IPR). The Innovation Law, approved at end-2005, is a step in the direction of removing these impediments. But boosting innovation is a multi-dimensional policy endeavour, as recognised by the authorities, which calls for a comprehensive approach that goes beyond the S&T area. In this respect, the strengthening of the current policy framework (PITCE) – by exploiting synergies between productivity-enhancing innovation and trade competitiveness, as well as refocusing industrial policy on trade promotion, rather than protection – is a significant step forward. So are the federal government's recent efforts to reduce the domestic tax burden on innovative enterprises. Notwithstanding these positive developments, import tariffs remain high for capital goods and intermediate inputs, and complementary measures to tackle the shortage of human capital, which is among the most

important constraints to innovation, should rank prominently in the government's policy reform agenda. To reach the OECD average of about 1.6% of GDP, Brazil's business R&D intensity would have to rise by a factor of 4 – an illustration that underscores the scope for improvement in this area.

Strengthening the framework conditions for innovation

Some of the key framework conditions for innovation are yet to be fulfilled. Macroeconomic volatility and high real interest rates reduce investors' appetite for risky projects, including R&D, in comparison with investment in fixed-income securities. The policies discussed in OECD (2006a), Chapter 2, to make the economy more resilient to shocks by consolidating macroeconomic adjustment will therefore contribute to making innovative activities and investment in R&D more attractive. Initiatives to deepen the financial markets would also contribute by improving the market environment for risky ventures. The reform of bankruptcy legislation and the strengthening of equity markets are among the key policy initiatives that have been taken in this area (Annex A1). But additional structural measures can be considered. These include further pro-competition regulatory reform in product markets, given the strong association between labour productivity growth and trade and investment openness, as well as the fact that innovation appears to be bolstered by competition from foreign firms.

On the basis of the indicators of restrictiveness in product market regulation (PMR), as reported and discussed in the *2005 Survey*, there appear to be reasonably robust economy-wide competitive pressures in Brazil. The country's score is on a par with Chile's and Mexico's, the Latin American comparators for which information is currently available, and the average of emerging markets in the OECD area. In a global environment where product market regulation is becoming increasingly competition-friendly, further reform in this area could make Brazil even more attractive to productivity-enhancing FDI. A 2004 survey conducted by the Economist Intelligence Unit found that Brazil ranked sixth on a list of targeted countries for foreign investment in R&D laboratories (Economist Intelligence Unit, 2004). However, Brazil fares particularly poorly on the basis of the PMR indicators with respect to outward-oriented policies, because average import tariffs remain relatively high, despite the gradual easing that took place over the 1990s. A further easing of tariff protection could therefore be innovation-enhancing, because the acquisition of capital goods and equipment is an important source of embodied technologies in the manufacturing sector. Stepping up the policy effort in this area would complement the measures (discussed above) to reduce the domestic tax burden on innovative activities.

Facilitating R&D co-operation between universities and businesses

Linkages between universities and businesses need to be strengthened. The main restriction today is the limited number of researchers working in the business sector. By removing the legal impediments for public universities and research institutions to protect, commercialise and share the proceeds of their joint intellectual property, the passing of the Innovation Law late in 2005 is a considerable step forward in this area. However, the requirement for a public tender for exclusive licensing is a serious limitation. Universities and research institutions can therefore act as contract researchers, which is especially useful for firms that are too small to finance in-house research. In this regard, initiatives, such as Unicamp's *Inova*, in the provision of legal and technical assistance to businesses in setting up collaborative ventures with universities and subsequently registering their joint IPR, are laudable. The recently introduced partial deductibility of expenditure on researcher salaries from corporate income taxation may also facilitate business-university co-operative ventures. But more is needed to expedite the registration of patents, especially given the increase in academic patenting in recent years, including by reducing the backlog of applications to be processed by INPI, the National Patent Office.⁶ Long delays in the processing of patent

6. INPI's effort to reduce this backlog includes the introduction of registration applications through the Internet for trademarks in April 2006 and for patents in November 2006, as well as hiring temporary workers.

and trademark application not only slow the diffusion of new technology, but also weaken the incentive for innovation by increasing the time span before IPR holders can begin to amortise their innovation costs.

