

Chapter 3

R&D Expenditures and Human Resources

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Part A

R&D expenditure in São Paulo State

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1. Introduction

Research and development (R&D) expenditure is a distinct portion of public and business expenditure that builds an economy's capabilities in technological innovation, focusing on competitiveness and with the aim of fostering development. Despite the strategic importance of R&D activities, it is not easy or straightforward to answer the question of how much a country or region spends on them.

Finding the answer is a laborious and complex task everywhere in the world. The concepts required are not always very precise. The quality of the information available varies considerably; it is often out of date, and may lack consistency and coherence, besides being insufficient in quantity. In Brazil the task is even more difficult because systematic data collection and treatment procedures have only recently been introduced in this field and much needs to be done to improve them.

In R&D, as in other fields of activity, sources of statistics are scarce, and surveys of private investment in R&D are partial and infrequent. Information on public investment in R&D may display the virtues of timeliness and transparency but it is hard to identify and relatively inconsistent. No specific R&D surveys were conducted nationwide in Brazil on a regular basis until recently. It was possible only to measure S&T expenditure, especially by the public sector, because this involves programs and, more recently, a function of government that must be itemized separately in official financial statements.¹

In order to try to fill this gap, at least in part, previous editions of this series of Science, Technology & Innovation Indicators in São Paulo State (FAPESP 2002, 2005) sought to measure or estimate R&D expenditure in São Paulo State and nationwide. Because this

was a unique and groundbreaking effort in São Paulo State and Brazil, the chapter on this topic devoted a considerable amount of space to methodological issues, detailing the methods used to calculate expenditure, especially in the public sector, describing the data sources used, and explaining how the data were identified and treated, including the hypotheses adopted and some simulations to assist comprehension by the reader.

The Office for Indicators at the Ministry of Science & Technology (MCT) conducts an annual survey of nationwide R&D and S&T expenditure.² The findings since 2000 are available on the ministry's institutional portal.³

As for private-sector expenditure, since 2000 IBGE has regularly conducted a survey of business investment in technological innovation called PINTEC.⁴

As noted above, a new, more detailed classification came into force in 2000 for public-sector expenditure, according to government functions and programs. In addition, the Fiscal Responsibility Law (LRF: Brazil, 2000) obliged state and city governments to provide the Finance Ministry with statistics on their expenditure more rapidly and in greater detail, according to a standard format, for use in consolidated "general government" accounts.⁵

In its surveys of basic statistics on R&D and S&T, MCT strives to use methodological criteria as close as possible to the internationally accepted standards. The same goes for all editions of this publication by FAPESP.⁶ It is important to note, however, that major challenges still have to be overcome in this field, especially with regard to the recording and classifying of expenditure by the national government and state governments, and the recording of business R&D expenditure.

The survey described in this chapter focuses solely on R&D expenditure. S&T expenditure is excluded, in

1. The federal government adopted a new expenditure classification system by function and program in 1999 (required by a Planning Ministry ordinance published on Feb. 14, 1999). In principle, other levels of government should use the same methodology but in practice this is not always the case. The Science & Technology function is identified by the code 19 and has three typical subfunctions: scientific development (code 571); technological development and engineering (572); and diffusion of scientific and technological knowledge (573). Measuring expenditure booked under the S&T function alone does not cover total government spending on S&T for the purposes of this chapter because S&T-related activities may be classified under other functions. A well-known example is the case of research by Fundação Oswaldo Cruz (Fiocruz), one of Brazil's leading research institutions, whose research expenditure is classified under the Health function for accounting purposes because it relates specifically to public health. For a more up-to-date version of the Technical Manual detailing classification concepts and forms, see <https://www.portalsof.planejamento.gov.br/bib/MTO/MTO2009_06.pdf>.

2. See *Metodologia e Critérios para Levantamento dos Investimentos Nacionais em Ciência e Tecnologia*, produced by MCT's Indicators Office (Assessoria de Acompanhamento e Avaliação das Atividades Finalísticas, Coordenadoria Geral de Indicadores), and available from the Executive Secretariat. Another key reference on S&T expenditure surveys is *Indicadores de Ciência, Tecnologia e Inovação no Brasil* (Viotti & Macedo, 2003).

3. The MCT's portal has a specific page on what it call's National S&T Indicators (<http://www.mct.gov.br/index.php/content/view/2042.html>). Under the heading "funds invested," the data are broken down into: "consolidated indicators, federal government, state governments, postgraduate courses, business sector."

4. See <<http://www.pintec.ibge.gov.br/>>.

5. The Treasury publishes an annual report with the consolidated amounts for all three tiers of government. See: <http://www.tesouro.fazenda.gov.br/contabilidade_governamental/execucao_orcamentaria_do_GF/Consolidacao_Contas_Publicas.xls>.

6. The Methodological Annex to the previous edition provides details of the methods and procedures used by FAPESP (<http://www.fapesp.br/indicadores2004/volume1/anexos.pdf>).

contrast with the MCT surveys, which cover “expenditure on S&T activities” as well as R&D. The rationale for focusing on R&D is that accurate measurement of R&D expenditure is far more essential to policymaking since the activities encompassed by the category R&D is more clearly defined both within in Brazil and internationally (see 2.1 below).

Thus this chapter sets out to determine the evolution of R&D expenditure, and its composition in terms of sources of funding, between 1995 and 2008 in São Paulo State, analyzing the tendencies identified and noting the similarities and contrasts between São Paulo State and Brazil in this regard. Moreover, as is usual in this type of study, international comparisons are made to help situate some of the challenges for the R&D system in São Paulo State.

2. Definitions and methodology

The key reference for surveys of financial and human resources in R&D is the *Frascati Manual*, produced by the Organization for Economic Cooperation & Development (OECD, 2002). A narrower framework used in some surveys, especially those focusing on S&T rather than R&D, is provided by UNESCO’s *Manual for Statistics on Scientific and Technological Activities*, which defines what it calls related S&T activities (UNESCO, 1984).

The details of the terminology used are relevant as a reflection of conceptual differences, which can lead to significant discrepancies, especially in the financial statistics collected for less developed economies (Box 1A). This chapter mainly adopts the most widely used concepts and recommendations in the international literature. Thus the concept of R&D expenditure covers the financial resources invested both to maintain and develop activities (including researchers’ salaries) and to acquire the capital goods used in research activities (typically a smaller proportion of the total).

Another relevant methodological issue refers to the sectors and functions covered by the survey. First, it is necessary to distinguish between sectors that are sources of funds and sectors that are “performers.” This distinction has rarely been made in Brazilian sur-

veys, possibly owing to lack of access to data disaggregated to this level. The analysis presented in this chapter is limited to sources of funds and other resources.

As for the administrative nature of sectors, the MCT survey covers:

- a) Public administration in all three tiers of government (federal, state and municipal), in the form of agencies that allocate resources from their budgets directly to R&D activities and services. R&D expenditure by public administration aims in principle to achieve public-interest objectives;
- b) Higher education, which even in the public sector enjoys a degree of autonomy, so that it makes sense to consider its budget allocations to R&D as investments for which it is responsible, rather than computing them simply as expenditure by public administration. In the case of private higher education institutions, the funds computed in connection with this source are of private origin. The MCT survey classifies them under business R&D. This is dubious, as the funds are invested in accordance with an academic logic determined by the postgraduate system and not with the aim of enhancing business competitiveness. The chapter therefore estimates R&D expenditure by higher education institutions on the basis of their postgraduate efforts and imputes the results to the public or private sector as the case may be;
- c) The private sector, whose expenditure is mostly made by business organizations. In certain situations it may be useful to distinguish between private-sector firms and state-owned enterprises, although from the conceptual standpoint the aim of R&D expenditure is to enhance competitiveness in both cases.

The *Frascati Manual* also contemplates two other sectors for the purposes of analyzing R&D expenditure: private nonprofit institutions serving households and individuals; and what it calls abroad, which includes international organizations. Systematic data permitting coverage of these sectors by MCT are not available in Brazil.

Another semantic issue should be anticipated here. It is necessary to distinguish between providers and beneficiaries of services. In the case of postgraduate studies at private institutions, expenses are paid by households even though the service is provided by a private institution and one that is often a business enterprise.

Box 1A – Terms and definitions

An initial commentary is in place on the terms used to refer to spending on R&D activities. Brazil's Science & Technology Ministry (MCT) uses two terms in its tabulations. Investment refers to all sums spent nationwide by the public and private sectors. Expenditure refers solely to government spending.

The term investment features in S&T indicators with a different, far broader scope than in public-sector or national accounts, where investment refers only to capital expenditure (acquisition of machinery and buildings, public works etc). However, the term investment can be used far more broadly based on the theoretical justification that in knowledge economies investment refers not only to fixed capital but also to intangible assets, especially those relating to R&D.

Another semantic dimension is that spending, expenditure and expenses are frequently used in the literature as synonyms. However, appropriating funds in a budget is different from obligating funds and thus firmly committing to purchase a good or contracting for a job of work or service, and both are different again from the settlement process and the disbursement of the funds to effect payment. In the private sector such differences are simply distinct stages of a given activity, but

in the public sector they may result in different values, not only owing to inflation (if a long period is involved), but also because in many cases obligated funds do not match the entire amount appropriated in the budget and/or may not be correctly settled, and not all settled funds are effectively disbursed (especially when projects not linked to routine activities are involved). While disbursements are relatively precise and easy to understand, on the other hand they are far harder to identify because the government reports and financial statements that detail expenditure by agency or function involve intermediate acts, i.e. a contract for or outlay of the items of expenditure concerned. This is the basis on which MCT calculates its indicators.

As for the international literature, the *Frascati Manual* defines the funds invested in R&D as current expenditure plus capital expenditure.* This concept is used in public-sector accounts but not in business accounts, where current expenditure is computed as cost (mostly operating cost), whereas capital expenditure is equivalent to acquisitions of fixed assets. In any event, once identified and counted, funds tend to be classified simply as R&D expenditure in the most widely used international bibliographic references.

* The *Frascati Manual* sometimes refers to these funds as “R&D inputs”. The recommendation to compute current as well as capital expenditure is in OECD 2002 (pp. 21 and 108).

2.1 The categories R&D and S&T

Research and development (R&D) is a category that refers to creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications (OECD, 2002, p. 30).

The R&D expenditure analyzed in this chapter includes both “S&T-related activities” and investment in the category defined as S&T. S&T-related activities, as defined by MCT, are broader than R&D proper and contribute to the creation, diffusion and application of scientific and technological knowledge.⁷

In these cases MCT is able to measure only public-sector expenditure (i.e. expenditure by government,

7. Mainly scientific and technological services (STS), including for example S&T activities of libraries, museums, zoos, botanical gardens, archives, collections (anthropological, archaeological, geological etc.), information and documentation centers, reference centers, scientific conference centers, databases and information treatment services; translation and editing of S&T literature (including both books and journals, except textbooks for schools and universities); geological and hydrological surveying and prospecting; routine astronomical, meteorological and seismological observation; inventorying of soil, plants, fish and other wildlife; routine soil, atmosphere and water testing; routine testing and control of radioactivity levels; prospecting for petroleum and other mineral resources; collecting data on human, social, economic and cultural phenomena to compile statistics on a regular basis (such as population censuses, production, consumption and distribution statistics, market research, social and cultural statistics etc.); testing, standardization and quality control (especially routine regular analysis, control and testing of materials, products, devices and processes using generally accepted methods, as well as the establishment and maintenance of standards and legal weights and measures); client counselling and advisory services (especially routine regular consulting work provided to clients, other sectors of an organization or independent users to help them apply scientific, technological and management knowledge, including extension and consulting services organized by government for farmers and manufacturers, except the normal activities of design and engineering offices); systematic scientific, legal and administrative activities relating to patent and licensing by public bodies. See <<http://www.mct.gov.br/index.php/content/view/302574.html>> and UNESCO (1984, pp. 30-33).

public-sector agencies and state-owned enterprises). Primary data sources are unavailable for the construction of a series covering private-sector expenditure on scientific and technological services (STS) and other S&T-related activities as defined by MCT.

If the distinction between R&D and STS can be demarcated in the conceptual field, it is extremely difficult to do so in terms of the procedures for measuring these two kinds of expenditure. It is important to note that the activities covered may not directly involve research (e.g. expenditure on libraries, museums, translation and editing of books, opinion surveys, quality testing etc). Such difficulties are common to most countries and this explains why the most important international comparative studies concentrate on indicators for R&D in the narrow sense rather than the broader category of S&T.⁸ Otherwise there would be a risk of computing items that are not pertinent, are inappropriate or are hard to audit. For the same reasons this chapter focuses exclusively on R&D indicators.

A third category that deserves to be mentioned here is innovation. In line with the *Oslo Manual* (OECD, 1997), the *Frascati Manual* recommends deployment of a concept of innovation that extends beyond R&D activities. Technological innovation activities involve all the scientific, technological, organizational, financial and commercial steps, including investment in new knowledge, which lead or are intended to lead to the implementation of technologically new or improved products and processes. R&D is only one of these activities and may be carried out at different phases of the innovation process. R&D may act not only as the original source of inventive ideas but also as a means of problem solving which can be called upon at any point up to implementation. Other activities may be part of the innovation process while not being classified as R&D, according to the *Oslo Manual*: “acquisition of disembodied technology and know-how, acquisition of embodied technology, tooling up and industrial engineering, industrial design n.e.c., other capital acquisition, production start-up, and marketing for new or improved products” (OECD, 2002, p. 18). Business innovation is discussed in detail in Chapter 7 of this publication.

Based on this characterization of activities, R&D can be classified into basic research, applied research,

and experimental development (OECD, 2002). Basic research consists of experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view. Applied research is also original investigation undertaken in order to acquire new knowledge, but directed primarily towards a specific practical aim or objective. Experimental development is systematic work that draws on knowledge gained from research and practical experience, and is directed to producing new materials, products and devices, installing new processes, systems and services, or improving substantially those already produced or installed.

2.2 Some characteristics of the data sources used by MCT for its S&T indicators

A number of comments should be made about the primary data sources used by MCT to calculate national indicators of R&D expenditure. First of all, total expenditure by public administration is theoretically the sum of all instances and agencies at all three levels of government – federal, state and municipal. In practice, however, municipal expenditure is frequently ignored in surveys. This does not affect the results to a significant extent in terms of the measurement of R&D efforts nationwide, since municipalities account for a very small share of expenditure classified in the S&T function. In 2007, for example, the Office of the National Treasury (STN) reported total municipal S&T expenditure of R\$ 54.2 million, less than 1% of the sum of all federal and state S&T expenditures. Nevertheless, these data are very important and should be collected, because there may be growth and if so it would be worth documenting and recognizing this tendency.⁹ The amounts reported by MCT are basically extracted from the financial statements published periodically by public-sector organizations, but MCT also verifies in greater detail the expenditure effected by selected entities when it accesses fiscal and financial administration systems for the purpose of generating special tabulations.¹⁰

8. Such as the country statistics regularly published by OECD, which consistently focus on R&D expenditure.

9. Municipal S&T spending is highly concentrated. Belo Horizonte alone accounted for 48% of the national total in 2006. In São Paulo State, only nine cities reported expenditure classified under this function in 2006, for a total of only R\$ 2.4 million. The largest amounts were spent by São José dos Campos, Ribeirão Preto, Sumaré and Araras. Some cities have reportedly announced tax incentives for investment in R&D in their jurisdictions, probably in accordance with state policy. However, there are no national or state surveys of tax expenditure in this sector.

10. MCT says whenever possible it uses information extracted directly from state and municipal financial administration systems (equivalent to Siafi for the federal tier). If a state's General Financial Statements (BGE) are not available, it takes information from budget bills (PLOA), annual budget laws (LOA) or partial budgetary and financial execution reports provided by state finance departments.

It is important to note that not all items of expenditure are computed to construct the indicators concerned, in contrast with traditional accounting procedures. Those that do not add value directly to R&D activities are excluded, e.g. public debt service (current interest expense and capital expenditure to repay debt); wages, salaries and benefits paid to inactive public-sector employees and retirees; back pay disbursed by court order (since retroactive inclusion in public-sector financial statements is impossible); and expenditure on production classified as industrial by public bodies (e.g. vaccines, pharmaceuticals, farm inputs and implements etc). In the case of higher education, expenditure on teaching hospitals is also excluded since this item is far more adequately classified under healthcare than R&D.

The data treatment process required for the construction of public-sector R&D indicators is not simple.¹¹ MCT adopts three approaches. First it selects S&T organizations deemed “typical” because they conduct permanent organized R&D activities and devote most of their budget to S&T. Next it extracts data on these organization’s expenditure by S&T function, subfunction and program. Finally it seeks to identify any other items of expenditure not booked under S&T but involving R&D-related projects and activities.¹²

While on one hand it is easier to find primary sources of regularly updated information to construct indicators for government R&D expenditure, on the other hand it is necessary to analyze this information with care owing to the specific procedures used to book and report public-sector expenditure. A clear example, as noted above, is the significant difference between budget appropriations, obligated funds, amounts settled and amounts disbursed.

Another relevant aspect of the methodology used is the classification and reporting of expenditure in systems open to public access, which do not always distinguish clearly between S&T expenditure and R&D expenditure, let alone by region. It may sometimes happen that funds actually spent by branch offices of

a decentralized agency are imputed to its central office or headquarters, and such distortions tend to be greatest for the organizations with the most regional units throughout Brazil.¹³

MCT bases its private-sector indicators on the Survey of Technological Innovation (PINTEC) conducted by IBGE, the Brazilian Institute of Geography & Statistics.¹⁴ PINTEC surveys are not carried out every year.¹⁵ The original survey focused on innovation by industry, but this was broadened in 2005 to include other sectors, particularly knowledge-intensive services. Even so the survey does not yet encompass the entire national economy.

MCT measures R&D expenditure by business enterprises for intramural R&D and for external acquisition of R&D as declared to PINTEC. Other data collected by PINTEC but not taken into account by MCT for its indicators because they are deemed to be unrelated to R&D include: acquisition of other external knowledge; acquisition of software; acquisition of plan and equipment; training; market introduction of innovations; and industrial design. Initially PINTEC covered only the mining and manufacturing industries, i.e. firms in groups C and D of the National Economic Activity Classification (CNAE). In the 2005 edition, however, IBGE also included three service industries: telecommunications; information technology and related services; and R&D.¹⁶ These sectors accounted for 30.4% of total declared R&D expenditure, which was R\$ 11.6 billion. R&D services alone accounted for 19.3%, making R&D the largest of all sectors covered by PINTEC, as was expected given the nature of this activity.

MCT extends the scope of its data collection to other federal state-owned enterprises not included in PINTEC, particularly water and power utilities (Box 2A)¹⁷ and financial services (Box 3A).

While the extension of PINTEC’s scope is advantageous, on the other hand it requires redoubled attention when analyzing the time series in order to avoid misinterpretation of the evolution of the indicators, since the survey universe has changed and coverage

11. For a fairly up-to-date detailed view of the budget process, it is worth consulting *Manual Técnico de Orçamento MTO-2009*, published by the Planning Ministry in 2008. This describes how accounts and programs are classified. See <https://www.portalsof.planejamento.gov.br/bib/MTO/MTO2009_04.pdf>.

12. Examples include expenditure on research activities conducted through bodies and institutions linked to the health and agriculture sectors, or investment projects implemented by the Navy and Air Force, which are booked by the federal government under the health, agriculture and national defense functions, respectively. This is correct from an accounting standpoint, of course, since book entries must be based on the principal function of the institutions concerned. For the purposes of measuring R&D expenditure, however, the items in question have to be reclassified.

13. It must be stressed that these distortions with regard to federal expenditure effected in São Paulo State mainly take the form of omission from the expenditure data extracted from Siafi of FINEP’s investments and of grants extended by CAPES and CNPq in the state.

14. PINTEC follows the methodological guidelines set out in the OECD’s *Oslo Manual (third edition, 2005)*. The first PINTEC survey covered the period 1998-2000. The second and third covered the periods 2001-03 and 2003-05, respectively.

15. Results are interpolated or projected for years when no field surveys are conducted.

16. The PINTEC 2005 sample size was 12,000 firms in mining and manufacturing, and 700 firms in telecom and IT. As for CNAE Division 73 (R&D), a census survey covering 42 firms was performed.

17. MCT strives to include the expenditure of federal power utilities in its indicators.

has expanded during the period. MCT calls attention to the fact that in order to compare the 2000 and 2003 survey with the 2005 survey it is necessary to estimate R&D expenditure by the service sector.¹⁸

Higher education is the category of both public- and private-sector expenditure that presents the greatest difficulty in terms of identification and even conceptualization. It is notoriously hard to identify research expenditure because research, like human and material resources, is simultaneously an input for education and S&T.

MCT opted to use postgraduate expenditure as a proxy for higher education R&D expenditure, based on the understanding that postgraduate students must do research in order to earn a degree, and that such research typically includes the elements of novelty and creativity considered characteristic of R&D. However, public university accounts do not distinguish between undergraduate and postgraduate expenditure, so MCT estimates the latter as equivalent to net expenditure on NRD3 academic staff in proportion to total teaching staff (excluding pensions, interest and other expenses).¹⁹ On this basis, it estimated public postgraduate expenditure at 0.3% of GDP in 2007. In the case of private expenditure,²⁰ it made a similar estimate and the resulting number was far smaller, corresponding to 0.03% of GDP in 2007. MCT acknowledges these methods may underestimate higher education R&D expenditure, but the amounts thereby produced are significant nonetheless, corresponding to 26.5% of national R&D expenditure in 2007. Government alone accounted for half the total (with the federal government accounting for three-quarters of typical R&D budget expenditure and state governments for 1.5 times more than typical expenditure).

Besides the numbers published as official indicators, it is worth noting a number of gaps or doubts. MCT itself acknowledges its inability to capture part of

the nation's R&D expenditure, explicitly stating that it cannot identify expenditure by non-governmental organizations or nonprofits. Even in the case of government and business, it recognizes that the data sources are insufficient or imprecise, including deficiencies in classifications and accounting procedures that also contribute to the lack of "available means to measure investment in R&D by nonprofits in the private sector".²¹

Other conceptual issues should be mentioned. One is the computing of subsidies and grants extended by research funding agencies such as the National Council for Scientific & Technological Development (CNPq), subordinated to MCT, the Coordination Office for the Improvement of Higher Education Personnel (CAPES) at the Education Ministry (MEC), and the National Innovation Agency (FINEP), also at MCT. These are not explicitly reported in the primary tabulations produced by MCT in its surveys.

Tax expenditure presents another difficulty. Defined as revenue losses attributable to exclusions, exemptions, deductions, nonrefundable credits, deferrals and preferential rates in the tax code, tax expenditure is not actually booked as expenditure in the national accounts. However, tax expenditure should be measured and publicized to foster best practice in governance and on grounds of transparency and fiscal responsibility. In all its various forms, tax expenditure undoubtedly reflects a set of privileges or advantages designed to stimulate certain kinds of behavior as a matter of public policy, including investment in R&D and technological capability building in both the private and public sectors.²² However, it is not computed as part of R&D expenditure, in accordance with the *Frascati Manual's* recommendations to avoid double counting, since its necessary counterpart is the acquisition of goods and services, or other expenditure made directly by the beneficiaries, typically business enterprises.