Improving the architecture of the NIS

Brazil's NIS has changed markedly since the creation of the sectoral funds and would benefit from greater clarity in the assignment of functions and responsibilities, particularly in the area of long-term strategic planning. These functions have become increasingly concentrated in cross-sectoral bodies, such as CCFS (*Comitê de Coordenação dos Fundos Setoriais*), created in 2004. Until then, these functions had been shared by CGEE, FINEP, CNPq and the sectoral funds' administrative committees, creating excessive fragmentation. In the current institutional set-up, however, the role of CGEE could be clarified so as to assign the agency a clearer advisory role in long-term planning. In doing so, more attention could be devoted to regular assessments of the economic impact of existing support programmes and the framework conditions needed in support of the government's overall S&T policies. In any case, efforts should be stepped up to foster coordination among CCT, CGEE, CNDI and ABDI at the federal level.

Intergovernmental co-operation should be enhanced to create policy synergies. Increased co-operation over time between FINEP and CNPq in the operation of the sectoral funds is a welcome development at the federal level. But this is not the case across the different levels of government. Intergovernmental co-operation could be strengthened by inviting representatives of the state-level S&T institutions to work closely with the federal government in setting priorities and carrying out strategic planning for the sectoral funds. They could also participate in the administrative committees of the funds that are most relevant to their own policy priorities, regional specificities and support portfolios. Increasing participation of the business sector in these administrative committees would also be welcome.

All in all, the increasing emphasis – within the government and beyond – that is being given to support for productivity enhancement, rather than R&D *per se*, and trade competitiveness within PITCE calls for greater co-operation among a broader range of policymakers. This includes not only the ministries of Science and Technology, and Education, and their subordinate agencies (FINEP and CNPq in the Ministry of Science and Technology, and CAPES in the Ministry of Education), but also the ministries of Development and Trade (especially CNDI and ABDI), National Integration, Agriculture and other bodies, such as BNDES, APEX (the trade financing agency), SEBRAE (the SME support agency), and the state-level S&T agencies. A flexible institutional setting, with a clear mandate for long-term planning and strong advisory capabilities, is therefore essential for policy synergies among these interlocutors to be maximised.

Improving the cost-effectiveness of government support

The current administration's objective of raising Brazil's R&D intensity to 2% of GDP, closer to the OECD average, predominantly on the back of higher government spending, is yet to be met. The main weakness of the current support mechanism is its reliance on earmarked funding, which creates budgetary rigidities and has failed to generate a stable source of government support for S&T. As in other areas, revenue earmarking is a common instrument in Brazil to deal with volatility in financing and hence to ensure continuity in public policies, especially in periods of fiscal stress. However, in addition to complicating macro-fiscal management, revenue earmarking prevents the allocation of funds to the sectors where their use could turn out to be most cost-effective. It may therefore also undermine contestability, which is a pre-requisite for cost-effectiveness in direct support for innovation, by creating captive sources of finance for selected sectors/activities. As a result, the goal of ensuring continuity and stable financing for innovation support programmes should be pursued through the prioritisation of programmes, rather than budget rigidities. It should nevertheless be noted that, in a situation of fiscal stress, it may be

particularly difficult to preserve budgetary appropriations for R&D while other outlays may be subject to sequestration.

The creation of the sectoral funds has been a landmark in Brazil's innovation policy, but more emphasis should be placed on cross-sectoral support, which would allow resources to be shifted horizontally across funds. Options for improvement in this area include focusing eligibility conditions on joint ventures between businesses and higher-education institutions, preferably with counterpart financing by businesses and including through the minority participation of the sectoral funds in venture capital initiatives. SMEs could also be included in the business-university R&D ventures benefiting from government support. These initiatives would contribute to strengthening transparency and contestability in the allocation of existing budgetary resources. In this regard, the experience of Spain in the OECD area with the creation of CENIT (*Consortios Estratégicos Nacionales para la Investigación Técnica*) in 2005 may be instructive, although it is too soon to evaluate the cost-effectiveness of the programme and its impact on productivity.⁷

The efficiency of tax incentives can be improved. The recent initiative (Law no. 11 196 of 2005) to streamline the legislation for tax incentives and to extend the benefits current available for the ICT sector to the rest of the economy is welcome. So is the exemption of IPOs and venture capital operations from bank debit taxation (CPMF). As a result of these measures, the tax incentive intensity is expected to increase over the coming years to 0.24% of GDP, or more than double the current level. But more can be done in the tax area to strengthen the market environment for risk-taking in the form of venture capital. Several provisions of the 2005 law are yet to be promulgated. Also, capital gains accruing from the sale of venture company shares could be exempted from income taxation as an additional support measure towards developing this market segment. Moreover, the phasing-out of the existing tax incentives for the firms located in the Manaus Free Trade Zone could be considered when it is due for renewal in 2013 as a means of making the provisions of the tax code more homogeneous across activities and regions.