18. As per the descriptions of methodological changes in the footnotes (especially note 2) to the tabulation posted by MCT at <<http://www.mct.gov.br/index.php/content/view/79063.html>> (last visited on Jan. 25, 2010).

19. NRD3 refers to teaching staff employed by higher education institutions (HEIs) for at least nine months in the year for a working week of at least 30 hours, at least 30% devoted to postgraduate programs.

20. The proxy used by MCT to measure postgraduate expenditure by private HEIs corresponds to the estimated amount of salaries and benefits paid annually to teachers in postgraduate programs, calculated on the basis of the earnings of S16 lecturers at Pontifícia Universidade Católica do Rio de Janeiro (PUC-RJ). The underlying assumption is that the system of Catholic universities accounts for the lion's share of research done by private HEIs in Brazil. The total is obtained by applying the coefficient described to the total number of teachers in postgraduate programs in private HEIs nationwide.

21. See for example item (c) of the note at <<http://www.mct.gov.br/index.php/content/view/9129.html>>.

22. For an in-depth discussion of public incentives for R&D, see Nelson (1959) and Arrow (1962).

Box 2A – Some items of R&D expenditure not captured by PINTEC (I): power sector

Although the scope of PINTEC was extended in 2005 to include three segments of the service sector (telecommunications, information technology and related services, and R&D), many firms and industries that invest significantly in R&D are still left out of IBGE's survey, which therefore underestimates business R&D expenditure.

Power utilities are a clear example. Thirty years ago the Eletrobras system established the Center for Research in Electric Power (Cepel) in response to demand for technology from the national power industry and to develop Brazil's science and research infrastructure. Cepel is a center of excellence for the sector both nationally and in Latin America. Its founders and controllers are Eletrobras, the state-owned holding company, and four of its subsidiaries, CHESF, Eletronorte, Eletrosul and Furnas, which contribute most of Cepel's funding.

In the context of the new model for the electric power industry and with the enactment of

Law 9991 on July 24, 2000, mandating investment in R&D and energy efficiency by power utilities in the public and private sectors, among other provisions, private-sector utilities operating under concessions or licences are obliged to invest 1% of annual net operating revenue in R&D, with 40% of the total going to the National Fund for Scientific & Technological Development (FNDCT), 40% to R&D projects approved by ANEEL, the electric power industry regulator, and 20% to the Mining & Energy Ministry to pay for power system expansion planning research as well as inventories and feasibility studies for hydroelectric power developments.

According to MCT statistics, in 2006 Cepel invested R\$ 143 million in R&D, while Eletrobras Group companies invested R\$ 167 million, for a total of R\$ 310 million at current prices. Table 3.1A presents the relevant numbers at constant 2007 prices.

Table 3.1A
R&D expenditure by state-owned electric power utilities – 2000-2007

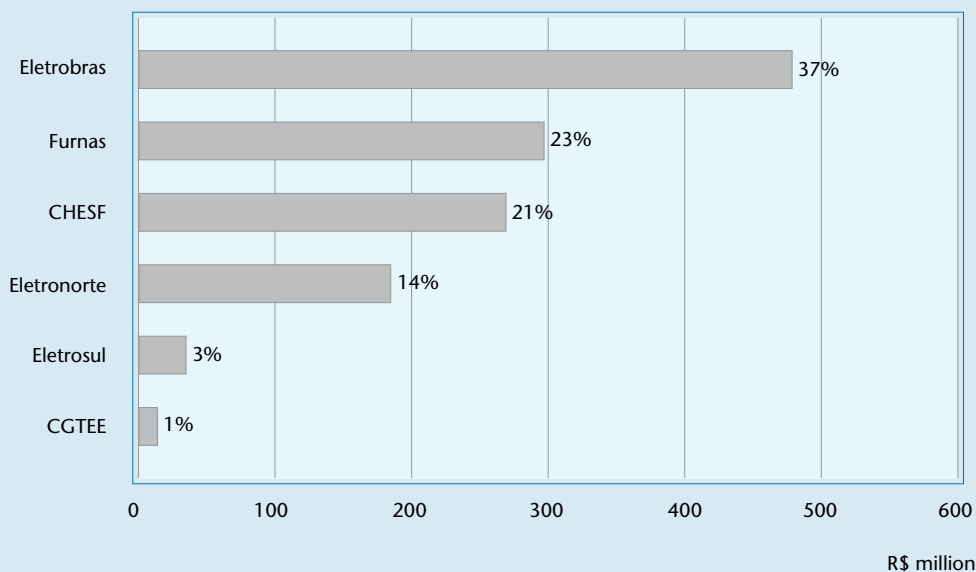
Year	R&D expenditure (2007 R\$ million)		
	Eletrobras	Cepel	Total
2000	1.1	98.1	99.2
2001	19.6	92.9	112.5
2002	41.5	103.5	145.1
2003	53.2	97.9	151.1
2004	108.3	108.1	216.4
2005	150.6	139.6	290.2
2006	173.3	148.3	321.7
2007	...	185.5	...

Source: MCT.

According to a report issued by Eletrobras, R&D expenditure totalled R\$ 988 million between the enactment of Law 9991 in 2000 and 2006. In 2007 it amounted to R\$ 288 million. Thus in

the seven years following enactment of the law, R&D expenditure totalled R\$ 1.277 billion. Figure 3.1A presents a breakdown of this expenditure by Eletrobras Group companies.

Figure 3.1A
R&D expenditure by power sector companies – 2000-2007



Source: Eletrobras. Comitê de Integração Corporativa de Pesquisa e Desenvolvimento Tecnológico (Cicop).

According to Eletrobras, the Power Sector Fund (CT-Energ), one of 16 sectoral funds that make up the FNDCT, expected to receive some R\$ 110 million in 2006. However, Eletrobras stresses that the FNDCT was systematically impounded by

the federal government until 2009, preventing new investment in R&D projects by the fund during the entire period. The total received by the Power Sector Fund between its creation and December 2006 was R\$ 795 million, but only 33% was invested.

Box 3A – Some items of R&D expenditure not captured by PINTEC (II): banking sector

A sense of the intensity of R&D expenditure by the banking sector can be derived from the 2008 R&D Scoreboard produced by the UK Department of Industry, Universities & Skills (DIUS), now the Department for Business, Innovation & Skills (BIS). According to this report, R&D expenditure by 17 financial institutions in the UK, Italy, Portugal, Denmark, Sweden and elsewhere totalled £2 billion, corresponding to 3.3% of their operating profit and 1% of their sales.

Data for Brazil available from Febraban, the national federation of banks, show significant expenditure and investment relating to information technology (IT), which should be taken into account when surveying national R&D expenditure. Banks' IT developer payroll in 2006 totalled R\$ 2.9 billion, or 0.1% of Brazil's GDP and 20% of banks' total IT expenditure. Budgets for 2007 allocate R\$ 3.1 billion to IT personnel and R\$ 15.5 billion to total IT expenditure (Table 3.2A).

Table 3.2A
Brazilian banks' IT payroll expense by function – 2005-2007

Function	Expense (in millions of current R\$)		
	2005	2006	2007(1)
IT payroll	2,500	2,900	3,100
Development: systems maintenance	100	800	700
Development: new applications	1,300	1,000	1,100
Other IT areas	1,100	1,100	1,300
Total IT expenditure	12,900	14,300	15,500

Source: Febraban.
(1) Budgeted.

IT investment by the financial services industry is substantial nationwide, and by definition must be particularly significant in São Paulo State. However, future PINTEC surveys should distin-

guish items legitimately classifiable as R&D expenditure among the areas shown in Table 3.2A. The area termed "new applications" may well include a substantial amount of R&D expenditure.

3. R&D expenditure in São Paulo State

It is essential to analyze R&D expenditure in São Paulo State in order to help understand public policy and strategy for S&T development in the state. MCT's indicators are a good starting-point,²³ but to orient strategy in São Paulo State it is necessary to obtain a level of detail not available from the federal survey. For example, it is important for the state to know how much federal research funding agencies such as FINEP, CAPES and MCT invest in São Paulo. Similarly, for strategic planning purposes São Paulo needs to know how much federally-owned enterprises such as Petrobras and Eletrobras, among others, spend on R&D in the state.

At the same time this chapter represents an opportunity to improve upon the survey produced by MCT, which as already noted acknowledges its own limitations, the need to review certain methodological criteria and statistical sources, and the importance of attempting to disaggregate some of the findings.

The analysis of R&D expenditure in São Paulo State presented here is based on the sources of funding grouped according to institutional objectives: research agencies, higher education, public research institutions, and business enterprises. The latter category includes private research institutions by virtue of the methodological change introduced by IBGE for PINTEC 2005. Thus the following sources of funding are covered:

- a) Research funding agencies:
 1. Federal research funding agencies
 2. State research funding agency
- b) Higher education:

1. Federal HEIs located in São Paulo State
 2. State HEIs
 3. Private HEIs located in São Paulo State
- c) R&D institutions:
 1. Federal R&D institutions located in São Paulo State
 2. State R&D institutions
 - d) Business enterprises:
 - Firms with R&D activities in São Paulo State.

3.1 R&D expenditure in São Paulo State by research funding agencies

3.1.1 R&D expenditure in São Paulo State by federal research funding agencies

Three federal agencies provide research funding in São Paulo State – CNPq, FINEP and CAPES. MCT's surveys do not provide detailed statistics for these agencies at the state level, presenting only national aggregates. The amounts spent in São Paulo by these three federal agencies can be obtained from management reports. CNPq issues regular reports containing these data.²⁴ In the case of CAPES, some data have been published since July 2009. In the case of FINEP, no data have been published but FAPESP commissioned a special survey from the presidency of the agency. The data obtained are presented in Table 3.3A.

3.1.2 R&D expenditure in São Paulo State by state research funding agencies

FAPESP's expenditure in 1995-2008 is presented in Table 3.4A, based on annual reports and statistics published, on the institutional web portal.

23. To produce national indicators MCT constructs statistical series by state and itemizes expenditure in each one by the federal government, state government and firms. Different tabulations for state government R&D expenditure, including a breakdown by state, are available at <<http://www.mct.gov.br/index.php/content/view/2065.html>>. R&D proper is distinguished from STS and other S&T-related activities only in consolidated state statistics. MCT computed R&D expenditure in São Paulo State as amounting to R\$ 11.4 billion at current prices in 2005, of which R\$ 3.8 billion by the federal government (including federal universities in the state), R\$ 3 billion by the state government and R\$ 4.6 billion by firms.

24. <<http://www.cnpq.br/estatisticas/index.htm>>.

Table 3.3A
Research and postgraduate expenditure in São Paulo State by federal agencies – 1995-2008

Agency / geography	Federal research & postgraduate expenditure (in millions of current R\$)													
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CNPq														
Brazil	500.3	534.6	513.1	425.9	441.1	494.0	581.2	598.7	651.2	794.2	852.1	908.5	1,199.2	1,203.6
São Paulo State	181.3	180.4	160.1	129.1	117.2	127.8	144.8	141.2	169.1	216.0	244.7	260.7	310.5	316.6
SP/BR (%)	36.2	33.7	31.2	30.3	26.6	25.9	24.9	23.6	26.0	27.2	28.7	28.7	25.9	26.3
CAPES														
Brazil	354.5	351.9	440.1	387.6	463.0	440.1	474.5	502.8	515.7	542.8	633.5	706.7	748.6	976.6
Brazil ex-portal	354.5	351.9	440.1	387.6	463.0	440.1	426.8	471.9	460.9	498.5	581.7	632.2	681.2	875.6
São Paulo State	78.9	68.1	78.7	87.8	96.4	93.5	105.6	107.3	137.6	151.8	169.9	165.4	196.8	241.2
SP/BR (%) (ex-portal)	22.3	19.4	17.9	22.7	20.8	21.2	24.7	22.7	29.9	30.5	29.2	26.2	28.9	27.5
FINEP														
Brazil	36.8	95.2	58.5	54.0	45.4	177.7	318.6	343.0	188.0	624.4	836.7	897.9	1,393.3	2,076.9
São Paulo State	10.6	28.6	16.5	15.8	11.9	23.8	46.9	58.0	67.0	131.3	134.3	119.5	257.6	262.1
SP/BR (%)	28.8	30.0	28.2	29.3	26.2	13.4	14.7	16.9	35.6	21.0	16.1	13.3	18.5	12.6

Source: CNPq; CAPES; FINEP.

CNPq: expenditure in SP 1995-2000: data furnished by presidency of CNPq to Scientific Dept. of FAPESP on May 6, 2008

Expenditure in SP 2001-2008: spreadsheet <ySaoPaulo2008.xls> on CNPq's stat site, accessed July 1, 2009

Total expenditure 1995-2000: Resenha Estatística CNPq 1995-2000 (CNPq, 2001)

Total expenditure 2001 -2008: spreadsheet <yBrasil2008> on CNPq's stat site, accessed July 1, 2009

CAPES: expenditure in SP 1995: FAPESP (1998)

Expenditure in SP 1996-2001: data furnished by presidency of CAPES to Scientific Dept. of FAPESP on Aug. 26, 2008

Expenditure in SP 2002-2008: GeoCapes queried on July 22, 2009

Total expenditure 1995-2000: <<http://www2.camara.gov.br/orcamentobrasil/orcamentouniao/loa/execucao.html>>

Total expenditure 2001-2008: spreadsheet detailing obligated funds processed for settlement, furnished by MCT Indicadores

Total expenditure excludes Journal Portal (Portal de Periódicos), basic education, administrative expense

FINEP: expenditure in SP 1995: FAPESP (1998)

Expenditure in SP 1996-2008: series furnished by presidency of FINEP to Scientific Dept. of FAPESP on June 29, 2009

Total expenditure 1996-2008: series furnished by presidency of FINEP to Scientific Dept. of FAPESP on June 29, 2009 (grants)

Note: See Detailed Table 3.2A.

Table 3.4A
R&D expenditure by FAPESP – 1995-2008

Agency	R&D expenditure (in millions of current R\$)													
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
FAPESP	97.9	206.9	254.6	304.8	477.4	460.9	493.1	455.5	354.8	393.9	481.7	521.8	542.0	637.9

Source: FAPESP, institutional portal (see <<http://www.fapesp.br/materia/381/estatisticas/dados-e-estatisticas-sobre-a-fapesp.htm>>).

3.2 R&D expenditure in São Paulo State by higher education institutions

It is notoriously difficult to distinguish between teaching and research expenditure in higher education institutions (HEIs). Even in countries with a longer history of maintaining databases and indicators, estimates inevitably have to be made. The challenge is how best to determine the proportion of each HEI's budget that can legitimately be attributed to R&D. This difficulty is internationally acknowledged, so much so that it is highlighted by the *Frascati Manual*, where a special appendix is devoted to recommendations and suggestions for addressing it.²⁵ One of the recommendations is that estimates of resources and personnel dedicated to R&D in higher education should be based on time use, although other methods may also be feasible.²⁶

The methodology adopted in this chapter is consistent with the recommendations of the *Frascati Manual* and analogous to that used by MCT for some years to estimate R&D expenditure by HEIs. The first step is to determine the total expenditure for each HEI that performs R&D activities. The proportion devoted to R&D is then estimated on that basis. This estimate is made using a different method from that used by MCT.

In order to assure international comparability, total expenditure for each HEI has to be adjusted, typically by excluding retirement pensions, which for many public HEIs in Brazil are part of the annual budget, and teaching hospital costs, which consist mostly of healthcare (not R&D) because of the way the public health system is organized in Brazil. This latter exclusion does not mean R&D activities performed by teaching hospitals attached to HEIs are ignored. On the contrary, they are accounted for by computing the proportion of academic staff in medical schools who devote most of their time to R&D, as described below.

3.2.1 Analysis of methodological alternatives for estimating the share of HEI budgets allocated to R&D

Once the total amount of expenditure budgeted by each HEI has been determined, the next step is to estimate the proportion of that expenditure associated with R&D activities. This entails measuring the number of “authorizers of R&D expenditure” and the

fraction of their time devoted to R&D. This procedure entails determining the number of staff devoted full-time or part-time to R&D (in the latter case, evidently, the proportion of their time devoted to R&D must also be determined). There are at least four ways of making this estimate:

- a) Computing the number of academic staff registered as permanent postgraduate personnel by CAPES;
- b) Computing the number of academic staff who hold PhDs;
- c) Computing the number of academic staff employed full-time (in teaching and research in the case of state HEIs in São Paulo);
- d) Computing the number of academic staff who hold PhDs and are employed full-time (in teaching and research in the case of state HEIs in São Paulo).

a) Estimates based on the number of academic staff registered as permanent postgraduate personnel by CAPES

The basic methodology used to construct MCT's indicators requires estimating expenditure by HEIs on the basis of the number of postgraduate staff in proportion to total academic staff. This is facilitated by the CAPES database that counts the number of postgraduate staff employed by private and public HEIs throughout Brazil. The assumption underlying this procedure is that only postgraduate staff perform R&D activities.

This assumption is excessively restrictive in our view. It is widely understood in Brazil that the number of academic personnel registered with CAPES may differ from the number dedicated to R&D at any given HEI. One reason for this is that CAPES prioritizes programs with proportionally more degree holders than staff. In addition, personnel may be dedicated to R&D without participating in postgraduate programs, especially at academically less mature HEIs. Thus the above methodology tends to underestimate R&D expenditure by HEIs.

Another drawback of the methodology in question is that CAPES changes definitions and criteria according to its institutional objectives and this hinders the establishment of a consistent time series from the standpoint of S&T indicators for Brazil. For example, until a few years ago CAPES classified academic staff into groups called núcleos (NRD3, NRD4 etc.), and

25. OECD, *Frascati Manual* (2002), Annex 2, p. 158.

26. OECD, *Frascati Manual* (2002), Annex 2, p. 158. “Time-use surveys or, if these are not possible, other methods of estimating shares of R&D (R&D coefficients) in total activities in the higher education sector are a necessary basis for statistics.”

more recently it has adopted a criterion based on employment relationships (e.g. “permanent”, “invited”, “associate”). Because CAPES does not publish a statistical yearbook, it is not possible currently to obtain historical values from the agency’s publications, while the values posted to GeoCapes, its recently launched georeferenced database, do not comply with the definitions used historically.

b) Estimates based on the number of academic staff who hold PhDs

Doctoral degrees are recognized in the academic world as a prerequisite for leadership of R&D activities. Only academics with PhDs can apply for funding from agencies such as CNPq and state research funding agencies (FAPs).

However, holding a PhD does not guarantee full-time employment, which typically enables academic staff to devote time to R&D activities in addition to teaching and extension. Hence this methodological alternative may overestimate R&D expenditure by HEIs.

c) Estimates computing the number of academic staff employed full-time (in teaching and research in the case of state HEIs in São Paulo)

The problem with this alternative is that full-time employment by federal and private HEIs does not entail dedication to research.²⁷ Although some federal universities have internal rules requiring a research plan to access the full-time career regime, large numbers of academics employed full-time by HEIs do not have PhDs (Table 3.5A), indicating that research is not necessarily prioritized.

Thus this method also tends to overestimate R&D expenditure by HEIs.

d) Estimates computing the number of academic staff who hold PhDs and are employed full-time (in teaching and research in the case of state HEIs in São Paulo)

An alternative that tends to reduce the distortions noted in connection with the previous two approaches entails computing staff who hold PhDs and are employed full-time. The combination of these two factors

(doctoral status plus full-time employment) justifies the assumption that the academics concerned perform research.

This methodology is consistent with the recommendations of the *Frascati Manual*, without being as excessively restrictive as the alternative described in item (a) above. It maintains the restriction, recommended in the Manual, of considering as R&D only activities that comprise “an appreciable element” of new knowledge and contribute to the “resolution of scientific and/or technological uncertainty.”²⁸ On the other hand, it also respects the recommendation that education and training should be excluded.²⁹ To this end the present analysis uses a “discount factor” to exclude the time devoted to teaching, as described below.

Furthermore, this methodology is based on rigorous institutional criteria, since the numbers of PhDs and full-time staff have an impact on payroll and are therefore carefully monitored by HEIs. These criteria also display a far greater historical permanence than those associated with alternative (a), permitting the construction of long time series.

3.2.2 Statistical counts of HEI academic staff

Table 3.5A presents the numbers of academics employed by federal, state and private HEIs in Brazil, categorized according to the qualifications specified in methodological alternatives (a), (b), (c) and (d) above.

The distortion introduced by alternative (c), which counts full-time academics, is quite evident, especially in the case of private HEIs. These institutions notoriously do very little science, both in terms of scientific articles published and in terms of research proposals presented to federal or state funding agencies. In this context, it is clear that the 38,671 academics reported as being full-time employees of private HEIs by INEP’s Sinopse for 2007 do not devote most of their time to research. The number of full-time academics employed by federal HEIs in 2007 was 53,413, while 30,455 of academics at federal HEIs had at least a PhD. Full-time academic staff at state HEIs totalled 31,781 in 2007, and 17,889 had PhDs.

27. The legal basis for the full-time employment of academics (40 hours per week) by federal HEIs is Decree 94,664, enacted on July 23, 1987. The regime is defined in article 14, §I, which makes no reference to the obligation to do research (our emphasis).

28. OECD, *Frascati Manual* (2002, p. 34): “The basic criterion for distinguishing R&D from related activities is the presence in R&D of an appreciable element of novelty and the resolution of scientific and/or technological uncertainty, i.e. when the solution to a problem is not readily apparent to someone familiar with the basic stock of common knowledge and techniques for the area concerned.”

29. OECD, *Frascati Manual* (2002, p. 31): “All education and training of personnel in the natural sciences, engineering, medicine, agriculture, the social sciences and the humanities in universities and special institutions of higher and post-secondary education should be excluded.”

Table 3.5A
Total academic staff in HEIs and staff registered as postgraduate (PG) with PhDs and employed full-time (FT)
by administrative jurisdiction – Brazil – 2000-2007

Administrative jurisdiction / academic category	Number of academics in HEIs							
	2000	2001	2002	2003	2004	2005	2006	2007
Federal HEIs								
Total academic staff	50,165	51,765	51,020	52,106	54,439	56,565	58,078	63,302
PG	12,761	12,844	14,050	15,245	17,034	18,114	19,467	21,084
PhDs	16,747	18,203	19,659	21,327	22,863	24,510	27,122	30,455
FT	42,599	43,494	42,889	43,270	44,837	47,649	48,580	53,413
FT + PhDs	14,221	15,295	16,526	17,710	18,830	20,647	22,687	25,697
State HEIs								
Total academic staff	33,730	34,618	35,354	36,098	38,182	39,780	41,007	44,346
PG	7,448	7,613	7,875	8,134	9,233	9,708	10,451	10,668
PhDs	11,152	12,205	12,972	14,015	14,741	15,555	16,427	17,889
FT	23,381	24,255	26,060	26,577	28,186	28,566	30,013	31,781
FT + PhDs	7,730	8,551	9,562	10,318	10,882	11,170	12,023	12,820
Private HEIs								
Total academic staff	109,558	128,997	150,260	172,953	192,818	201,841	209,883	218,823
PG	2,063	2,424	3,085	3,629	5,729
PhDs	12,401	15,278	17,566	19,973	22,641	24,641	25,851	26,890
FT	18,121	21,838	24,460	25,325	27,632	32,802	33,754	38,671
FT + PhDs	2,051	2,586	2,859	2,925	3,245	4,005	4,157	4,752

Source: INEP (Sinopses Estatísticas) – total academic staff, PhDs, FT; MCT (Indicadores de C&T) – postgraduate staff; FT + PhDs estimated based on FT staff as proportion of total PhDs (see 3.2.1 above).

On the other hand, it is clear that counting academics dedicated to postgraduate programs at public HEIs fails to take into account part of these institutions' research efforts. In 2007 federal HEIs had 21084 academics in postgraduate programs and 25,697 employed full-time with PhDs, while state HEIs had 10,668 registered with CAPES as permanent postgraduate staff and an estimated total of 12,820 full-time academics with PhDs. In both cases the numbers with PhDs and employed full-time are approximately 20% higher than the numbers of postgraduate staff. Private HEIs, in contrast, had 20% more postgraduate academics than full-time academics with PhDs.

3.2.3 Estimating the fraction of time devoted to R&D by full-time academics with PhDs

The *Frascati Manual* recommends that the time devoted to activities not classified as R&D should be excluded from staffing estimates undertaken to calculate R&D expenditure. Such activities include education, training, administration and support. Several methods have been used to estimate the time devoted to R&D by academics in HEIs. The *Frascati Manual* recommends time-use surveys of academic staff or estimates based on other methods.³⁰ For the purposes of this analysis it

30. OECD, *Frascati Manual*, Annex 2 (2002, p. 158): "Time-use surveys or, if these are not possible, other methods of estimating shares of R&D (R&D coefficients) in total activities in the higher education sector are a necessary basis for statistics."

was decided to estimate time devoted to R&D based on the difference between the salary paid to part-time and full-time academics by state universities in São Paulo. This difference has remained constant for several years and is equivalent to 82.7%.

3.2.4 R&D expenditure by HEIs in São Paulo State

In accordance with the above, R&D expenditure by public HEIs in São Paulo State (E_{HEIPub}) is calculated as follows:

$$D_{\text{HEIPub}} = \sum_{k=1}^n 82,7\% \times \left(\frac{N_{\text{DR+FT}}}{N_{\text{Total}}} \right) \times EB_k,$$

where $N_{\text{DR+FT}}$ is the headcount of full-time academics with PhDs, N_{Total} is the total academic staff headcount and EB_k is the “excluded budget” of institution “k,” i.e. the total budget less the cost of retirement pensions, hospitals and museums. The reduction factor 82.7% excludes the time devoted to activities not classified as R&D.

R&D expenditure by private HEIs (E_{HEIPrv}) is also calculated by counting full-time personnel with PhDs and multiplying by a factor for average cost based on the Level 6 salary paid by the Catholic University of

Rio de Janeiro (SalPUC), in accordance with the methodology used by MCT:³¹

$$D_{\text{HEIPrv}} = \sum_{i=1}^n 82,7\% \times (N_{\text{DR+FT}})_i \times \text{SalPUC},$$

where $\sum n$ is the sum of the “n” private HEIs located in São Paulo State.

Table 3.6A presents the numbers of academics in each category for HEIs in São Paulo State. It is worth noting that the numerical difference between categories PG, PhD and PhD+FT for public HEIs in São Paulo State (Table 3.6A) is far smaller than the difference for public HEIs in Brazil (Table 3.5A), evidencing the higher level of academic maturity of São Paulo’s public HEIs, which use the available resources more efficiently.

Budget data for public HEIs were extracted for this chapter from the expenditure accounts obtained whenever possible from each of the institutions concerned, excluding the cost of inactive employees and hospital costs, in accordance with international recommendations regarding the measurement of R&D expenditure.³²

The findings for R&D expenditure by HEIs in São Paulo State are presented in Table 3.7A.³³ The primary data used can be examined in Detailed Tables 3.3A (state HEIs) and 3.4A (federal HEIs).

31. See <<http://www.mct.gov.br/index.php/content/view/27961.html>> (last visited Jan. 25, 2010).

32. There are significant inconsistencies in the expenditure accounts used by MCT to estimate R&D expenditure for state universities in São Paulo, from which postgraduate expenditure is excluded. The principal inconsistency is non-deduction of the cost of inactive employees in the first three years of the decade. This can lead to a mistaken inference that state expenditure in the segment fell sharply in the period. In addition, the number of academics registered as employed in postgraduate work is less than the number recorded by INEP’s Census of Higher Education.

33. The changes made by this chapter to the methodology for calculating R&D expenditure in São Paulo State and the updated parameters used (including regional GDP) explain the differences between the data presented here and the data presented in the previous edition of this publication (FAPESP, 2005).

Table 3.6A
Total academic staff in HEIs and staff registered as postgraduate (PG) with PhDs and employed full-time (FT) by administrative jurisdiction – São Paulo State – 2000-2007

Administrative jurisdiction / academic category	Number of academic staff in HEIs							
	2000	2001	2002	2003	2004	2005	2006	2007
Federal HEIs								
Total academic staff	1,400	1,447	1,492	1,454	1,715	1,777	1,858	2,095
PG	845	817	894	911	959	994	1,036	1,184
PhDs	1,049	1,096	1,139	1,139	1,142	1,234	1,267	1,603
FT	1,263	1,278	1,380	1,320	1,533	1,612	1,495	1,816
FT + PhDs	946	968	1,053	1,034	1,021	1,119	1,019	1,390
State HEIs								
Total academic staff	11,244	11,107	11,124	11,216	11,356	11,870	12,114	12,302
PG	6,455	6,402	6,594	6,624	7,452	7,691	7,969	7,877
PhDs	8,143	8,754	8,956	9,298	9,402	9,716	10,031	10,275
FT	8,747	8,887	8,866	8,836	8,736	8,975	9,199	9,452
FT + PhDs	6,335	7,004	7,138	7,325	7,233	7,346	7,617	7,895
Private HEIs								
Total academic staff	40,209	46,058	50,533	54,218	57,410	57,250	58,116	60,593
PG	990	1,185	1,442	1,698	2,114	2,298	2,433	2,589
PhDs	6,293	7,730	8,217	9,102	10,001	10,096	10,599	10,973
FT	6,310	6,813	7,883	7,149	8,195	9,872	10,823	11,722
FT + PhDs	988	1,143	1,282	1,200	1,428	1,741	1,974	2,123

Source: INEP (Sinopses Estatísticas) – total academic staff, PhDs, FT; MCT (Indicadores de C&T) – postgraduate staff; FT + PhDs estimated based on FT staff as proportion of total PhDs (see 3.2.1 above).

Table 3.7A
Higher education R&D expenditure in São Paulo State by type of HEI – 1995-2008

Administrative jurisdiction	Higher education R&D expenditure (in millions of current R\$)													
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Higher Education	593.8	697.6	772.2	746.0	819.2	1,115.3	1,178.3	1,321.5	1,452.0	1,678.0	1,868.8	2,286.4	2,570.9	3,274.1
Federal HEIs	69.9	73.7	67.0	68.9	49.5	75.4	89.5	97.4	169.3	144.8	154.1	279.3	357.2	425.6
State HEIs	506.0	605.3	685.1	654.5	735.8	983.9	1,019.9	1,142.3	1,196.2	1,417.9	1,565.6	1,828.5	2,011.2	2,646.0
Private HEIs	17.9	18.6	20.1	22.6	33.9	56.0	68.9	81.9	86.5	115.3	149.1	178.6	202.5	202.5

Source: Data obtained directly from each institution (budget execution), whenever possible, excluding cost of inactive employees and hospital costs.

Notes: 1. Calculations performed in accordance with methodology described in 3.2 above.
2. See Detailed Table 3.3A and 3.4A.

3.3 R&D expenditure in São Paulo State by R&D institutions

This section focuses on R&D expenditure by state and federal research institutions. There are also some private research institutions but these are covered by IBGE's PINTEC survey.

3.3.1 R&D expenditure by state research institutions

Measuring R&D expenditure by state research institutions requires several approximations, since many of the institutions concerned perform functions that frequently extend beyond R&D activities proper. The state's budget execution reports do not accurately reflect the R&D activities performed by each institution and hence the need for approximations in each case.

There are 16 state research institutions in São Paulo, distributed as follows:

- a) Department of Development (1 institution): Instituto de Pesquisas Tecnológicas (IPT);³⁴
- b) Department of Agriculture (6 institutions and 15 regional centers, all of which have been subordinated since 2002 to Agência Paulista de Tecnologia dos Agronegócios, APTA): Instituto Agrônomo de Campinas (IAC), Instituto de Zootecnia (IZ), Instituto da Pesca (IP), Instituto de Tecnologia de Alimentos (Ital), Instituto Biológico (IB), Instituto de Economia Agrícola (IEA), APTA Regional;
- c) Department of the Environment (3 institutions): Instituto Geológico (IG), Instituto Florestal (IF), Instituto de Botânica (IBot);
- d) Department of Health (7 institutions and two other organizations): Instituto Butantan, Instituto Adolfo Lutz, Instituto da Saúde, Instituto Emílio Ribas, Instituto Lauro Souza Lima, Instituto Pasteur, Instituto Dante Pazzanese, Superintendência de Controle de Endemias, Fundação Oncocentro.

IPT furnished FAPESP with a breakdown of funding received from the state treasury in the period 1995-2008. It is important to note that IPT, the state technological research institute, has other sources of revenue, especially contracts with business enterprises to provide consulting and research services. However, these activities are not considered for the purposes of this subsection, which covers only government sources of funding. In principle, they will have been included in business R&D expenditure.

For the institutions subordinated to APTA, R&D expenditure in the period 1995-2003 was computed using data reported in Gonçalves et al. (2004). For 2004-05, the same authors supplied FAPESP with an updated series. For 2006-08, annual data were extracted from the São Paulo State Budget (Lei Orçamentária do Estado de São Paulo).

For the three institutions subordinated to the Department of the Environment, a series covering the period 2000-08 was furnished by the department.³⁵ Values for the period 1995-99 were estimated, assuming real values to be for 2000 and using the IGP-DI inflation index as a deflator to obtain values in current reais (R\$).

For the institutions subordinated to the Department of Health, estimating R&D expenditure is more complex because many of them are intensely involved in providing healthcare. The analysis followed the methodology in FAPESP (2002), which presented data for R&D expenditure by these institutions in 1995-98. For the period 1998-2002, the data published in FAPESP (2005) were retrieved. For the period 2005-07, budget execution data furnished by the São Paulo State Department of Finance were used. Finally, values for 2003 and 2004 were obtained by linear interpolation based on the values for 2002 and 2005; for 2008, the real value for 2007 was repeated.

The findings for R&D expenditure by state research institutions are presented in Table 3.8A.

34. Instituto de Pesquisas Energéticas e Nucleares (IPEN) is administratively subordinated to the Department of Development, but its budget is federal and it is therefore included in the subsection on federal research institutions.

35. FAPESP is grateful to Dr. Vera Bonomi for her generous assistance and courtesy in collecting the data and discussing with the authors of this chapter the appropriate method of producing the estimates required while excluding activities not classifiable as R&D.

Table 3.8A
R&D expenditure by state research institutions – São Paulo State – 1995-2008

Institution	R&D expenditure by state research institutions (in millions of current R\$)													
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total	155.6	170.9	193.1	187.5	209.9	232.2	245.1	262.2	270.9	293.3	352.3	384.9	413.2	449.3
IPT	66.1	73.3	78.8	82.1	82.1	81.7	84.4	94.5	102.2	106	116.3	121.8	116.9	118.9
APTA	42.2	48.8	50.6	47	59	74	76.4	74.9	77.5	82.6	96.7	109.5	126.3	162.1
Dept. of Health	32.4	32.3	45.9	40	48.3	53.1	59.8	62.1	64.3	68.5	89.4	97.5	112.2	124.8
Dept. of Environment	14.8	16.4	17.7	18.4	20.5	23.3	24.5	30.7	26.9	36.1	49.9	56.2	57.8	43.5

Source: IPT (Executive Committee in response to request from FAPESP); APTA (2000-05, Sidney Sanches; 2006-08, SP State Budget); Dept. of Health (2000-01, FAPESP 2005; 2002-08, budget execution, SP Dept. of Finance); Dept. of Environment (Vera Bonomi, Mar. 9, 2009, in response to request from FAPESP).

3.3.2 R&D expenditure by federal research institutions

Eight federal institutions dedicated to R&D activities are located in São Paulo State:

- a) Instituto Nacional de Pesquisas Espaciais (INPE)
- b) Instituto de Pesquisas Energéticas e Nucleares (IPEN)
- c) Centro Tecnológico Aeroespacial (CTA)
- d) Centro de Tecnologia da Informação Renato Archer (CTI, ex-Cenpra)
- e) Laboratório Nacional de Luz Síncrotron (LNLS)
- f) Centro Tecnológico da Marinha em São Paulo (CTMSP)
- g) Ibama (Superintendência do Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais), São Paulo and regional offices
- h) Embrapa (Empresa Brasileira de Pesquisa Agropecuária), five centers: Embrapa Pecuária Sudeste (CPPSE), Embrapa Informática Agropecuária (CNPDTIA), Embrapa Meio Ambiente

(CNPMA), Embrapa Monitoramento por Satélite (CNPMS), Embrapa Instrumentação Agropecuária (CNPDTIA).

Data on budget execution with direct funding from the National Treasury were furnished by INPE, IPEN, CTI and LNLS.³⁶ In the case of LNLS, management did not have data for the period 1995-99 and the real value for 2000 was therefore repeated for these years, deflated by the IGP-DI to obtain current values for each year.

Data on R&D expenditure by CTA, CTMSP, Ibama and Embrapa for the period 2000-08 were supplied in special tabulations by MCT. For the period 1995-99, the real value spent in 2000 by each institution was repeated, deflated by the IGP-DI to obtain current annual values. In the case of Embrapa, in addition to current expenditure and capital expenditure in the MCT tables, Embrapa's management furnished data on payroll expenditure by units located in São Paulo State (Feb. 9, 2010).

The findings for R&D expenditure by federal research institutions are presented in Table 3.9A.

36. Funding from other federal agencies or from other states or private sources was not computed in these cases owing to the unavailability of data.

Table 3.9A
R&D expenditure by federal research institutions – São Paulo State – 1995-2008

Institution	R&D expenditure by federal research institutions (in millions of current R\$)													
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total	247.5	217.4	262.6	295.6	321.0	374.0	406.3	362.1	373.3	452.9	582.9	621.2	672.6	783.4
INPE	71.5	58.6	85.2	105.4	118.1	145.1	127.3	104.2	109.5	144.5	223.8	237.8	257.4	266.6
IPEN	71.8	47.6	49.5	57.8	61.3	68.3	99.6	98.8	102.0	117.9	127.0	146.0	153.8	181.8
CTA	35.8	39.7	42.9	44.5	36.5	38.5	41.0	38.2	35.0	55.0	69.3	70.5	74.1	82.4
CTI-Cenpra	9.3	11.1	13.1	12.3	13.8	14.8	15.1	16.9	16.8	17.4	20.7	21.0	23.6	23.6
LNLS	6.7	7.5	8.1	8.4	13.4	11.3	14.7	18.2	15.0	22.6	22.6	21.3	22.3	24.8
CTMSP	30.6	34.0	36.7	38.1	48.2	63.1	72.3	47.8	52.8	45.6	59.2	54.1	59.0	111.5
Ibama	0.0	0.0	0.0	0.0	0.0	0.8	1.5	1.3	1.1	1.4	2.3	2.1	2.0	...
Embrapa	21.9	18.9	27.1	29.0	29.6	32.2	34.9	36.8	41.1	48.6	58.0	68.5	80.6	92.7

Source: INPE, IPEN, CTI-Cenpra, LNLS (data supplied by management in response to request from FAPESP); CTA, CTMSP, Ibama, Embrapa (special tabulation supplied by Renato Viotti, Ascav/MCT).

Note: Values for the period 1995-97 for CTA, LNLS, CTMSP and Embrapa were estimated using the *Real* value for 1998 deflated to obtain current value.

3.4 Business expenditure on R&D in São Paulo State

Business expenditure on R&D (BERD) is not measured to a significant extent in Brazil. Some relatively reliable data were collected by IBGE's PINTEC surveys in 2000, 2003 and 2005, but the irregularity of this survey is an evident drawback.

Between 1995 and 1999, the National Association for R&D in Innovative Companies (ANPEI), produced an annual survey of BERD and other aspects of business R&D. Its coverage was irregular although in some years the companies surveyed accounted for more than 40% of Brazil's industrial GDP.

In this context estimating BERD in São Paulo State over a relatively long period (since 1995), as this chapter set out to do, entailed a number of approximations. These are described below, bearing in mind the following three challenges:

- Limitations to the classification of BERD by region or state;
- Changes to the scope of the PINTEC survey, which in 2005 was extended to include some service segments (in addition to mining and manufacturing, covered by the 2000 and 2003 surveys);

- Development of a methodology to estimate BERD in years for which PINTEC did not collect data in the field.

3.4.1 Limitations to estimates of BERD due to the regionalization system used by PINTEC

Another important issue relating to IBGE's approach to regionalization is that the shares of some states in total BERD tend to be overestimated because PINTEC collects corporate data, attributing all R&D expenditure to firms' head offices or parent organizations. São Paulo State in particular is home to the largest industrial firms in Brazil, most of which may well effect R&D expenditure in branches located in other territories. Conversely, large federally-owned enterprises such as Petrobras and Eletrobras probably perform some R&D activities in São Paulo State although their head offices are located in Brasília or Rio de Janeiro; the same applies to the major telecommunications and mining companies. Given that PINTEC does not provide primary microdata enabling recalculation of BERD in such cases, in this chapter the data are left unchanged as published by IBGE and should therefore be interpreted in light of the distortions mentioned.

3.4.2 Estimating BERD for the service sector

The change in PINTEC's scope in 2005, when it was extended to include services, was highly positive because it made the survey more representative but it also poses a challenge in the sense that the 2005 data have to be harmonized with the 2000 and 2003 data. Although this entails estimates, it is justified by mak-

ing an analysis possible over a longer period, which is valuable when discussing the evolution of national and state R&D expenditure. Thus any loss in precision is more than offset by scope gains.

Tables 3.10A and 3.11A present a summary of the data reported by PINTEC³⁷ completed with estimates to harmonize the series, since PINTEC did not cover the service sector in 2000 or 2003. The approximations used for this harmonization were as follows:

Table 3.10A
Business expenditure on R&D by major economic sector – Brazil & São Paulo State – 1995-2008
(years for which data are available)

Economic sector	BERD (in millions of current R\$)		
	2000	2003	2005
Total Brazil (1)	6,279.7	8,292.1	11,588.8
Mining & manufacturing	4,372.3	5,773.5	8,068.9
Services	1,907.4	2,518.6	3,519.9
Total Brazil accdgd to MCT (2)	5,312.0	7,014.3	9,803.0
Mining & manufacturing	4,372.3	5,773.5	8,068.9
Services	939.7	1,240.8	1,734.1
Total São Paulo State (1)	3,181.6	4,323.7	5,690.7
Mining & manufacturing	2,559.5	3,478.3	4,578.1
Services	622.1	845.4	1,112.7

Source: IBGE, PINTEC 2000, 2003, 2005.

- R&D Brazil:

2000: <H1-SP.xls> (IBGE), Tab 5A, line 8, sum of intramural and externally acquired R&D (data available for mining and manufacturing only)

2003: Tab 208, line 9 (IBGE), sum of intramural and externally acquired R&D (data available for mining and manufacturing only)

2005: Tab 1108, line 9, sum of intramural and externally acquired R&D

2000, 2003, 2005, Services: MCT website <<http://www.mct.gov.br/index.php/content/view/79063.html>> states that "PINTEC covered services only in 2005; values for 2000-04 and 2006-08 were estimated considering the percentage share of the service sector in the total for 2005 (17.7 %). Values for R&D institutions already included in surveys of public investment (Embrapa, Fiocruz etc.) were subtracted in 2005". The value used in this table for services in 2005 in Brazil is that of MCT (1734.137, instead of 3519.9 in PINTEC).

- R&D SP:

2000: <H1-SP.xls> (IBGE), Tab 5A, line 9, sum of intramural and externally acquired R&D (data available for mining and manufacturing only)

2003: Tab 2.8, line 21 (IBGE), sum of intramural and externally acquired R&D (data available for mining and manufacturing only)

2005: <SaoPaulo_H1.xls> (IBGE), Tab 2.8, line 10, sum of intramural and externally acquired R&D (data available for mining and manufacturing only).

(1) According to PINTEC.

(2) According to PINTEC, adjusted by Ascav/MCT to exclude state and federal institutions.

Note: PINTEC records quantitative variables for the year immediately prior to the survey year. Thus BERD values stated here are for 2000, 2003 and 2005 (since data for the corresponding PINTEC surveys were collected in 2001, 2004 and 2006).

37. The analysis that follows is based on the sum of expenditures for intramural and extramural R&D, together comprising BERD.

Table 3.11A
Number of researchers in business enterprises by major economic sector – Brazil & São Paulo State – 1995-2008 (years for which data are available)

Economic sector	Number of researchers in business enterprises		
	2000	2003	2005
Total Brazil	35,968	38,974	49,355
Mining & manufacturing	20,114	21,795	27,600
Services (1)	15,854	17,179	21,755
Total São Paulo State	16,374	18,689	23,747
Mining & manufacturing	11,632	13,277	16,870
Services (1)	4,742	5,412	6,877

Source: IBGE, PINTEC 2000, 2003, 2005.

- researchers Brazil:

2000: <H1-SP.xls> (IBGE), Tab 9, line 7 (data available for mining and manufacturing only)

2003: PINTEC 2003, Tab 1.1.12

2005: Tab 1112 (IBGE), line 8 (data available for mining, manufacturing and services)

- researchers SP

2000: <H1-SP.xls> (IBGE), Tab. 9, line 8 (data available for mining and manufacturing only)

2003: Tab 212-SP (IBGE), line 8 (data available for mining, manufacturing and services)

2005: <Sao_Paulo-H1.xls> (IBGE), Tab 2.9, line 9 (data available for mining and manufacturing only)

2005, Services: data supplied by MCT from PINTEC (IBGE), detailing numbers of researchers in service sector by state

(1) 2000 and 2003: estimates; 2005: data from PINTEC 2005.