In any case, it should be recognised that the optimal balance of support instruments – between direct subsidies and tax incentives – is not clear-cut, because both policy instruments involve deadweight losses (*i.e.* support may be granted to activities that would have taken place anyway) and pose governance risks. The cost-effectiveness of alternative policies also depends on design and implementation, which calls for a careful assessment of plans and outcomes (OECD, 2006b). In general, because small firms often do not have enough tax liabilities to benefit from tax incentives, or a solid credit history and tangible assets that can be used as collateral to tap credit markets, a case can be made for greater reliance on subsidies for support to innovation in the SME sector, including start-ups. As a general principle, however, transparency and contestability are important pre-requisites for effective support, regardless of enterprise size.

The need for high-quality information on S&T and R&D indicators and outcomes to undertake analysis of cost-effectiveness should not be underestimated. The Ministry of Science and Technology is working on improving the quality of S&T and R&D indicators, as well as on the reporting and dissemination of these indicators on a regular and timely basis, in accordance with the recommendations of the Frascati, Cambera and Oslo manuals. Policy effort in this area is therefore welcome.

7. The programme consists of consortia involving at least four companies, including two small enterprises, and at least two public research institutions. Each consortium is led by one of the large participating companies. Projects must extend over a four-year span, with a budget of EUR 5-10 million per year, and include advanced scientific and technological developments. The leader and the other private-sector participants must provide at least 50% of the funds, with the remainder financed by the programme. The consortia must invest 25% of the funds in public research institutions and at least 16% in the participating small enterprises. The leading companies obtain 9% of public funding but can steer the direction of the research effort towards their strategic objectives.

Addressing problems in higher education and vocational training

The main challenge for higher education is to expand supply while reducing the quality gap between private and public universities. The increase in the number of private higher-education institutions, coupled with the relatively poor performance of the students enrolled in these institutions on the basis of ENADE (Box 6), raises questions about quality control. The challenge of reducing the quality gap will need to be addressed, preferably before the demand pressures associated with the expansion in enrolment at the secondary education level reach the tertiary level. Making curricula more attuned to market demands, updating libraries and increasing the availability of ICT equipment are all part of the solution, based on the weaknesses identified in the 2004 ENADE. Student performance indicators could also be used for tightening the accreditation requirements of private institutions. In any case, given the wealth of information provided by ENADE, including on students' socio-economic backgrounds, more research should be done on the policy determinants of performance in tertiary education.

At the same time, universal access to publicly funded higher education fails to address some of the equity challenges that have arisen from the expansion of the private university network. Because there are no tuition fees in public institutions, students from disadvantaged backgrounds would not in principle be constrained from enrolling in higher education on the basis of income. However, these students are less likely to attain upper-secondary education and many times do not have the academic performance required to compete for a place at a public university with better-off students who had the means to attend better, most often private, secondary schools. They are left with the option of enrolling in private institutions, but currently do not receive means-tested support from the government to pay for tuition fees and to cover their living expenses during their studies. Therefore, the fact that higher education is provided free of charge in public universities does not *per se* remove financial constraints to higher education for students from disadvantaged backgrounds. Effort to improve the quality of secondary education and to raise enrolment among the disadvantaged would consequently go a long way in making higher education more equitable. The introduction of quotas for students based on ethnicity does not solve this problem, because the intended beneficiaries may lack the means to support themselves during their studies. This policy measure would instead contribute to the perpetuation of high drop-out rates among vulnerable socio-economic groups. Instead, the introduction of quotas based on social background, rather than ethnicity, can improve access by students from disadvantaged backgrounds to higher education to some extent, as evidenced by the experience of the universities of Campinas and Sao Paulo.