Note: PINTEC records quantitative variables for the year immediately prior to the survey year. Thus numbers of researchers in business enterprises stated here are for 2000, 2003 and 2005 (since data for the corresponding PINTEC surveys were collected in 2001, 2004 and 2006).

- BERD in the service sector nationwide in 2000 and 2003 was estimated using the proportion between R&D expenditure in services and in mining/manufacturing in 2005;
- BERD in the service sector in São Paulo State in 2005 was estimated using R&D expenditure per researcher nationwide multiplied by the number of researchers in the service sector reported for São Paulo State by PINTEC 2005 (Table 3.11A);
- BERD in the service sector in São Paulo State in 2000 and 2003 was estimated using the proportion between BERD in services in São Paulo State and in mining/manufacturing in São Paulo State for 2005.

3.4.3 Using gross fixed capital formation (GFCF) to estimate BERD over the long term

A long series of business expenditure on R&D would be highly desirable for a better understanding of the evolution of the ST&I system in São Paulo State. As noted above, this is not the case as PINTEC data are available only for 2000, 2003 and 2005. Data were collected by ANPEI for the period 1994-99 but the methodology used to collect them was different from PINTEC's. Moreover, the coverage of ANPEI's survey was partial and its data cannot be reproduced year by year, hindering their use in a trend analysis. This justifies a search for indicators that can be used as proxies for BERD in a long-term series.

Starting from the idea that business R&D efforts correspond to business investment capacity, it seems reasonable to assume that BERD correlates with gross fixed capital formation (GFCF),³⁸ which is part of the system of national accounts in most countries.³⁹

From the data displayed in Detailed Tables 3.5A and 3.6A it is possible to calculate correlations between time series for GFCF and BERD. The results are

shown in Table 3.12A. The correlations are very high, except in three cases: Japan, Portugal and Germany.

On the other hand, the correlation is 1.00 for Norway and 0.99 for Australia, China, Greece, Spain and the U.S. In the case of Germany, it can easily be verified that reunification caused a break in the trend, with correlations of 0.92 and 0.62 before and after reunification respectively. Portugal's correlations before and after join-

Table 3.12A
Correlation between gross fixed capital formation (GFCF) and business expenditure on R&D (BERD) – selected countries – 1981-2008

Country	Correlation
Australia	0.99
Austria	0.96
Belgium	0.98
Canada	0.95
China	0.99
Denmark	0.97
Finland	0.90
France	0.96
Germany	0.88
Greece	0.99
Ireland	0.98
Italy	0.98
Japan	0.63
Mexico	0.97
Netherlands	0.98
New Zealand	0.98
Norway	1.00
Portugal	0.73
South Korea	0.98
Spain	0.99
Sweden	0.94
Switzerland	0.93
UK	0.97
USA	0.99

Source: OECD. *Main Science, Technology and Innovation Indicators*; UNStats.

Note: See Detailed Tables 3.5A and 3.6A.

38. Defined thus by OECD: "Gross fixed capital formation is measured by the total value of a producer's acquisitions, less disposals, of fixed assets during the accounting period plus certain additions to the value of non-produced assets (such as subsoil assets or major improvements in the quantity, quality or productivity of land) realized by the productive activity of institutional units." See <<http://stats.oecd.org/glossary/detail.asp?ID=1171>> (last visited Feb. 1, 2010).

39. A description of the system of national accounts can be found at <<http://unstats.un.org/unsd/nationalaccount/sna.asp>> (last visited Feb. 1, 2010).

ing the euro zone are 0.98 and 0.93 respectively. Japan appears to present the greatest challenge: its correlation for the period 1981-91 is 0.98, but the correlation for the period 1991-2008 is negative (-0.72).

In sum, the fact that the correlation between GFCF and BERD is more than 0.9 for 21 out of these 24 countries tends to support the hypothesis.

Moreover, the correlation has broader implications, as demonstrated below. A series of regressions calculated using statistical normalization can be performed to convert the series X into a nondimensional series n with an average of zero and normalized variance (Hoffman, 1991, p. 355):

$$v_i = \frac{X_i - \bar{X}}{s_x}$$

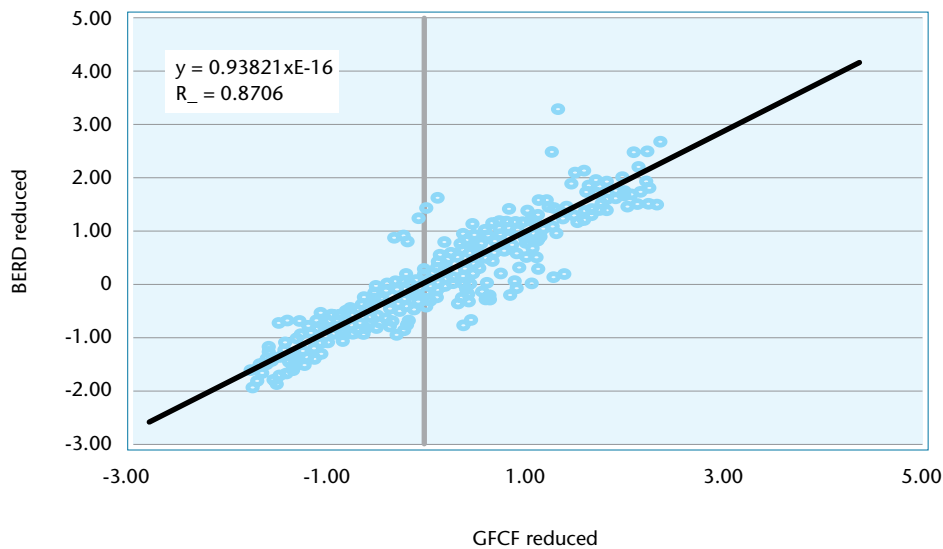
where \bar{X} is the average value of X; and $s_x = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$, where n is the number of points.

Reduction of the variables to the series of pairs of values with (BERD, GFCF) yields the distribution shown in Figure 3.2A.

The strong correlation between BERD and GFCF is cogently shown in Figure 3.2A. The figure also shows the result of linear regression between the two reduced variables, indicating a coefficient of determination $R^2=0.87$.

The next interesting finding results from superimposition of the data in Figure 3.2A on to the data for Brazil and São Paulo State obtained from PINTEC 2000, 2003 and 2005. Values of BERD for Brazil and São Paulo were obtained from the PINTEC data (in the case of Brazil, corrected by MCT to eliminate double counting). Values of GFCF for Brazil were obtained from IBGE (Sidra); GFCF for São Paulo was calculated from state GDP, assuming the same composition as for Brazil, since it was not possible to find measures of GFCF at the state level.

Figure 3.2A
 Linear regression between gross fixed capital formation (GFCF) and business expenditure on R&D (BERD) – selected countries – 1981-2008



Source: OECD, *Main Science, Technology and Innovation Indicators*; UNStats.

Notes: 1. Reduced values of BERD and GFCF (see 3.4 above), showing 554 pairs of points obtained for 24 countries listed in Table 3.12A.
 2. See Detailed Tables 3.5A and 3.6A.

Reduction of the variables by the same method as before yields the points shown in Figure 3.3A.

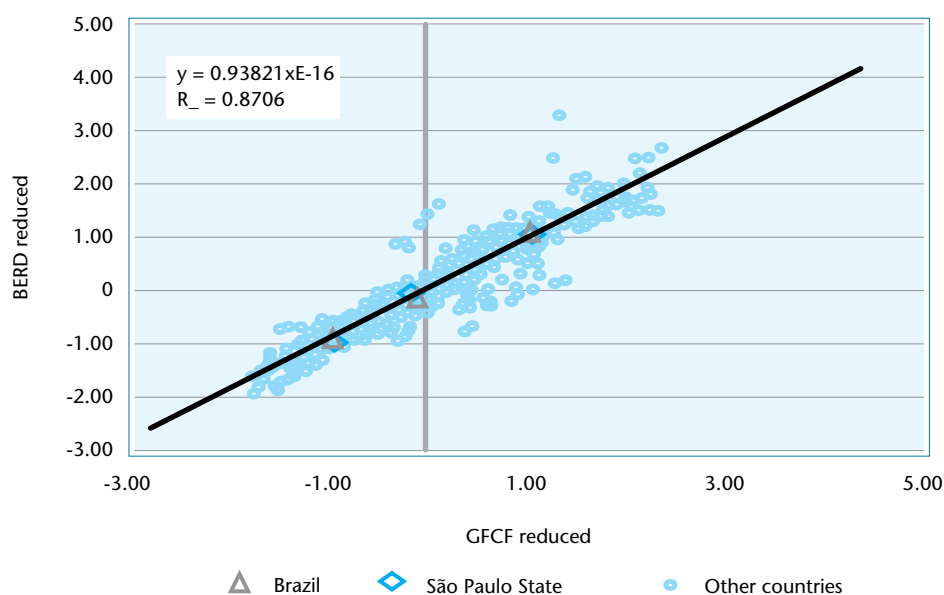
It is worth noting that in Figure 3.3A the three pairs of points for Brazil and the three pairs of points for São Paulo align with the straight line obtained by

the regression for all 554 pairs of points for the 24 selected countries.

The regression coefficients can be used to obtain the complete series for BERD in Brazil and São Paulo State presented in Table 3.14A.

Figure 3.3A

Linear regression between gross fixed capital formation (GFCF) and business expenditure on R&D (BERD) – Brazil, São Paulo State & selected countries – 1981-2008



Source: Brazil: IBGE, Sidra; PINTEC 2000, 2003, 2005. São Paulo State: estimate based on state GDP and percent GFCF for Brazil; IBGE, PINTEC 2000, 2003, 2005. Selected countries: OECD. *Main Science, Technology and Innovation Indicators*; UNStats.

Notes: 1. . Reduced values of BERD and GFCF (see 3.4 above), showing 554 pairs of points obtained for 24 countries listed in Table 3.12A and including values for Brazil and São Paulo State.

2. See Table 3.13A and Detailed Tables 3.1A, 3.5A and 3.6A.

Table 3.13A

Business expenditure on R&D (BERD) and gross fixed capital formation (GFCF) – Brazil & São Paulo State – 2000, 2003 & 2005

Value (in billions of current R\$)	2000	2003	2005
Brazil			
BERD	5.3	7.0	9.8
GFCF	198.2	259.7	342.2
São Paulo State			
BERD	3.2	4.3	5.7
GFCF	71.3	88.6	115.9

Source: BERD: IBGE, PINTEC 2000, 2003, 2005; GFCF: Brazil, Sidra (IBGE); São Paulo State: estimated based on percentage of Brazilian GDP.

Table 3.14A
Business expenditure on R&D (BERD) – Brazil & São Paulo State – 1995-2008

Geography	Business expenditure on R&D													
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
BERD (mm current R\$) (1)														
Brazil	3,334	3,719	4,329	4,419	4,435	5,359	6,055	6,654	7,171	8,724	9,599	10,984	13,186	16,032
São Paulo State	2,111	2,305	2,722	2,722	2,727	3,317	3,719	3,977	4,225	5,010	5,655	6,493	7,833	9,553
Residuals (mm current R\$) (2)														
Brazil	-	-	-	-	-	-47	-	-	-157	-	204	-	-	-
São Paulo State	-	-	-	-	-	-135	-	-	99	-	36	-	-	-
Residuals (%) (2)														
Brazil	-	-	-	-	-	-1%	-	-	-2%	-	2%	-	-	-
São Paulo State	-	-	-	-	-	-4%	-	-	2.0%	-	1%	-	-	-

Source: IBGE, PINTEC 2000, 2003 and 2005; Sidra.

(1) Values calculated by the method described in section 3.4 of this chapter.

(2) Residuals relative to values measured by PINTEC (IBGE) for 2000, 2003 and 2005 in absolute amounts (millions of current reais (R\$) and percentage of values measured.

The regression residuals relative to the values measured by PINTEC, shown in Table 3.14A, are strikingly low, reinforcing confidence in the regression performed.

Finally, a number of caveats should be noted. First, it is always important to bear in mind that if two series are correlated this does not necessarily mean there is a cause and effect relationship between them. The correlation shown here simply means that BERD correlates with GFCF rather than depending on it. It is easy to imagine situations in which R&D activities assure the feasibility of capital expenditure, just as it is easy to imagine that R&D entails capital expenditure. Next, this discussion does not make the claim that calculating GFCF eliminates the need to measure BERD via surveys such as PINTEC. What it does aim to do is to develop an approximation for the value of BERD, given that frequent measurements of this value are not performed. Thus what is involved is merely an approximation, not a substitution. Lastly, it should be noted that the existence of a correlation does not mean the two series adhere at all points. For example, in the event of an economic crisis of national or sectoral proportions firms may interrupt any R&D projects that are under way, and this may produce a lag in BERD relative to GFCF. On the other hand, when aggressive policy measures to stimulate business investment in R&D are effective, the BERD series may decouple from the GFCF series by growing at a faster rate. Some of these hypotheses can be tested when more PINTEC surveys take place.

4. Consolidated results for R&D expenditure in São Paulo State

The consolidated results for R&D expenditure in São Paulo State by sources of funding are presented in Table 3.15A. In contrast with MCT, we classify sources by their nature with regard to research activities. Thus private HEIs are considered part of higher education (whereas for MCT they are business enterprises). In our view this typology facilitates comprehension of the relative magnitude of R&D efforts undertaken by the three basic sectors that make up an innovation system: higher education, research institutions, and business.

As can be seen from Table 3.16A and Figure 3.4A, R&D expenditure in São Paulo State corresponded to 1.52% of the state's GDP in 2008.

A breakdown by institutional category (Table 3.17A) shows the private sector predominating in 2008, with 63.3% of the total. BERD accounts for almost all private-sector R&D expenditure in this year, with 62%, while private HEIs account for the remaining 1.3%. State R&D expenditure ranks second with 24% of the total, followed by federal R&D expenditure in São Paulo, with 13%, only 1 percentage point more than half of the state's share. Figure 3.5A plots the distribution of R&D expenditure by each sector in proportion to the state's GDP.

Table 3.15A
R&D expenditure by type of institution and administrative jurisdiction of funding source – São Paulo State – 1995-2008

Type of institution & administrative jurisdiction of funding source	R&D expenditure (in millions of current R\$)													
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total	3,477.7	3,876.4	4,461.5	4,488.8	4,780.0	5,609.1	6,339.1	6,684.6	7,148.4	8,327.6	9,525.3	10,852.7	12,794.8	15,523.6
Higher education	593.8	697.6	772.2	746.0	819.2	1,115.3	1,178.3	1,321.5	1,452.0	1,678.0	1,868.8	2,286.4	2,570.9	3,274.1
Federal HEIs	69.9	73.7	67.0	68.9	49.5	75.4	89.5	97.4	169.3	144.8	154.1	279.3	357.2	425.6
State HEIs	506.0	605.3	685.1	654.5	735.8	983.9	1,019.9	1,142.3	1,196.2	1,417.9	1,565.6	1,828.5	2,011.2	2,646.0
Private HEIs	17.9	18.6	20.1	22.6	33.9	56.0	68.9	81.9	86.5	115.3	149.1	178.6	202.5	202.5
Research funding agencies	368.7	484.1	509.9	537.5	703.0	706.0	790.3	762.0	728.5	893.0	1,030.5	1,067.4	1,306.9	1,457.8
CNPq	181.3	180.4	160.1	129.1	117.2	127.8	144.8	141.2	169.1	216.0	244.7	260.7	310.5	316.6
CAPEs	78.9	68.1	78.7	87.8	96.4	93.5	105.6	107.3	137.6	151.8	169.9	165.4	196.8	241.2
FINEP	10.6	28.6	16.5	15.8	11.9	23.8	46.9	58.0	67.0	131.3	134.3	119.5	257.6	262.1
FAPESP	97.9	206.9	254.6	304.8	477.4	460.9	493.1	455.5	354.8	393.9	481.7	521.8	542.0	637.9
Research institutions	404.6	390.0	457.5	483.1	530.9	606.2	651.4	624.3	644.2	746.1	935.3	1,006.1	1,083.7	1,238.5
Federal RI	249.0	219.1	264.4	295.6	321.0	374.0	406.3	362.1	373.3	452.9	582.9	621.2	670.5	789.2
State RI	155.6	170.9	193.1	187.5	209.9	232.2	245.1	262.2	270.9	293.3	352.3	384.9	413.2	449.3
Business	2,110.6	2,304.7	2,721.9	2,722.2	2,726.9	3,181.6	3,719.1	3,976.8	4,323.7	5,010.5	5,690.7	6,492.8	7,833.3	9,553.3
Mining & manufacturing	1,697.9	1,854.1	2,189.7	2,189.9	2,193.7	2,559.5	2,991.9	3,199.2	3,478.3	4,030.8	4,578.1	5,223.3	6,301.7	7,685.4
Services	412.7	450.6	532.2	532.3	533.2	622.1	727.2	777.6	845.4	979.7	1,112.7	1,269.5	1,531.6	1,867.9

Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS; IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

Notes: 1. R&D expenditure by HEIs calculated by the method described in section 3.2 of this chapter; BERD calculated by the method described in section 3.4 of this chapter.
 2. See Tables 3.3A, 3.4A, 3.7A, 3.8A, 3.9A and 3.14A.

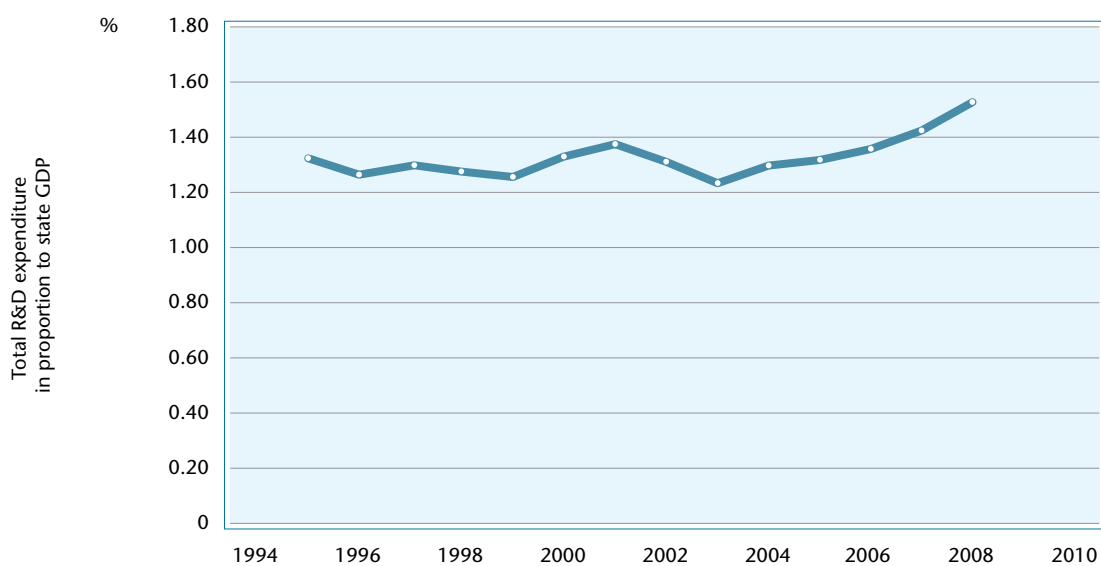
Table 3.16A
R&D expenditure in proportion to state GDP by type of institution and administrative jurisdiction of funding source – São Paulo State – 1995-2008

Type of institution & administrative jurisdiction of funding source	R&D expenditure in proportion to state GDP (%)													
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total	1.32	1.26	1.29	1.27	1.25	1.32	1.37	1.31	1.23	1.29	1.31	1.35	1.42	1.52
Higher education	0.23	0.23	0.22	0.21	0.21	0.26	0.25	0.26	0.25	0.26	0.26	0.28	0.28	0.32
Federal HEIs	0.03	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.04	0.04
State HEIs	0.19	0.20	0.20	0.19	0.19	0.23	0.22	0.22	0.21	0.22	0.22	0.23	0.22	0.26
Private HEIs	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02
Rsrch funding agencies	0.14	0.16	0.15	0.15	0.18	0.17	0.17	0.15	0.13	0.14	0.14	0.13	0.14	0.14
CNPq	0.07	0.06	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
CAPES	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
FINEP	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.03	0.03
FAPESP	0.04	0.07	0.07	0.09	0.12	0.11	0.11	0.09	0.06	0.06	0.07	0.07	0.06	0.06
Research institutions	0.15	0.13	0.13	0.14	0.14	0.14	0.14	0.12	0.11	0.12	0.13	0.13	0.12	0.12
Federal RI	0.09	0.07	0.08	0.08	0.08	0.09	0.09	0.07	0.06	0.07	0.08	0.08	0.07	0.08
State RI	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04
Business	0.80	0.75	0.79	0.77	0.71	0.75	0.80	0.78	0.75	0.78	0.78	0.81	0.87	0.94
Mining & mfg	0.64	0.60	0.63	0.62	0.57	0.60	0.65	0.63	0.60	0.63	0.63	0.65	0.70	0.75
Services	0.16	0.15	0.15	0.15	0.14	0.15	0.16	0.15	0.15	0.15	0.15	0.16	0.17	0.18

Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS, IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

Notes: 1. R&D expenditure by HEIs calculated by the method described in section 3.2 of this chapter; BERD calculated by the method described in section 3.4 of this chapter.
 2. See Table 3.15A and Detailed Table 3.1A.

Figure 3.4A
Total R&D expenditure in proportion to state GDP – São Paulo State – 1995-2008



Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS, IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, Pintec 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by Fapesp); Fapesp (1998); São Paulo State Budget.

Notes: 1. R&D expenditure by HEIs calculated by the method described in section 3.2 of this chapter; BERD calculated by the method described in section 3.4 of this chapter.

2. See Table 3.15A and Detailed Table 3.1A

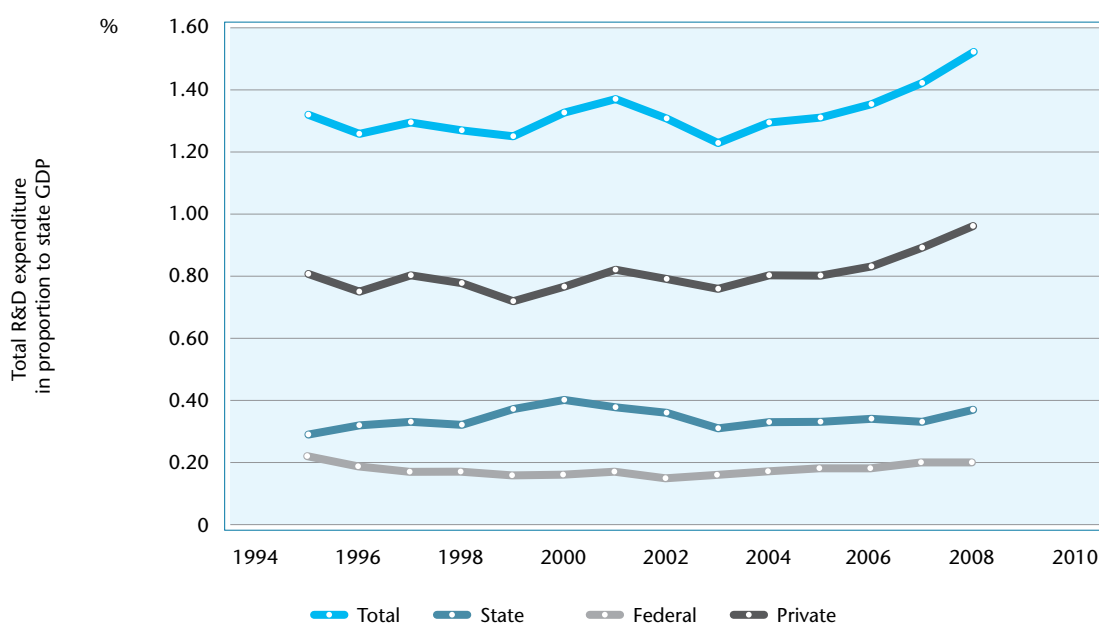
Table 3.17A
Distribution of R&D expenditure by type of institution and administrative jurisdiction of funding source
– São Paulo State – 1995-2008

Type of institution & administrative jurisdiction of funding source	R&D expenditure (%)													
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Higher education	17.1	18.0	17.3	16.6	17.1	19.9	18.6	19.8	20.3	20.1	19.6	21.1	20.1	21.1
Federal HEIs	2.0	1.9	1.5	1.5	1.0	1.3	1.4	1.5	2.4	1.7	1.6	2.6	2.8	2.7
State HEIs	14.6	15.6	15.4	14.6	15.4	17.5	16.1	17.1	16.7	17.0	16.4	16.8	15.7	17.0
Private HEIs	0.5	0.5	0.4	0.5	0.7	1.0	1.1	1.2	1.2	1.4	1.6	1.6	1.6	1.3
Rsrch funding agencies	10.6	12.5	11.4	12.0	14.7	12.6	12.5	11.4	10.2	10.7	10.8	9.8	10.2	9.4
CNPq	5.2	4.7	3.6	2.9	2.5	2.3	2.3	2.1	2.4	2.6	2.6	2.4	2.4	2.0
CAPES	2.3	1.8	1.8	2.0	2.0	1.7	1.7	1.6	1.9	1.8	1.8	1.5	1.5	1.6
FINEP	0.3	0.7	0.4	0.4	0.2	0.4	0.7	0.9	0.9	1.6	1.4	1.1	2.0	1.7
FAPESP	2.8	5.3	5.7	6.8	10.0	8.2	7.8	6.8	5.0	4.7	5.1	4.8	4.2	4.1
Research institutions	11.6	10.1	10.3	10.8	11.1	10.8	10.3	9.3	9.0	9.0	9.8	9.3	8.5	8.0
Federal RI	7.2	5.7	5.9	6.6	6.7	6.7	6.4	5.4	5.2	5.4	6.1	5.7	5.2	5.1
State RI	4.5	4.4	4.3	4.2	4.4	4.1	3.9	3.9	3.8	3.5	3.7	3.5	3.2	2.9
Business	60.7	59.5	61.0	60.6	57.0	56.7	58.7	59.5	60.5	60.2	59.7	59.8	61.2	61.5
Mining & manuf.	48.8	47.8	49.1	48.8	45.9	45.6	47.2	47.9	48.7	48.4	48.1	48.1	49.3	49.5
Services	11.9	11.6	11.9	11.9	11.2	11.1	11.5	11.6	11.8	11.8	11.7	11.7	12.0	12.0

Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS, IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

Notes: 1. R&D expenditure by HEIs calculated by the method described in section 3.2 of this chapter; BERD calculated by the method described in section 3.4 of this chapter.
 2. See Table 3.15A

Figure 3.5A
R&D expenditure in proportion to state GDP by administrative jurisdiction of funding source – São Paulo State – 1995-2008



Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS, IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

Notes: 1. R&D expenditure by HEIs calculated by the method described in section 3.2; BERD calculated by the method described in section 3.4 of this chapter.
2. See Table 3.15A and Detailed Table 3.1A.

4.1 Consolidated results for national R&D expenditure calculated by method based on full-time academics with PhDs and estimated BERD based on GFCF

The use of a different methodology from that used by MCT to calculate R&D expenditure by HEIs could hinder comparison with the values calculated by MCT for national R&D expenditure. The effects of the methodology used here to calculate national postgraduate expenditure are analyzed below.

The values reported by MCT on March 21, 2010, are presented in Table 3.18A. Table 3.19A presents the MCT indicators and the values calculated using the methodology described in this chapter (full-time academics with PhDs multiplied by 82.7% for reduction to time devoted to R&D).

As can be seen from Table 3.19A, the differences are relatively small. Table 3.20A presents the difference between the values calculated by MCT and the findings of this study for the three administrative jurisdictions in absolute numbers, as a percentage of GDP and as a percentage of the total calculated by MCT. The values of BERD, calculated using GFCF as described in 3.4.3 above, are presented in Table 3.14A.

While the methodology described in this chapter to calculate R&D expenditure by HEIs does not produce significantly different results from those produced by MCT's methodology, computing BERD on the basis of GFCF produces higher values than those estimated by MCT. For example, our finding for nationwide expenditure in 2008 is 1.14% of GDP (Tables 3.21A and 3.22A), compared with 1.09% according to MCT (Table 3.18A).

Table 3.18A
Values of R&D expenditure according to MCT by funding source – Brazil – 2000-2008

Funding source	R&D expenditure (in millions of current R\$)									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Total	12,030	13,602	14,577	16,311	17,493	20,857	23,649	28,554	32,768	
Public expenditure	6,494	7,448	7,761	8,826	9,335	10,371	11,911	15,185	17,681	
Federal expenditure	4,008	4,563	4,828	5,802	6,418	7,085	8,483	10,445	12,069	
Postgraduate programs	1,523	1,590	1,861	2,159	2,543	2,616	3,320	4,392	5,033	
Budget execution	2,484	2,973	2,967	3,643	3,875	4,469	5,164	6,053	7,036	
State expenditure	2,486	2,884	2,933	3,024	2,917	3,286	3,428	4,740	5,612	
Postgraduate programs	1,544	1,759	1,971	2,098	1,850	1,965	2,002	3,023	3,600	
Budget execution	942	1,125	961	925	1,067	1,321	1,426	1,717	2,011	
Business expenditure	5,536	6,154	6,816	7,485	8,157	10,485	11,738	13,424	15,088	
Private & state-owned enterprises	5,332	5,902	6,471	7,041	7,610	9,803	11,081	12,526	14,159	
Other federal enterprises	61	74	103	123	187	269	190	227	221	
Postgraduate programs	144	179	242	321	360	414	468	671	708	

Source: MCT <<http://www.mct.gov.br/index.php/content/view/29144.html>> (Last visited Mar. 21, 2010).

Table 3.19A
R&D expenditure by HEIs in each administrative jurisdiction: comparison of values calculated by MCT and this study – Brazil – 2000-2008

Administrative jurisdiction	R&D expenditure by HEIs (in millions of current R\$)									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Federal postgraduate programs										
MCT (CAPES staff)	1,523.4	1,590.4	1,861.4	2,159.3	2,542.9	2,616.1	3,319.5	4,391.9	5,062.5	
This study (DR+FT)	1,224.9	1,335.2	1,638.5	1,912.4	2,259.2	2,430.7	3,188.6	4,311.7	5,102.8	
State postgraduate programs										
MCT (CAPES staff)	1,544.4	1,758.9	1,971.3	2,098.4	1,849.7	1,965.3	2,001.6	3,022.9	3,234.1	
This study (DR+FT)	1,325.6	1,633.9	1,979.5	2,201.4	1,802.8	1,870.0	1,904.3	3,004.3	3,214.2	
Private postgraduate programs										
MCT (CAPES staff)	143.6	179.3	241.9	321.0	359.6	413.6	467.6	670.7	746.0	
This study (DR+FT)	118.1	158.2	185.4	214.0	232.3	292.7	308.9	460.1	511.7	

Source: MCT; INEP.

Notes: 1. Values in this study were calculated according to the methodology described in section 3.2 above (based on the number of full-time academics – FT – with PhDs – DR).

2. Values were calculated by MCT based on the number of academics in postgraduate programs in proportion to total academic staff.

3. See Table 3.7A.

Table 3.20A
R&D expenditure by HEIs – comparison of values calculated by MCT and this study – Brazil – 2000-2008

R&D expenditure by HEIs	2000	2001	2002	2003	2004	2005	2006	2007	2008
Difference in absolute values calculated by MCT and in this study (millions of current R\$)	542.7	401.2	271.2	250.9	457.9	401.5	386.8	309.4	213.9
% GDP	0.05	0.03	0.02	0.01	0.02	0.02	0.02	0.01	0.01
% total value MCT	4.5	2.9	1.9	1.5	2.6	1.9	1.6	1.1	0.7

Source: MCT; INEP.

Notes: 1. Values in this study were calculated according to the methodology described in section 3.2 above (based on the number of full-time academics with PhDs).
 2. Values were calculated by MCT based on the number of academics in postgraduate programs in proportion to total academic staff.
 3. See Detailed Table 3.1A.

Table 3.21A
Value of R&D expenditure in each administrative jurisdiction according to MCT adjusted by method used in this study – Brazil – 2000-2008

Administrative jurisdiction	R&D expenditure (in millions of current R\$)								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total	11,515	13,354	14,489	16,190	18,149	20,251	23,166	28,958	34,191
Public expenditure	5,977	7,068	7,546	8,682	9,005	10,091	11,683	15,086	17,426
Federal expenditure	3,709	4,308	4,605	5,556	6,135	6,900	8,353	10,365	12,139
Postgraduate programs (DR+FT)	1,225	1,335	1,638	1,912	2,259	2,431	3,189	4,312	5,103
Budget execution	2,484	2,973	2,967	3,643	3,875	4,469	5,164	6,053	7,036
State expenditure	2,267	2,759	2,941	3,127	2,870	3,191	3,330	4,722	5,287
Postgraduate programs	1,326	1,634	1,979	2,201	1,803	1,870	1,904	3,004	3,214
Budget execution	942	1,125	961	925	1,067	1,321	1,426	1,717	2,073
Business expenditure	5,538	6,286	6,943	7,508	9,144	10,160	11,483	13,872	16,765
Private & state-owned enterprises	5,359	6,055	6,654	7,171	8,724	9,599	10,984	13,186	16,032
Other federal enterprises	61	74	103	123	187	269	190	227	221
Postgraduate programs	118	158	185	214	232	293	309	460	512

Source: MCT.

Notes: 1. Values published by MCT adjusted to include effects of calculating R&D expenditure by HEIs based on number of full-time academics with PhDs and BERD based on GFCF.
 2. See sections 3.2 and 3.4 above.

Table 3.22A
R&D expenditure according to MCT adjusted by method used in this study as proportion of GDP by administrative jurisdiction – Brazil – 2000-2008

Administrative jurisdiction	R&D expenditure as proportion of national GDP (%)								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total	0.98	1.03	0.98	0.95	0.93	0.94	0.98	1.09	1.14
Public expenditure	0.51	0.54	0.51	0.51	0.46	0.47	0.49	0.57	0.58
Federal expenditure	0.31	0.33	0.31	0.33	0.32	0.32	0.35	0.39	0.40
Postgraduate programs (DR+ST)	0.10	0.10	0.11	0.11	0.12	0.11	0.13	0.16	0.17
Budget execution	0.21	0.23	0.20	0.21	0.20	0.21	0.22	0.23	0.23
State expenditure	0.19	0.21	0.20	0.18	0.15	0.15	0.14	0.18	0.18
Postgraduate programs	0.11	0.13	0.13	0.13	0.09	0.09	0.08	0.11	0.11
Budget execution	0.08	0.09	0.07	0.05	0.05	0.06	0.06	0.06	0.07
Business expenditure	0.47	0.48	0.47	0.44	0.47	0.47	0.48	0.52	0.56
Private & state-owned enterprises	0.45	0.46	0.45	0.42	0.45	0.45	0.46	0.50	0.53
Other federal enterprises	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Postgraduate programs	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02

Source: MCT.

Notes: 1. Values published by MCT adjusted to include effects of calculating R&D expenditure by HEIs based on number of full-time academics with PhDs and BERD based on GFCF.
2. See sections 3.2 and 3.4 above.

4.2 Difference between values of state R&D expenditure estimated by the methodology used in this study and MCT indicators

In the case of state universities in São Paulo, R&D expenditure estimated using the methodology presented in this chapter was less than estimated in the MCT indicators (Table 3.23A). The methodology used here is evidently more restrictive in this case. The differences appear to result from two factors.

MCT based its indicators on values for each HEI extracted from the São Paulo State financial statements (Balço Geral do Estado de São Paulo). However, these statements include other HEI receipts besides the funding received from the state treasury, such as payments for healthcare under agreements with the national health service (SUS) or for postgraduate programs under agreements with CAPES. An examination of the state's financial statements shows

that inclusion of these other receipts is still erratic, rather than consistent, but they nonetheless represent significant values. For example, the value reported for state HEIs in 2008 is R\$ 5.896 billion, while total tax revenue amounted in the same year to R\$ 5.429 billion, for a difference of R\$ 467 million. The approach used in this chapter, which takes into account only the value derived from state tax revenue, avoids double counting of funding received from CAPES, FNDCT and other agencies, which is computed under federal expenditure.

The second difference is that the MCT methodology counts permanent academic staff registered by CAPES, without applying a reduction factor to discount the time devoted to other activities not classified as R&D, such as teaching undergraduates or extension work, for example. The methodology used for this chapter applies a reduction factor of 82.7% to effect this discount, as described in 3.2.4 above.

Table 3.23A
Comparison between estimates of R&D expenditure by state HEIs in São Paulo State according to MCT indicators and methodology used in this study – 2000-2008

Institution	R&D expenditure by state HEIs in São Paulo (in millions of current R\$)								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Data source: MCT indicators									
State HEIs SP	1,447.9	1,629.5	1,855.8	1,934.6	1,671.7	1,772.8	1,783.4	2,640.8	3,181.7
USP	906.2	984.8	1,123.1	1,215.4	1,022.9	1,081.5	1,059.9	1,585.3	1,919.0
Unesp	240.0	278.9	339.9	365.8	291.3	293.2	315.0	478.3	598.1
Unicamp	297.2	359.8	385.4	345.9	348.8	387.4	405.7	572.5	658.5
Famema	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Famerp	1.5	1.6	2.3	2.6	2.9	2.9	2.8	4.7	6.1
Faenquil	3.0	4.4	5.2	5.0	5.7	7.8	0.0
Data source: this chapter									
State HEIs SP	983.9	1,019.9	1,142.3	1,196.2	1,417.9	1,565.6	1,828.5	2,011.2	2,646.0
USP	496.3	498	570.6	611	732.1	795.3	931.2	1,048.3	1,346.3
Unesp	226.8	249.3	266.2	278.1	335.7	384	463	487.3	693.3
Unicamp	242.5	248	274.5	281.4	322.6	353.2	400.5	445.7	575.4
Famema	10.9	15.6	18.2	15	15.2	17.3	18.9	23.5	23.7
Famerp	2.5	2.9	4.1	4.2	4.9	4.8	6.3	6.5	7.3
Faenquil	4.9	6	8.7	6.4	7.5	11.1	8.6	0	0
Difference: MCT / this chapter									
State HEIs SP	464.0	609.6	713.5	738.4	253.8	207.1	-45.1	629.5	535.7

Source: MCT; INEP.

Notes: 1. Values published by MCT adjusted to include effects of calculating R&D expenditure by HEIs based on number of full-time academics.
 2. See section 3.2 above.

5. Analysis

This section is divided into two parts. The first subsection analyzes R&D expenditure in São Paulo State in terms of the administrative jurisdiction of the funding source (federal, state, private). The second analyzes R&D expenditure in São Paulo in comparison with R&D expenditure in Brazil and in other Brazilian states.

5.1 Federal, state and private shares of R&D expenditure in São Paulo State

An analysis of R&D expenditure in São Paulo State classified according to the administrative juris-

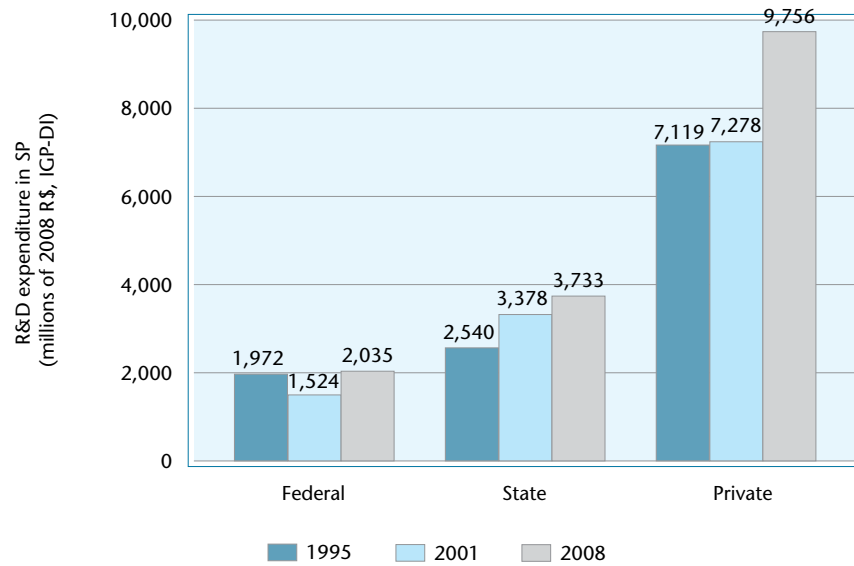
dition of the funding source for the years 1995, 2001 and 2008 (Figure 3.6A, in millions of 2008 reais deflated by the IGP-DI) shows that in real terms federal R&D expenditure in 2008 was practically the same as in 1995, following a dip in 2001. As a share of total R&D expenditure in the state, federal expenditure fell from 17% in 1995 to 13% in 2008 (Figure 3.7A).

State R&D expenditure rose 46% between 1995 and 2008, but this growth did not significantly increase its share of the total, which was 22% in 1995 and 24% in 2008 (Figure 3.7A).

Private R&D expenditure rose 37% in real terms between 1995 and 2008, accounting in the latter year for 63% of the total (Figure 3.7A).

Thus the only significant change in the composition of R&D expenditure in São Paulo between 1995 and 2008 was a fall of almost 25% in the federal share (4 percentage points out of 17 pp).

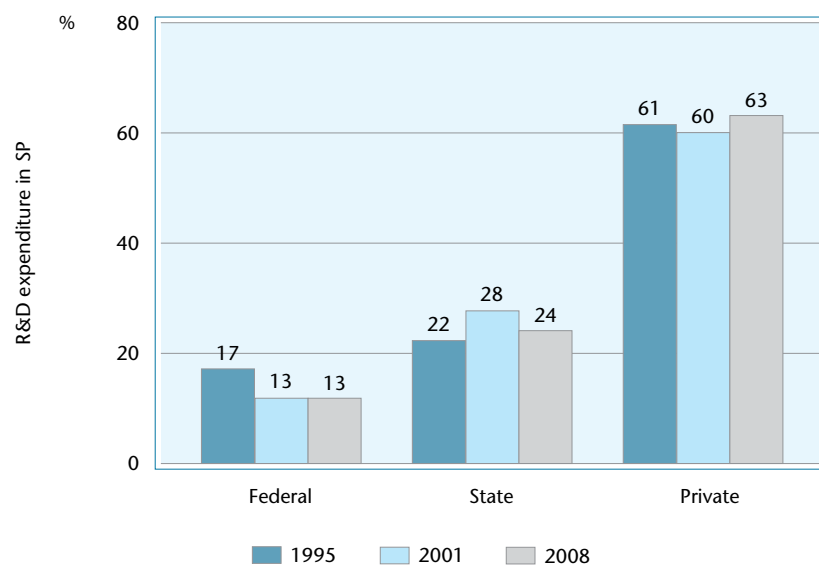
Figure 3.6A
R&D expenditure by administrative jurisdiction of funding source – São Paulo State – 1995, 2001 & 2008



Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS; IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

Note: See Detailed Tables 3.1A and 3.7A.

Figure 3.7A
Funding source shares in total R&D expenditure by administrative jurisdiction – São Paulo State – 1995, 2001 & 2008



Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS; IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

Note: See Detailed Table 3.7A.

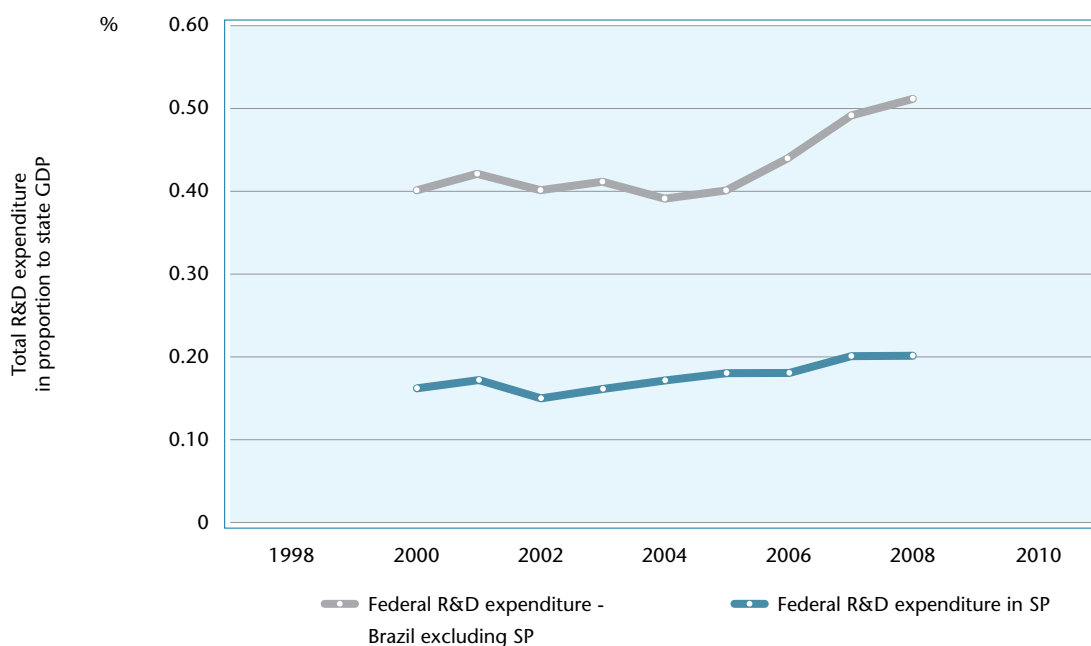
In contrast with the trend observed in national R&D expenditure by the public sector,⁴⁰ in São Paulo the state government spends far more than the federal government: in 2008 R&D expenditure by the state totalled R\$ 3.7 billion (including higher education), almost double the amount spent by the federal government, which was R\$ 2 billion (Table 3.26A).