On vocational/technical training, Brazil is not alone in struggling to find options for better preparing youths for the labour market, particularly those who are unlikely to pursue tertiary education. The Brazilian education system does not have separate streams for vocational and general education, which can be argued to be a positive pre-condition for building an effective system of lifelong learning. Nevertheless, there is a lack of options for vocational training, which may discourage enrolment in upper-secondary education by those students who cannot, or do not wish to, go on to university, despite the fact that returns to education are high at that level. The government intends to create double qualification (general and vocational) programmes at the upper-secondary education level. This would be welcome.

With regards to the technological institutes, which typically have tertiary-education status, the fact that they have outdated equipment and curricula makes them ill-prepared to respond to market demands. This raises concern about the quality of services and makes co-operative ventures with businesses difficult. The government's intention to increase the supply of tertiary education-level technological institutes by setting up new institutions and converting a few current institutions into universities is questionable. Instead, it would be advisable to step up efforts to monitor the quality and market-orientation of the training offered in these institutions on a regular basis before new ones are created. More generally, the increase in youth unemployment in recent years and the fact that the labour market is putting an increasingly high premium on skills calls for greater policy effort in this area as a

means of reversing the deterioration in low-skill individuals' employability. Increasing the supply of shorter tertiary-education programmes would also be advisable as a means of meeting the demand for higher-education qualifications with a more practical, less academic focus. The example of the technological faculties (FATECs) in the state of São Paulo could be considered at the federal level (Box 7).

Box 7. Short-term higher-education technology courses: The experience of São Paulo

A new strategy for the expansion of higher-education opportunities attuned to regional demands has been pursued by the state of São Paulo over the last ten years in parallel with the expansion of enrolment in the state's three traditional, academic research-oriented universities (University of São Paulo, USP; University of Campinas, Unicamp; and University of the State of São Paulo, Unesp). To do so, the state has created a parallel university system – the technological faculties (FATECs) – to meet a growing demand for professionals with the technological skills required by industry.

The number of FATECs rose from 6 in 1994 to 26 in 2006, bringing total enrolment from 5 000 to 18 000 students. The creation of another nine campuses is planned for the next few years. The campuses are located across the state, with the expansion planned to cover those areas that are currently underserved. There is fierce competition for vacancies in the three-year courses offered: typically one in every eight candidates is accepted through a selective entrance examination. The operating cost is about USD 3 000 per enrolled student per year, significantly lower than the average cost of higher education in Brazil.

Almost all campuses offer training in management and informatics, and most also cover fields related to the regional economy. For example, located in the city of São Paulo, the largest campus offers training in industrial automation, construction, materials technology, mechanics, hydraulics and sanitation. Other campuses focus on textile technology, logistics and transportation, electronics and agribusiness.

Summary of recommendations

This paper's main policy recommendations are presented in Box 8.

Box 8. Summary of recommendations: Innovation

Strengthen the framework conditions for innovation

- Continue to reduce the domestic tax burden on capital and ICT goods.
- Gradually eliminate import tariffs on capital goods and intermediate inputs to facilitate access to productivity-enhancing technologies embodied in imports.

Simplify regulations for exclusive licensing of academic IP

- Take steps to reduce the current backlog of patent and trademark applications to be reviewed by INPI.

Address the problems of higher education and vocational training

- Make curricula more attuned to market demands, update libraries and increase the availability of computers.
- Use student performance indicators (on the basis of ENADE) for tightening the accreditation requirements of private institutions and for encouraging improvement through greater co-operation with the government.
- Create double qualification (general and vocational) programmes at the upper-secondary education level.
- Increase the supply of shorter, more practically-oriented post-secondary education programmes.

Improve the cost-effectiveness of direct government support

- Conduct regular impact assessments of the existing instruments, including those financed by the sectoral funds.
- Focus sectoral-fund support on horizontal projects with counterpart financing from businesses.

- Introduce alternative support instruments, such as risk-sharing, matching grants and loan subsidisation, which may be more applicable to start-ups.
- Improve contestability in the allocation of sectoral-fund support by reducing emphasis on regional and sectoral earmarking.

Improve the cost-effectiveness of tax instruments

- Conduct regular impact assessments of the existing tax instruments, including those related to the Manaus Free Trade Zone.
- Exempt the capital gains from the sale of venture company shares from income taxation.

Strengthen the National Innovation System

- Promote co-operation between federal and the state-level S&T and innovation promotion agencies.
- Assign CGEE a clear advisory role in long-term planning.

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