5.1.1 Federal and state expenditure on R&D in public HEIs

The highlight in state R&D expenditure is the proportion allocated to university research. In 2008, state

HEIs accounted for 17% of the total spent on R&D in São Paulo (Table 3.28A). It is a well-known fact that the state government is the leading player in higher education and research, spending far more than the federal government on these activities in the state. This disparity reflects on one hand the state's long-standing support for public higher education, dating from the establishment of the University of São Paulo (USP) in 1934, and on the other hand a longstanding shortage of federal funding for public higher education in São Paulo State. In the other states the situation is reversed: R&D expenditure in Brazil excluding São Paulo is concentrated in federal HEIs, corresponding to almost eight times the amount spend on state HEIs.

Figure 3.8A
Federal R&D expenditure in proportion to state GDP – São Paulo State & all other states – 2000-2008



Source: CNPq; CAPES; FINEP; INEP; INPE; IPEN; CTI-Cenpra; LNLS; MCT.

Note: See Tables 3.15A and 3.21A, and Detailed Table 3.1A.

40. According to MCT's survey of national R&D expenditure (<<http://www.mct.gov.br/index.php/content/view/2068.html>>), federal expenditure was almost twice the sum of state expenditures in 2008.

Figure 3.9A shows how much more state HEIs spend on R&D than federal or private HEIs, despite strong growth in R&D expenditure by both of the latter between 1995 and 2008. In 2008, R&D expenditure by state HEIs was 6.2 times greater than R&D expenditure by federal HEIs and 13.1 times greater than R&D expenditure by private HEIs. It is worth noting that although R&D expenditure by private HEIs continued to account for the smallest share of the total it increased substantially in the period analyzed, jumping from R\$ 60 million in 1995 to R\$ 202 million in 2008.

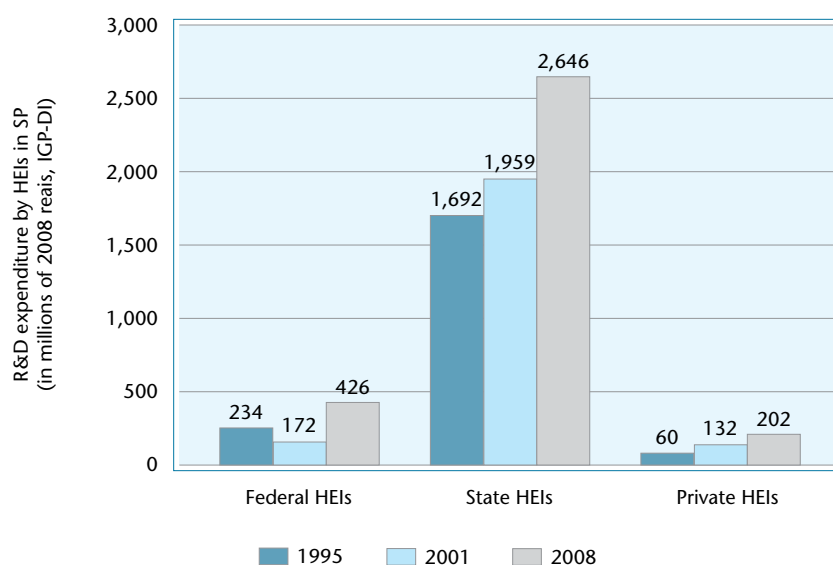
The São Paulo State government's efforts in this field far exceed those of the other 26 states, both to collect tax and to invest a significant proportion of its revenue, especially from sales tax (ICMS), in higher education. In 2008, for example, the state spent R\$ 2.646 billion on R&D in higher education (Table 3.26A), or 30% more than the federal government spent on R&D in São Paulo State that year.

Federal underinvestment in public higher education in São Paulo State is historical. Inexplicably, São Paulo is one of the few states that does not have a full-scale federal university, although it does have four small but very well-qualified federal institutions, which

are among the best federal HEIs in Brazil.⁴¹ Moreover, São Paulo State has a huge contingent of young people with a complete secondary education who want to attend good public HEIs. The magnitude of this inequality deserves a brief analysis in this section.

Opportunities to access federal HEIs for young people aged 16-24 are drastically unequal across Brazil, as can be seen from the state-by-state breakdown of enrollment in proportion to university-age population in Table 3.24A. Young people aged 16-24 with between 11 and 14 years of schooling (i.e. with the appropriate academic and demographic profile to compete for places in higher education) account for 10% of enrollment in federal HEIs across Brazil on average. This estimate is based on enrollment at the federal HEIs covered by INEP's 2008 Statistical Survey of Higher Education⁴² (universities, university centers, colleges and technical schools). While 10% of Brazilians in the university-age cohort and with a complete secondary education have access to federal HEIs on average, the likelihood that a qualified individual in this age group is enrolled at a federal HEI in Acre is 70%, for example, while in São Paulo it is only 1% (last line of Table 3.24A).

Figure 3.9A
R&D expenditure by HEIs according to administrative jurisdiction – São Paulo State, 1995 – 2001 & 2008



Source: MCT; INEP.

Note: See Detailed Tables 3.1A and 3.7A.

41. This in itself is a good reason for the federal government to intensify its efforts in public higher education in the state.

42. Sinopse Estatística da Educação Superior 2008. See <<http://portal.inep.gov.br/superior-censosuperior-sinopse>>. (Last visited Dec. 29, 2009).

Table 3.24A

Variation in opportunities to access federal public higher education for young people aged 16-24 with 11-14 years of schooling by state – Brazil – 2008

Region	Population aged 16-24 with 11-14 years of schooling (A)	Enrollment at federal HEIs (B)	Enrollment/pop. (B/A) (%)
Brazil	6,498,981	643,101	10.0
Acre	13,175	9,185	69.7
Alagoas	49,941	14,227	28.5
Amapá	16,270	7,946	48.8
Amazonas	80,502	18,564	23.1
Bahia	332,489	24,292	7.3
Ceará	185,254	28,968	15.6
Distrito Federal	114,966	18,230	15.9
Espírito Santo	127,658	15,554	12.2
Goiás	171,778	18,530	10.8
Maranhão	123,789	13,249	10.7
Mato Grosso	93,226	14,923	16.0
Mato Grosso do Sul	80,477	15,471	19.2
Minas Gerais	700,628	81,782	11.7
Pará	140,585	34,071	24.2
Paraíba	76,317	29,588	38.8
Paraná	433,047	33,470	7.7
Pernambuco	224,135	33,865	15.1
Piauí	51,124	17,461	34.2
Rio de Janeiro	598,440	60,720	10.1
Rio Grande do Norte	80,787	22,432	27.8
Rio Grande do Sul	426,389	54,063	12.7
Rondônia	35,840	6,432	17.9
Roraima	10,901	4,172	38.3
Santa Catarina	233,722	18,852	8.1
Sergipe	40,172	15,170	37.8
Tocantins	32,208	7,808	24.2
São Paulo	2,025,158	15,076	0.7

Source: IBGE, Sidra (population); INEP, Sinopse Estatística do Ensino Superior 2008 (enrollment).

It is perfectly legitimate for the federal government to introduce policies with the aim of reducing regional inequality. Such policies are more than legitimate: they are necessary to Brazil’s development. At the same time, educational policy cannot and must not abandon sectors of the population who have the required academic qualifications to access higher education and pay a significant proportion of federal taxes.⁴³ It is worth recalling that article 206 of the Constitution requires “equality of conditions for access to and completion of education.” Furthermore, article 211, paragraph 1 (as altered by Amendment 14, enacted Sep. 12, 1996), reads as follows: “The Union shall organize the federal system of education and that of the Territories, fund the federal education institutions, and perform redistribution and supplementation in

the educational sphere so as to assure equalization of educational opportunities and a minimum standard of quality in education through the provision of technical and financial assistance to the States, Federal District and Municipalities.”

Another way of showing how much São Paulo stands out in terms of the state government’s efforts to support R&D through its HEIs is to compare these efforts with the federal government’s support for R&D nationwide through federal HEIs based on the respective shares of tax revenue allocated to this activity in each case (Table 3.25A). This analysis shows that São Paulo invested three to four times more in proportion to tax revenue than the federal government in the period 2000-08, for which data are available on R&D expenditure by federal HEIs in Brazil (MCT Indicators).

Table 3.25A
Tax revenue and percentage invested in R&D at public HEIs – Brazil & São Paulo State – 2000-2008

Year	Tax revenue			
	Total (in millions of current R\$)		% invested in R&D at public HEIs	
	Brazil	São Paulo State	Brazil	São Paulo State
2000	194 768.8	33 733.7	0.80	2.90
2001	224 416.3	37 345.4	0.70	2.70
2002	263 916.7	41 512.4	0.70	2.80
2003	296 430.3	45 117.4	0.70	2.70
2004	352 057.9	51 477.0	0.70	2.80
2005	404 438.3	57 294.7	0.60	2.70
2006	450 725.4	64 146.7	0.70	2.90
2007	513 268.2	72 166.3	0.90	2.80
2008	583 582.9	86 565.8	0.90	3.10

Source: São Paulo State Dept. of Finance (SP tax revenue); <http://www.stn.fazenda.gov.br/estatistica/est_resultado.asp> (federal tax revenue).

- R&D expenditure at state HEIs in SP: data from this chapter (Table 3.7A)

- R&D expenditure at federal HEIs in Brazil: MCT Indicators.

43. In 2007, for example, federal taxes collected in São Paulo accounted for 45.5% of total nationwide federal tax revenue, or 43.9% if “social contributions” are included (see <<http://www.receita.fazenda.gov.br/Historico/Arrecadacao/PorEstado/2007/default.htm>>). In contrast, São Paulo accounted for 33.2% of Brazil’s GDP and 22% of its population in the same year.

Table 3.26A
R&D expenditure by type of institution and administrative jurisdiction of funding source – São Paulo State – 1995-2008

Type of institution & administrative jurisdiction of funding source	R&D expenditure in São Paulo State (in millions of current R\$)													
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total	3,477.7	3,876.4	4,461.5	4,488.8	4,780.0	5,609.1	6,339.1	6,684.6	7,148.4	8,327.6	9,525.3	10,852.7	12,794.8	15,523.6
Federal	589.7	569.9	586.7	597.2	596.0	694.5	793.1	766.0	916.3	1,096.7	1,285.9	1,446.0	1,792.6	2,034.7
Federal HEIs	69.9	73.7	67.0	68.9	49.5	75.4	89.5	97.4	169.3	144.8	154.1	279.3	357.2	425.6
Federal RIs	249.0	219.1	264.4	295.6	321.0	374.0	406.3	362.1	373.3	452.9	582.9	621.2	670.5	789.2
Federal agencies	270.8	277.1	255.3	232.7	225.5	245.1	297.3	306.5	373.7	499.1	548.8	545.5	764.9	819.9
State	759.5	983.2	1,132.8	1,146.8	1,423.2	1,677.0	1,758.0	1,859.9	1,821.9	2,105.1	2,399.7	2,735.3	2,966.5	3,733.2
State HEIs	506.0	605.3	685.1	654.5	735.8	983.9	1,019.9	1,142.3	1,196.2	1,417.9	1,565.6	1,828.5	2,011.2	2,646.0
State RIs	155.6	170.9	193.1	187.5	209.9	232.2	245.1	262.2	270.9	293.3	352.3	384.9	413.2	449.3
State agency	97.9	206.9	254.6	304.8	477.4	460.9	493.1	455.5	354.8	393.9	481.7	521.8	542.0	637.9
Private	2,128.5	2,323.3	2,742.0	2,744.8	2,760.8	3,237.6	3,788.0	4,058.7	4,410.2	5,125.7	5,839.8	6,671.5	8,035.8	9,755.8
Business	2,110.6	2,304.7	2,721.9	2,722.2	2,726.9	3,181.6	3,719.1	3,976.8	4,323.7	5,010.5	5,690.7	6,492.8	7,833.3	9,553.3
Private HEIs	17.9	18.6	20.1	22.6	33.9	56.0	68.9	81.9	86.5	115.3	149.1	178.6	202.5	202.5

Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS; IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

Note: See Detailed Table 3.7A. 2. RI = research institution; HEI = higher education institution.

Table 3.27A
R&D expenditure in proportion to state GDP by type of institution and administrative jurisdiction of funding source – São Paulo State – 1995-2008

Type of institution & administrative jurisdiction of funding source	R&D expenditure in proportion to state GDP (%)													
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total	1.32	1.26	1.29	1.27	1.25	1.32	1.37	1.31	1.23	1.29	1.31	1.35	1.42	1.52
Federal	0.22	0.19	0.17	0.17	0.16	0.16	0.17	0.15	0.16	0.17	0.18	0.18	0.2	0.2
Federal HEIs	0.03	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.04	0.04
Federal RIs	0.09	0.07	0.08	0.08	0.08	0.09	0.09	0.07	0.06	0.07	0.08	0.08	0.07	0.08
Federal agencies	0.1	0.09	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.08	0.08	0.07	0.08	0.08
State	0.29	0.32	0.33	0.32	0.37	0.4	0.38	0.36	0.31	0.33	0.33	0.34	0.33	0.37
State HEIs	0.19	0.2	0.2	0.19	0.19	0.23	0.22	0.22	0.21	0.22	0.22	0.23	0.22	0.26
State RIs	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04
State agency	0.04	0.07	0.07	0.09	0.12	0.11	0.11	0.09	0.06	0.06	0.07	0.07	0.06	0.06
Private	0.81	0.75	0.8	0.78	0.72	0.76	0.82	0.79	0.76	0.8	0.8	0.83	0.89	0.96
Business	0.8	0.75	0.79	0.77	0.71	0.75	0.8	0.78	0.75	0.78	0.78	0.81	0.87	0.94
Private HEIs	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02

Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS; IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

Note: See Detailed Tables 3.1A and 3.7A. 2. RI = research institution; HEI = higher education institution.

Table 3.28A
Breakdown of R&D expenditure by type of institution and administrative jurisdiction of funding source
– São Paulo State – 1995-2008

Type of institution & administrative jurisdiction of funding source	R&D expenditure in São Paulo State (%)													
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Federal	17.0	14.7	13.2	13.3	12.5	12.4	12.5	11.5	12.8	13.2	13.5	13.3	14.0	13.1
Federal HEIs	2.0	1.9	1.5	1.5	1.0	1.3	1.4	1.5	2.4	1.7	1.6	2.6	2.8	2.7
Federal RIs	7.2	5.7	5.9	6.6	6.7	6.7	6.4	5.4	5.2	5.4	6.1	5.7	5.2	5.1
Federal agencies	7.8	7.1	5.7	5.2	4.7	4.4	4.7	4.6	5.2	6.0	5.8	5.0	6.0	5.3
State	21.8	25.4	25.4	25.5	29.8	29.9	27.7	27.8	25.5	25.3	25.2	25.2	23.2	24.0
State HEIs	14.6	15.6	15.4	14.6	15.4	17.5	16.1	17.1	16.7	17.0	16.4	16.8	15.7	17.0
State RIs	4.5	4.4	4.3	4.2	4.4	4.1	3.9	3.9	3.8	3.5	3.7	3.5	3.2	2.9
State agency	2.8	5.3	5.7	6.8	10.0	8.2	7.8	6.8	5.0	4.7	5.1	4.8	4.2	4.1
Private	61.2	59.9	61.5	61.1	57.8	57.7	59.8	60.7	61.7	61.6	61.3	61.5	62.8	62.8
Business	60.7	59.5	61.0	60.6	57.0	56.7	58.7	59.5	60.5	60.2	59.7	59.8	61.2	61.5
Private HEIs	0.5	0.5	0.4	0.5	0.7	1.0	1.1	1.2	1.2	1.4	1.6	1.6	1.6	1.3

Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS; IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

Note: See Detailed Tables 3.1A and 3.7A. 2. RI = research institution; HEI = higher education institution.

5.1.2 R&D expenditure by research funding agencies

Figure 3.10A presents the evolution of R&D expenditure by each of the three federal research and postgraduate funding agencies in São Paulo State. The curves plot the state's share in the total for each agency as a percentage, using the data from Table 3.3A.

CNPq's share of total expenditure by the three federal agencies in São Paulo State fell from 36% in 1995 to 26% in 2008. FINEP's share fell more sharply, from 29% in 1995 to only 13% in 2008. In the case of CAPES, the percentage rose moderately,⁴⁴ from 22% in 1995 to 28% in 2008.

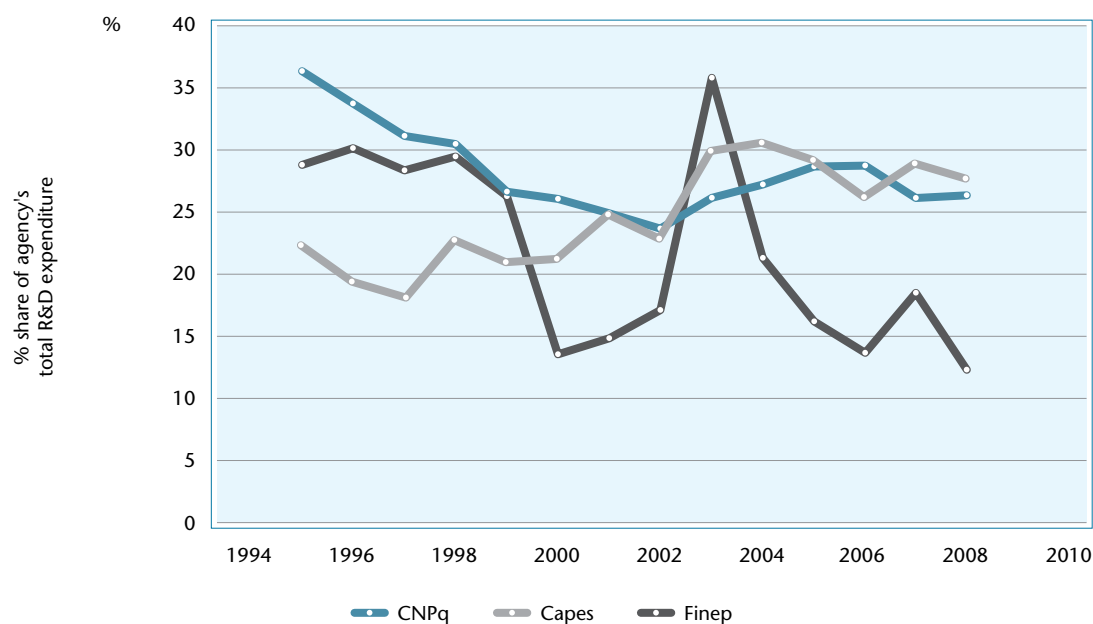
When the values are deflated by the IGP-DI, the shares of both CNPq and CAPES decrease for both Brazil as a whole and specifically for São Paulo (Figure 3.11A). In the case of FINEP, however, investment increases significantly in real terms.

In 2008 *reais*, CNPq invested R\$ 1.204 billion nationwide, or 28% less than in 1995 (R\$ 1.673 billion). Its investment in São Paulo fell 48%, from R\$ 606 million to R\$ 317 million.

Investment by CAPES nationwide fell 18%, from R\$ 1.186 billion in 1995 to R\$ 977 million in 2008, while its investment in São Paulo fell 9%, from R\$ 264 million to R\$ 241 million.

44. The method used to calculate CAPES share entailed discounting the amount invested in Portal de Periódicos and basic education programs created in or after 2007.

Figure 3.10A
 Evolution of R&D expenditure in São Paulo State by CNPq, CAPES and FINEP – 1995-2008



Source: CNPq; CAPES; FINEP.

- CNPq: expenditure in SP 1995-2000: data supplied by presidency of CNPq to FAPESP's Science Director on May 6, 2008; exp. in SP 2001-08: <ySaoPaulo2008.xls> (website Estatísticas CNPq, July 1, 2009); total exp. 1995- 2000: Resenha Estatística CNPq 1995-2000 (CNPq, 2001); total exp. 2001-08: <yBrasil2008> (website Estatísticas CNPq, July 1, 2009)

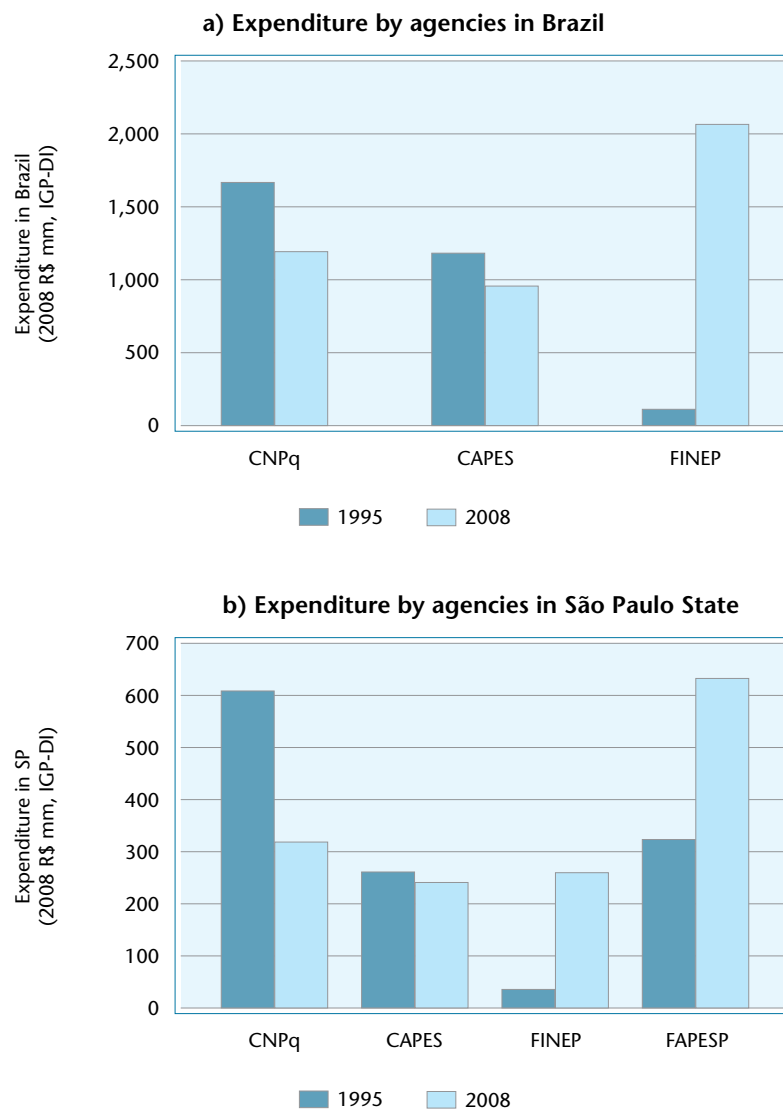
- CAPES: exp. in SP 1995: FAPESP (1998); exp. in SP 1996 -2001: data supplied by presidency of CAPES to FAPESP's Science Director on Aug. 26, 2008; exp. in SP 2002-08: GeoCapes (queried July 22, 2009); total exp. 1995-2000:

<<http://www2.camara.gov.br/orcamentobrasil/orcamentouniao/loa/execucao.html>>; total exp. 2001-08: obligated funds settled (spreadsheet supplied by MCT Indicators); total exp. excludes Portal de Periódicos, basic education, administrative expense

- FINEP: exp. in SP 1995: FAPESP (1998); exp. in SP 1996-2008: series supplied by presidency of FINEP to FAPESP's Science Director on June 29, 2009; total exp. 1996-2008: series supplied by presidency of FINEP to FAPESP's Science Director on June 2, 2009 (grants)

Note: See Table 3.3A.

Figure 3.11A
Expenditure by government research and postgraduate funding agencies – Brazil & São Paulo State – 1995 & 2008



Source: CNPq; CAPES; FINEP; FAPESP

- CNPq: expenditure in SP 1995-2000: data supplied by presidency of CNPq to FAPESP's Science Director on May 6, 2008; exp. in SP 2001-08: <ySaoPaulo2008.xls> (website Estatísticas CNPq, Jul. 1, 2009); total exp. 1995- 2000: Resenha Estatística CNPq 1995-2000 (CNPq, 2001); total exp. 2001-08: <yBrasil2008.xls> (website Estatísticas CNPq, July 1, 2009)

- CAPES: exp. in SP 1995: FAPESP (1998); exp. in SP 1996 -2001: data supplied by presidency of CAPES to FAPESP'S Science Director on Aug. 26, 2008; exp. in SP 2002-08: GeoCapes (queried July 22, 2009); total exp. 1995-2000:

<<http://www2.camara.gov.br/orcamentobrasil/orcamentouniao/loa/execucao.html>>; total exp. 2001-08: obligated funds settled (spreadsheet supplied by MCT Indicators); total exp. excludes Portal de Periódicos, basic education, administrative expense

- FINEP: exp. in SP 1995: FAPESP (1998); exp. in SP 1996-2008: series supplied by presidency of FINEP to FAPESP's Science Director on June 29, 2009; total exp. 1996-2008: series supplied by presidency of FINEP to FAPESP's Science Director on June 2, 2009 (grants)

FAPESP: <<http://www.fapesp.br/materia/381/estatisticas/dados-e-estatisticas-sobre-a-fapesp.htm>>.

Note: See Detailed Tables 3.3A e 3.4A and Detailed table 3.1A.

FINEP's contribution increased significantly owing to the creation of the sectoral funds and the resulting leverage of FNDCT (see Box 2A above), with the gradual release of impounded funds thanks to successful lobbying by the scientific community. FINEP invested R\$ 123 million nationwide in 1995 and R\$ 2.077 billion in 2008, for growth of 1,586%.⁴⁵ Its expenditure in São Paulo State grew 649%. In both cases (nationwide and in São Paulo) it began in 1995 from a far smaller base than the other agencies (Table 3.29A).

In the case of FAPESP, Figure 3.11A and Table 3.29A show that expenditure grew 95% from R\$ 327 million in 1995 to R\$ 638 million in 2008.

5.1.3 Business expenditure on R&D in São Paulo

Private R&D expenditure consists of BERD and R&D expenditure by private HEIs (Figure 3.12A).

R&D expenditure by private HEIs in 2008 *reais* grew more than threefold between 1995 and 2008, but even so corresponded to only 0.02% of the state's GDP and to only 1.3% of total R&D expenditure in the state (Detailed Table 3.7A).

BERD modelled on GFCF (see 3.4.3 above) grew from 0.80% of GDP in 1995 to 0.94% in 2008. Even the 1995 percentage exceeded the target set by MCT for Brazil in its "ST&I Action Plan," announced in 2007, with the aim of building BERD to 0.65% of GDP.⁴⁶

Table 3.29A
Research and postgraduate expenditure by agency – Brazil & São Paulo State – 1995 e 2008

Agency	Research & postgraduate expenditure					
	Brazil			São Paulo State		
	Amount (2008 R\$ mm, IGP-DI)		2008/1995 (%)	Amount (2008 R\$ mm, IGP-DI)		2008/1995 (%)
1995	2008	1995		2008		
CNPq	1,673	1,204	-28.0	606	317	-47.7
CAPES	1,186	977	-17.6	264	241	-8.7
FINEP	123	2,077	1,588.6	35	262	648.6
FAPESP	-	-	-	327	638	95.1

Source: CNPq; CAPES; FINEP; FAPESP.

- CNPq: expenditure in SP 1995-2000: data supplied by presidency of CNPq to FAPESP's Science Director on May 6, 2008; exp. in SP 2001-08: <ySaoPaulo2008.xls> (website Estatísticas CNPq, July 1, 2009); total exp. 1995- 2000: Resenha Estatística CNPq 1995-2000 (CNPq, 2001); total exp. 2001-08: <yBrasil2008.xls> (website Estatísticas CNPq, July 1, 2009)

- CAPES: exp. in SP 1995: FAPESP (1998); exp. in SP 1996 -2001: data supplied by presidency of CAPES to FAPESP's Science Director on Aug. 26, 2008; exp. in SP 2002-08: GeoCapes (queried July 22, 2009); total exp. 1995-2000: <http://www2.camara.gov.br/orcamento-brasil/orcamentouniao/loa/execucao.html>; total exp. 2001-08: obligated funds settled (spreadsheet supplied by MCT Indicators); total exp. excludes Portal de Periódicos, basic education, administrative expense

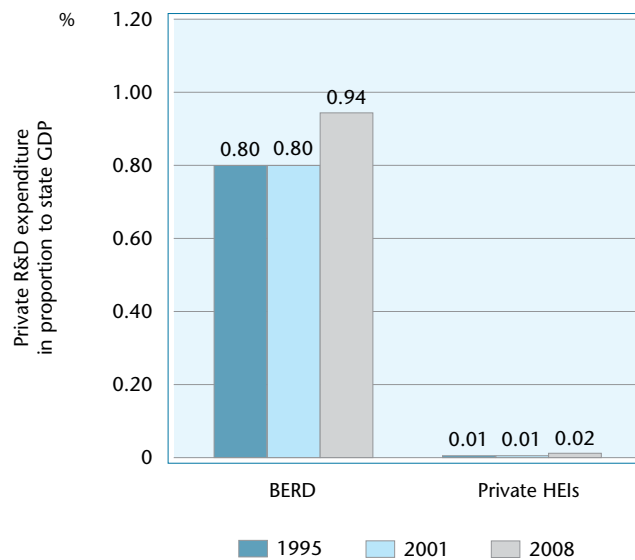
- FINEP: exp. in SP 1995: FAPESP (1998); exp. in SP 1996-2008: series supplied by presidency of FINEP to FAPESP's Science Director on June 29, 2009; total exp. 1996-2008: series supplied by presidency of FINEP to FAPESP's Science Director on June 2, 2009 (grants) FAPESP: <http://www.fapesp.br/materia/381/estatisticas/dados-e-estatisticas-sobre-a-fapesp.htm>.

Note: See Tables 3.3A and 3.4A, and Detailed Table 3.1A.

45. In 2001, when the first of today's 16 sectoral funds were set up, S&T Minister Ronaldo Sardenberg said they would be the equivalent for Brazil of creating "five FAPESPs". The current numbers show he was right.

46. MCT, 2007 (Plano de Ação para CT&I).

Figure 3.12A
Private R&D expenditure in proportion to state GDP by type of institution as funding source
– São Paulo State – 1995, 2001 & 2008



Source: IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP).

Note: See Table 3.27A.

In the rest of Brazil, BERD corresponded to 0.34% of Brazil's GDP excluding São Paulo. This disparity, which is discussed in more detail in section 5.2 below, shows the importance of S&T indicators, since policy designed on the basis of national averages may not be capable of addressing the needs of either of the actually existing extremes.

5.2 Heterogeneity of the national S&T system: an analysis of R&D expenditure in São Paulo, Brazil, and Brazil excluding São Paulo

The heterogeneity of the Brazilian S&T system has been recognized by many authors and S&T policymak-

ers. A proper understanding of this characteristic of the Brazilian S&T system requires the use of national and regional indicators. This section sets out to contribute to such an understanding, using the indicators of R&D expenditure calculated in the study presented in this chapter as well as the national indicators calculated by MCT.

Because R&D expenditure in São Paulo State accounts for a large proportion of national R&D expenditure, trends in national expenditure are strongly affected by expenditure in São Paulo. Thus in order to show regional contrasts more clearly, this section uses a classification into three regions: Brazil (BR), São Paulo (SP), and Brazil excluding São Paulo (BR ex-SP). Given the availability of indicators of national expenditure only since 2000, the analysis that follows covers only the period 2000-08.

Table 3.30A
R&D expenditure by type of institution and administrative jurisdiction of funding source (1) – Brazil, São Paulo State & Brazil excluding São Paulo – 2000-2008

Type of institution & administrative jurisdiction of funding source	R&D expenditure (in millions of current R\$)								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Brazil									
Total	12,057.6	13,755.1	14,760.0	16,440.7	18,606.8	20,652.5	23,552.7	29,267.6	34,404.6
Federal	4,007.7	4,563.4	4,828.3	5,802.4	6,418.3	7,085.2	8,483.5	10,444.8	12,098.4
Federal HEIs	1,523.4	1,590.4	1,861.4	2,159.3	2,542.9	2,616.1	3,319.5	4,391.9	5,062.5
Budget execution	2,484.3	2,973.0	2,966.9	3,643.2	3,875.4	4,469.0	5,164.0	6,052.9	7,035.9
State	2,486.2	2,884.4	2,932.6	3,023.6	2,917.0	3,286.1	3,427.6	4,740.1	5,307.2
State HEIs	1,544.4	1,758.9	1,971.3	2,098.4	1,849.7	1,965.3	2,001.6	3,022.9	3,234.1
Budget execution	941.8	1,125.4	961.3	925.2	1,067.3	1,320.8	1,426.0	1,717.2	2,073.1
Private	5,563.8	6,307.3	6,999.1	7,614.7	9,271.5	10,281.3	11,641.6	14,082.7	16,999.0
Business	5,420.2	6,128.0	6,757.2	7,293.7	8,911.9	9,867.7	11,174.0	13,412.0	16,253.0
Private HEIs	143.6	179.3	241.9	321.0	359.6	413.6	467.6	670.7	746.0
São Paulo State									
Total	5,609.1	6,339.1	6,684.6	7,148.4	8,327.6	9,525.3	10,852.7	12,794.8	15,523.6
Federal	694.5	793.1	766.0	916.3	1,096.7	1,285.9	1,446.0	1,792.6	2,034.7
Federal HEIs	75.4	89.5	97.4	169.3	144.8	154.1	279.3	357.2	425.6
Budget execution	619.1	703.6	668.6	747.0	951.9	1,131.7	1,166.7	1,435.4	1,609.1
State	1,677.0	1,758.0	1,859.9	1,821.9	2,105.1	2,399.7	2,735.3	2,966.5	3,733.2
State HEIs	983.9	1,019.9	1,142.3	1,196.2	1,417.9	1,565.6	1,828.5	2,011.2	2,646.0
Budget execution	693.1	738.2	717.7	625.7	687.2	834.0	906.8	955.2	1,087.1
Private	3,237.6	3,788.0	4,058.7	4,410.2	5,125.7	5,839.8	6,671.5	8,035.8	9,755.8
Business	3,181.6	3,719.1	3,976.8	4,323.7	5,010.5	5,690.7	6,492.8	7,833.3	9,553.3
Private HEIs	56.0	68.9	81.9	86.5	115.3	149.1	178.6	202.5	202.5
Brazil excluding São Paulo									
Total	6,448.5	7,416.0	8,075.4	9,292.3	10,279.2	11,127.2	12,700.0	16,472.7	18,880.9
Federal	3,313.2	3,770.3	4,062.3	4,886.2	5,321.6	5,799.3	7,037.5	8,652.2	10,063.7
Federal HEIs	1,448.0	1,500.9	1,764.0	1,990.0	2,398.1	2,462.0	3,040.2	4,034.7	4,636.9
Budget execution	1,865.2	2,269.4	2,298.3	2,896.2	2,923.5	3,337.3	3,997.3	4,617.5	5,426.8
State	809.2	1,126.3	1,072.7	1,201.7	811.8	886.4	692.3	1,773.6	1,574.0
State HEIs	560.5	739.1	829.0	902.2	431.7	399.7	173.1	1,011.6	588.1
Budget execution	248.7	387.3	243.7	299.5	380.1	486.7	519.2	762.0	986.0
Private	2,326.2	2,519.3	2,940.4	3,204.5	4,145.8	4,441.5	4,970.2	6,046.9	7,243.2
Business	2,238.6	2,409.0	2,780.4	2,970.0	3,901.5	4,176.9	4,681.2	5,578.7	6,699.6
Private HEIs	87.6	110.4	160.0	234.5	244.3	264.6	289.0	468.2	543.5

Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS; IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

(1) For the sake of comparability, BERD for Brazil was estimated on the basis of GFCF for the years when PINTEC surveys were not carried out, as in the case of São Paulo (see 3.4.3 above).

Note: See Table 3.18A, 3.19A, 3.21A and 3.26A.

Table 3.31A
R&D expenditure in proportion to regional GDP by type of institution and administrative jurisdiction of funding source (1) – Brazil, São Paulo State & Brazil excluding São Paulo – 2000-2008

Type of institution & administrative jurisdiction of funding source	R&D expenditure in proportion to regional GDP (%)								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Brazil									
Total	1.02	1.06	1.00	0.97	0.96	0.96	0.99	1.10	1.14
Federal	0.34	0.35	0.33	0.34	0.33	0.33	0.36	0.39	0.4
Federal HEIs	0.13	0.12	0.13	0.13	0.13	0.12	0.14	0.17	0.17
Budget execution	0.21	0.23	0.2	0.21	0.2	0.21	0.22	0.23	0.23
State	0.21	0.22	0.2	0.18	0.15	0.15	0.14	0.18	0.18
State HEIs	0.13	0.14	0.13	0.12	0.1	0.09	0.08	0.11	0.11
Budget execution	0.08	0.09	0.07	0.05	0.05	0.06	0.06	0.06	0.07
Private	0.47	0.48	0.47	0.45	0.48	0.48	0.49	0.53	0.57
Business	0.46	0.47	0.46	0.43	0.46	0.46	0.47	0.5	0.54
Private HEIs	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.02
São Paulo State									
Total	1.32	1.37	1.31	1.23	1.29	1.31	1.35	1.42	1.52
Federal	0.16	0.17	0.15	0.16	0.17	0.18	0.18	0.20	0.20
Federal HEIs	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.04	0.04
Budget execution	0.15	0.15	0.13	0.13	0.15	0.16	0.15	0.16	0.16
State	0.40	0.38	0.36	0.31	0.33	0.33	0.34	0.33	0.37
State HEIs	0.23	0.22	0.22	0.21	0.22	0.22	0.23	0.22	0.26
Budget execution	0.16	0.16	0.14	0.11	0.11	0.11	0.11	0.11	0.11
Private	0.76	0.82	0.79	0.76	0.80	0.80	0.83	0.89	0.96
Business	0.75	0.80	0.78	0.75	0.78	0.78	0.81	0.87	0.94
Private HEIs	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02
Brazil excluding São Paulo									
Total	0.85	0.88	0.84	0.83	0.79	0.78	0.81	0.94	0.95
Federal	0.44	0.45	0.42	0.44	0.41	0.41	0.45	0.49	0.51
Federal HEIs	0.19	0.18	0.18	0.18	0.18	0.17	0.19	0.23	0.23
Budget execution	0.25	0.27	0.24	0.26	0.23	0.23	0.26	0.26	0.27
State	0.11	0.13	0.11	0.11	0.06	0.06	0.04	0.10	0.08
State HEIs	0.07	0.09	0.09	0.08	0.03	0.03	0.01	0.06	0.03
Budget execution	0.03	0.05	0.03	0.03	0.03	0.03	0.03	0.04	0.05
Private	0.31	0.30	0.30	0.29	0.32	0.31	0.32	0.34	0.36
Business	0.30	0.29	0.29	0.27	0.30	0.29	0.30	0.32	0.34
Private HEIs	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03

Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLs; IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

(1) For the sake of comparability, BERD for Brazil was estimated on the basis of GFCF for the years when PINTEC surveys were not carried out, as in the case of São Paulo (see 3.4.3 above).

Note: See Table 3.30A and Detailed Table 3.1A.

5.2.1 R&D intensity in São Paulo, Brazil and Brazil excluding São Paulo

Figure 3.13A displays the evolution of R&D expenditure in São Paulo, Brazil and Brazil excluding São Paulo in proportion to regional GDP for the period 2000-08. R&D expenditure in São Paulo corresponded to 1.52% of the state's GDP in 2008, compared with 1.14% of national GDP in Brazil and 0.95% of the respective GDP in Brazil excluding São Paulo.

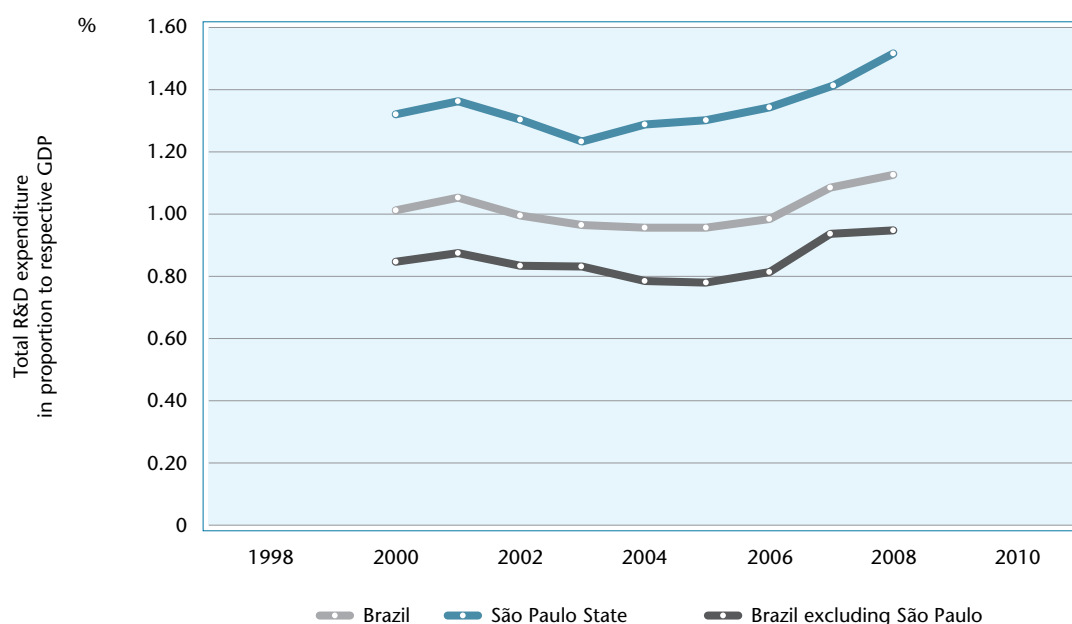
In all three cases, R&D expenditure trended up from 2006 on, but with different components. In São

Paulo growth in 2006-08 was driven mainly by rising private R&D expenditure in proportion to GDP, up 20% in the period, followed by state expenditure, up 12%, and federal expenditure, up 11%. In Brazil excluding São Paulo, the main driver was state expenditure, up 33%, followed by federal expenditure, up 24%, and business expenditure, up 16% (Table 3.31A).

5.2.2 Composition of total R&D expenditure

Figure 3.14A presents the breakdown of total R&D expenditure by the administrative jurisdiction of the various funding sources in 2008. For São Paulo

Figure 3.13A
Evolution of R&D expenditure by administrative jurisdiction of funding source – Brazil, São Paulo State & Brazil excluding São Paulo – 2000-2008



Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS; IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

Note: See Table 3.31A.

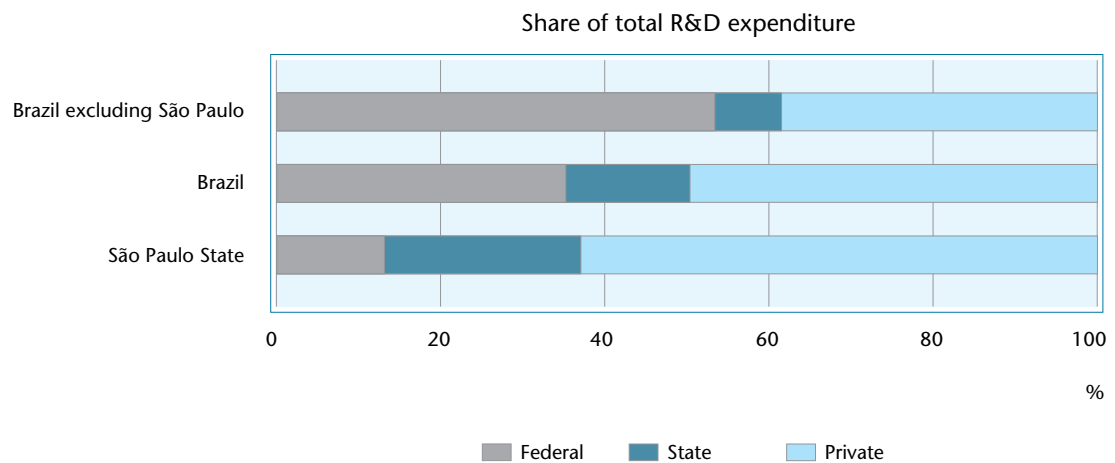
State, private expenditure accounted for the largest share, with 24%, while federal expenditure accounted for 13%.

For the rest of Brazil, in contrast, federal expenditure accounted for 53% of the total, followed by private expenditure with 38% and state expenditure with 8%.

5.2.3 Composition of public R&D expenditure

The composition of public R&D expenditure varies significantly depending on the region analyzed (Figure 3.15A). In São Paulo State, state expenditure accounted for 65% of public expenditure in 2008. In

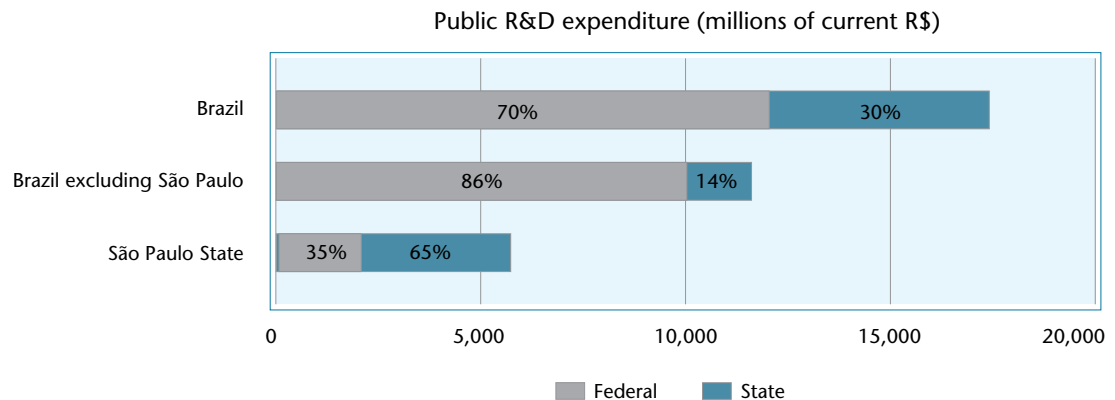
Figure 3.14A
Breakdown of R&D expenditure by administrative jurisdiction of funding source – Brazil, São Paulo State & Brazil excluding São Paulo – 2008



Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS; IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

Note: See Table 3.30A.

Figure 3.15A
Breakdown of R&D expenditure by administrative jurisdiction of funding source – Brazil, São Paulo State & Brazil excluding São Paulo – 2008



Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS; IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

Notes: 1. Percentages inside the bars refer to the respective shares of total public R&D expenditure. 2. See Table 3.30A.

Brazil the breakdown is almost exactly complementary, with federal expenditure accounting for 70% of total public expenditure. In Brazil excluding São Paulo, the federal contribution accounts for 86% of total public expenditure.

In the context of state expenditure the outstanding magnitude of São Paulo's effort is clear. State expenditure in São Paulo is 2.4 times the sum of state expenditure in the rest of Brazil.

On the other hand, the uneven distribution of federal funding is conspicuous (Figure 3.15A and Table 3.30A). Federal expenditure in São Paulo amounted in 2008 to only R\$ 2 billion out of R\$ 12.1 billion all told, or 17%.

The federal government's small contribution to research funding in São Paulo has been a major constraint on the state's scientific and technological development. This is detrimental to the entire nation's development, especially in light of the fact that São Paulo produces about 50% of the scientific articles published in Brazil and awards 45% of its doctoral degrees.

5.2.4 Business share of R&D expenditure

Table 3.32A presents the evolution of the business share of R&D expenditure in percentage terms for the period 2000-08 (excluding private HEIs).

Whereas business enterprises account for the largest share of R&D expenditure in São Paulo, in the rest of Brazil BERD is in the minority. BERD fluctuated in the period 2000-08 as a percentage of total R&D expenditure in Brazil excluding São Paulo, rising from 35% in 2000 to 38% in 2004 and ending the period on 35%. In São Paulo, however, BERD grew continuously as a share of the total, from 57% to 62%.

This is another conspicuous feature of São Paulo's economy, which is more industrialized than those of other states and where business contributes the lion's share of R&D expenditure.⁴⁷ It is worth noting that although business expenditure on R&D includes expenditure by state-owned enterprises, the latter is probably not significant in São Paulo – in contrast with other states, such as Rio de Janeiro, strongly impacted by the R&D activities of Petrobras – since SOEs do not play a major role in the activities ranked as most important by PINTEC. The leading sectors in terms of R&D expenditure, according to PINTEC, include the automotive, chemical and heavy engineering industries, as well as telecommunications services.

To find that São Paulo accounts for the largest proportion of national business expenditure on R&D is not new, as this is a finding of PINTEC, but nevertheless it is worth stressing that BERD in São Paulo var-

Table 3.32A
Business share of R&D expenditure (1) – São Paulo State & Brazil excluding São Paulo – 2000-2008

Year	Business expenditure on R&D (% total)	
	São Paulo State	Brazil excluding São Paulo
2000	57	35
2001	59	32
2002	59	34
2003	60	32
2004	60	38
2005	60	38
2006	60	37
2007	61	34
2008	62	35

Source: IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP).

(1) For the sake of comparability, BERD for Brazil was estimated on the basis of GFCF for the years when PINTEC surveys were not carried out, as in the case of São Paulo (see 3.4.3 above).

Note: See Table 3.30A.

47. The leading role played by business in funding R&D in the state had already been identified in the previous edition of this publication (FAPESP, 2005).

ied between 56.2% and 60.7% of the national total in the period 2000-08. This proportion is far greater than São Paulo's contribution to GDP, which is in the range of 33%. The comparatively high intensity of business R&D in São Paulo may derive from the fact observed by Tironi & Cruz (2008) that firms located in São Paulo are more likely to innovate radically than firms in other states.⁴⁸

5.2.5 Per capita R&D expenditure

Regional R&D efforts can be gauged through an analysis of R&D expenditure in proportion to the population. Table 3.33A presents per capita R&D expenditure for São Paulo State and Brazil excluding São Paulo.

Per capita R&D expenditure in São Paulo in 2008 was R\$ 377, three times more than in Brazil excluding São Paulo (R\$ 127). This much higher prioritization of R&D in São Paulo than in other states on average

remained relatively constant throughout the period 2000-08 (Table 3.34A). While the difference fell from 3.1 in 2000 to 2.7 times in 2003, it rebounded in the ensuing years. Despite a relative recovery by the system of state research funding agencies, its overall effects were negligible since most R&D expenditure came from higher education and business.

The categorization of funding sources used in Table 3.33A enables a number of differences to be observed. Table 3.34A illustrates these differences.

The main difference is in per capita state expenditure: São Paulo's was 8.3 times greater than the rest of Brazil's in 2008. The difference had been even greater: it was 13.6 times in 2006, when per capita state expenditure in São Paulo was R\$ 68, compared with R\$ 5 in the rest of Brazil. This difference reflects the priority placed by the São Paulo State Government on maintaining and developing three major state universities as well as a large number of state R&D institutions.

Table 3.33A
Per capita R&D expenditure by administrative jurisdiction of funding source (1) – São Paulo State & Brazil excluding São Paulo – 2000-2008

Administrative jurisdiction of funding source	Per capita R&D expenditure (current R\$)								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
São Paulo State									
Total	151	168	175	185	212	240	269	314	377
Federal	19	21	20	24	28	32	36	44	49
State	45	47	49	47	54	60	68	73	91
Private	87	101	106	114	131	147	166	197	237
Brazil excluding São Paulo									
Total	48	55	59	67	73	79	89	114	127
Federal	25	28	30	35	38	41	49	60	68
State	6	8	8	9	6	6	5	12	11
Private	17	19	22	23	30	31	35	42	49

Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS; IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

(1) For the sake of comparability, BERD for Brazil was estimated on the basis of GFCF for the years when PINTEC surveys were not carried out, as in the case of São Paulo (see 3.4.3 above).

Note: See Table 3.30A and Detailed Table 3.1A.

48. São Paulo's leading share of BERD is compatible with other findings of a recent study published by Instituto de Pesquisa Econômica Aplicada (IPEA), also based on PINTEC microdata. According to Tironi & Cruz (2008, p. 24): "Another interesting observation is that firms whose research labs are headquartered in São Paulo and participate in cooperative arrangements are 2.423 times more likely to innovate radically than firms located in other states. This finding may indicate a strong presence of local externalities linked to innovation, in the sense that being located in São Paulo gives these firms greater access to services and enables them to obtain information on new technology at a lower cost, among other advantages." It is worth noting that years earlier another study by IPEA had focused on R&D activities by industry in São Paulo and the "spillovers" into other sectors and regions (Silva, 2005).

Table 3.34A
Ratio of per capita R&D expenditure in São Paulo State and Brazil excluding São Paulo by administrative jurisdiction of funding source – 2000-2008

Administrative jurisdiction of funding source	Ratio of per capita R&D expenditure in São Paulo State / Brazil excluding São Paulo								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total	3.1	3.1	3.0	2.7	2.9	3.0	3.0	2.8	3.0
Federal	0.8	0.8	0.7	0.7	0.7	0.8	0.7	0.7	0.7
State	7.4	5.6	6.2	5.4	9.2	9.6	14.0	5.9	8.3
Private	5.0	5.4	4.9	4.9	4.4	4.7	4.8	4.7	4.8

Source: CNPq; CAPES; FINEP; FAPESP; INEP; INPE; IPEN; CTI-Cenpra; LNLS; IPT; APTA; MCT; São Paulo State Depts. of Health and Environment; IBGE, PINTEC 2000, 2003, 2005 (tabulations open to public access on respective institutional portals, or special tabulations requested by FAPESP); FAPESP (1998); São Paulo State Budget.

(1) For the sake of comparability, BERD for Brazil was estimated on the basis of GFCF for the years when PINTEC surveys were not carried out, as in the case of São Paulo (see 3.4.3 above).

Note: See Table 3.33A.

There is also a considerable difference between São Paulo and the rest of Brazil in terms of per capita business expenditure on R&D. São Paulo's ranged from 4.4 to 5.3 times the rest of Brazil's in the period analyzed, reaching 4.8 times in 2008.

In the opposite direction, federal R&D expenditure in São Paulo was R\$ 49 per capita in 2008, corresponding to 72% of the average for the rest of Brazil.

6. Some salient features of R&D

Some peculiarities of national investment in R&D are worth a separate discussion, both because of their importance (as in the case of tax expenditure and subsidized loans), and in order to present more detail regarding information already discussed in a previous section (as in the case of the different concepts of government expenditure).

An aspect of the indicators that deserves redoubled attention relates to business expenditure, which accounts

for a significant share of R&D expenditure in Brazil. As noted in 5.1.3 above, BERD is strongly affected in Brazil by the efforts of business enterprises in São Paulo State.

The significance of BERD is even greater in São Paulo State than Brazil as a whole, and this justifies a more in-depth analysis of the results extracted from PINTEC's special tabulations. In 2005, PINTEC identified 11,602 innovative firms in São Paulo State, or 35% of the survey sample. These firms invested a total of some R\$ 21.7 billion in innovation, of which R\$ 5.7 billion in intramural and externally acquired R&D. Detailed statistics, including a breakdown by sector, are presented in Chapter 7 of this publication.

One of the major challenges for S&T policy in Brazil since 1999 has been to stimulate more BERD. It is therefore worth looking at the R&D efforts of Brazilian firms compared with their global competitors. Unfortunately no organizations in Brazil have ever taken an interest in this type of study, although the UK Department for Business, Innovation & Skills (BIS), formerly the Department of Industry, Universities & Skills (DIUS), until recently has published an annual global ranking of BERD.⁴⁹ Five Brazilian firms featured in the 2008 ranking: Petrobras, Vale, a Embraer, Braskem and WEG (Box 4A).

49. UK Department for Business, Innovation & Skills: <<http://www.bis.gov.uk/policies/innovation/business-support/research-and-development/randd-scoreboard>>.

Box 4A – Global leaders in business expenditure on R&D

According to a U.K. government study, the average amount spent on R&D by the 1,250 most active firms on this criterion corresponded to about 3.5% of sales in 2005-06, although the aggregate volume of R&D expenditure grew 10% to £244 billion (about US\$504 billion), with firms in the U.S., Japan, Germany, France and the U.K. itself accounting for 81% of the total.

Five Brazilian firms rank among the 1,400 most active companies globally in R&D for 2008: Petrobras, Vale, Embraer, Braskem and WEG. All but the last two also ranked among the G1400 in the previous year. The five firms invested a total of £984 million in R&D in 2007.

Petrobras ranks second in oil and gas, with R&D expenditure of £442 million or 1% of sales. This is 124% more than the average for the previous four years. Petrobras ranks 119th in the G1400, ahead of all other Brazilian firms.

Vale ranks first in mining, with R&D expenditure of £368 million or 2.3% of sales, well above the average for all mining firms surveyed, which is 0.4%. Vale's R&D expenditure rose 156% in 2007 compared with the average for the previous four years. Vale ranks 145th in the G1400.

Embraer ranks 16th in aerospace and defense. According to the UK study, it invested 5% of sales in 2007, while the average for the other firms sur-

veyed in the same sector was 4.4%. Embraer's R&D expenditure is reported there as £131 million, up 145% compared with the average for the previous four years. Embraer ranks 327th in the G1400.

Braskem ranks 90th in chemicals, with R&D expenditure of £22 million or 0.4% of sales (compared with an average of 2.8% for the sector). Growth over the average for the previous four years was 64%. Braskem ranks 1,245th in the G1400.

WEG ranks 106th among electronic and electrical equipment manufacturers, with R&D expenditure of £21 million or 2.1% of sales (compared with an average of 4.1% for the sector). Growth over the average for the previous four years was 93%. WEG ranks 1,283th in the G1400.

Among the four main BRICs, Brazil outperforms only Russia in terms of the number of firms ranked among global leaders in R&D. Russia has three, while China and India have nine and 15, respectively.

Although fewer in number, the Brazilian firms ranked among the G1400 outperform those of China and India in terms of growth in R&D expenditure, which increased 131% compared with the average for the previous four years. The Chinese firms covered by the survey invested £992 million, up 59%, while the Indian firms invested £752 million, up 43%.

Table 3.35 displays the ten companies that most invested in R&D worldwide in 2007 according to the UK 2008 R&D Scoreboard. It is interesting to note how widely the percentage of sales invested in R&D varies in this list. In pharmaceuticals it is as high as 18%, while in automotive manufacturing it is about 4% and in software and IT it ranges from 10% to 13.5%.

Some specific features of innovation activities, especially R&D, are not always captured by panoramic studies such as the UK scoreboard or surveys such as PINTEC. To pinpoint these, R&D expenditure by two of the Brazilian firms that most invest in these activities, Petrobras and Vale, were surveyed specially for this chapter.

Petrobras (Box 5A) is the largest Brazilian company and invests far more than any other in R&D. The

state-owned enterprise has many divisions operating in a wide array of activities, but oil and gas is its core business and accounts for most of its investment. In 2007, the Consolidated Petrobras System (Petrobras Holding + Petrobras Distribuidora) invested R\$ 1.7 billion in R&D, equivalent to 1% of the company's net operating revenue, which was R\$ 170.6 billion. This R&D expenditure was allocated to exploration and production (50.7%), supply (19.5%), corporate services (18.2%), gas and energy (10.7%), distribution (0.7%) and international projects (0.2%) (Table 3.36A).

Petrobras invested R\$ 443 million and R\$ 439 million in R&D activities performed by HEIs throughout Brazil in 2006 and 2008, respectively. São Paulo State accounted for 18% of the total in 2006 and 16% in 2008 (Table 3.37A).

Table 3.35A
Global ranking of top ten firms by R&D expenditure – 2008

Firm	Home country	Rank	R&D expenditure (£ million)	Percentage of sales invested in R&D (%)
Microsoft	USA	1st	4,101.28	13.5
General Motors	USA	2nd	4,069.13	4.4
Pfizer	USA	3rd	4,063.60	16.7
Toyota Motor	Japan	4th	4,005.68	3.9
Nokia	Finland	5th	3,878.81	10.3
Johnson & Johnson	USA	6th	3,858.13	12.6
Ford Motor	USA	7th	3,767.71	4.3
Roche	Switzerland	8th	3,679.89	18.0
Volkswagen	Germany	9th	3,615.87	4.5
Daimler	Germany	10th	3,590.16	3.8

Source: U.K. government (Department for Business, Innovation & Skills, 2008 R&D Scoreboard).

Box 5A – R&D expenditure by Petrobras

Petrobras is one of the world's top five integrated energy companies, as well as being the Latin American leader and having a presence in 27 countries. It typically invests 1% of sales in R&D, given that technology is the main driver of its growth in the global energy sector.

In 1963 Petrobras established its R&D Center (Centro de Pesquisas e Desenvolvimento Leopoldo Américo Miguez de Mello, or Cenes for short) to meet its technology requirements. With 30 pilot units and 137 laboratories, Cenes has a large, highly qualified staff with 178 PhDs and 478 holders of master's degrees. Besides process and product technology, Cenes has capabilities in other areas, such as biostratigraphy, sedimentology and geochemicals, assuring a world-class standard of quality. Several of its projects have put Brazil among the holders of leading-edge technology, including deepwater platforms, underwater production systems, refinery construction, expansion and modernization projects, robots and remotely operated vehicles for undersea work, catalyzts, and special vessels and anchoring systems.

The company's technology development strategy currently has four priorities: building deepwa-

ter and ultra-deepwater production capabilities; enhanced oil recovery; new refining technologies to adjust production to the types of crude oil available in Brazil and the characteristics of refined product consumption; and alternative technologies for transporting natural gas and developing renewable energy.

Petrobras is obliged by the regulator, ANP, to invest 1% of gross revenue from the crude oil and natural gas it produces, and half of this must be invested in projects and programs at universities and R&D institutions (ANP Resolution 33, issued on Nov. 24, 2005). To organize these operations it has established a structure of technology networks and regional competence centers. Forty technology networks focus on strategic themes, each involving at least five universities, which receive support in the form of infrastructure and human resources for R&D. Over 77 higher education institutions and technology institutes in 19 Brazilian states are currently part of this system. Seven regional competence centers are in operation, comprising universities or research institutions located near business units of Petrobras to meet regional demand.

Table 3.36A
Petrobras System (1) R&D expenditure by sectoral allocation – 2005-2007

Year	R&D expenditure (in thousands of current R\$)						Total
	Supply	Corporate	Exploration & production	Gas & energy	Distribution	International	
2005	133,728	369,283	371,814	53,314	1,973	4,488	934,600
2006	312,045	332,238	757,797	169,053	10,765	4,589	1586,489
2007	333,328	312,976	868,077	182,907	11,636	3,411	1712,338

Source: Petrobras (special tabulation received in June 2008).
(1) Holding company and distribution unit.

Table 3.37A
R&D expenditure by Petrobras on higher education institutions (HEIs) – Brazil & São Paulo State – 2006-2008

Year	R&D expenditure by Petrobras on HEIs (in millions of current R\$)		
	Brazil	São Paulo State	SP/BR (%)
2006	443	79	17.8
2007	437	55	12.6
2008 (1)	439	70	15.9

Source: Petrobras.
(1) Preliminary estimate.

Vale, the largest private-sector firm in Brazil and the world's leading iron ore miner, is another emblematic example. Box 6A summarizes its R&D expenditure between 2002 and 2008. In 2002, Vale invested some US\$50 million, or 1.2% of annual gross revenue, in R&D. In 2007 it invested US\$733 million, equivalent to 2.2% of gross sales. In 2008 it expected to invest US\$884 million (Table 3.38A).

Finally, tax expenditure is a key policy tool to foster R&D in countries with a diversified production structure such as Brazil and where direct government intervention in production is limited to a few segments. Tax expenditure entails different forms of incentives, benefits and advantages extended by government to business enterprises and other entities in order to stimulate R&D and technological capability building. While not requiring the direct disbursement of public funds, tax expenditure is a means of transferring funds from government to other economic agents, especially firms, and thus embodies an effort

by government and society in general to support the development of S&T. In this context, measuring tax expenditure is a key requirement if this effort is to be evaluated.

The OECD highlights tax expenditure by Brazil, India, Singapore and South Africa as an effort to provide generous and competitive tax environments for R&D expenditure. The OECD countries have tended to reduce direct subsidies to business and increase tax incentives as a way of stimulating investment in R&D by the private sector, leaving the choice of project types to market forces.

The OECD recently noted that new tax expenditure schemes have been increasingly adopted and existing ones altered to make them even more generous and focus on certain types of beneficiary, especially small business enterprises or specific industries. Special tax treatment for R&D expenditure includes immediate write-off of current BERD and various types of tax relief such as tax credits, allowances against taxable

Box 6A – R&D expenditure by Vale

Vale has invested heavily and increasingly in R&D in recent years as part of its long-term growth strategy and to create new products and business lines. It manages R&D expenditure so as to keep costs low and speed up the cycle of discovery, assuring project quality from mineral research to the production of the studies required to develop already discovered reserves and research on the feasibility of new projects to expand production capacity. It also invests in research on new processes, technological innovation and adaptation of new technology to the production chain with the aim of achieving excellence in production. In the context of its strategy to consolidate and diversify business areas, Vale researches ore deposits worldwide

as well as multicommodities that offer significant tonnage, high mineral content, low operating cost, expansion capacity and a long useful life.

An analysis of the regional distribution of Vale's R&D expenditure shows that 48% (US\$355 million) was allocated to overseas projects in 2007. In Brazil, it was concentrated in two states where the company's presence is strongest – Pará (US\$193 million) and Minas Gerais (US\$126 million). The amount invested in São Paulo State was negligible (US\$9 million). A breakdown of R&D expenditure in 2007 by business area shows that 38% went to the non-ferrous segment, 19% to the ferrous segment, 15% to copper, 9% to coal, 6% to bauxite, 6% to logistics and 5% to energy.

Table 3.38A
R&D expenditure by Vale – 2002-2008

Year	Amounts (US\$ million)		
	R&D	Gross sales	R&D / gross sales (%)
2002	50	4,282	1.2
2003	82	5,545	1.5
2004	153	8,479	1.8
2005	277	13,405	2.1
2006	481	25,714	1.9
2007	733	33,115	2.2
2008	884

Source: Vale (special tabulation).
(1) Vale plus affiliates and subsidiaries.

income and accelerated depreciation. Thus tax expenditure enables governments to reduce the cost of doing business for firms that perform R&D activities.

During the period 1999-2007 tax expenditure in favor of large corporations increased significantly in Mexico, Norway and, to a lesser extent, Portugal, New Zealand, France, Belgium, Japan and the United Kingdom. Other OECD countries made no significant changes.

Estimates indicate that in 2005 R&D-related tax expenditure totalled US\$5 billion in the United States, more than US\$800 million in Canada, France and the UK, and between US\$ 300 million and US\$400 million in Australia, Belgium, the Netherlands, Spain and Mexico.

In 2006, 20 OECD countries offered tax credits to firms, compared with only 12 in 1995 and 18 in 2004. Tax credits are increasingly deployed by both OECD members and non-members. Since 2006, Spain, China, Mexico and Portugal have had the most generous incentives, without distinguishing between large and small firms. Policies in Canada and the Netherlands continue to be increasingly favorable to small business.

Box 7A presents an assessment of tax expenditure by the federal government of Brazil, as officially estimated in recent budgets. While there are no nationwide surveys of tax expenditure by state governments, it is important to note that some states also seek to foster R&D activities in their territory using a wide array of programs offering tax incentives and subsidies.⁵⁰

In Brazil, R&D-related tax expenditure is (or was) disciplined by the following legal instruments:

a) Law 8010/90, granting exemption from import duty (II) and excise tax (IPI) on imports

of goods such as machinery, apparatus, instruments and parts for scientific and technological research;

- b) Law 8032/90, granting exemption or reduced rates of II and IPI on foreign purchases by S&T institutions, scientists and researchers;
- c) Law 8248/91 (altered by Law 10176/01), introducing incentives designed to enhance capacity building and competitiveness in the IT and automation sectors, such as reduced rates of IPI on goods for IT and automation produced in accordance with a government-approved production process (Processo Produtivo Básico, PPB), and IPI credits on raw materials, intermediate goods and packaging materials used to manufacture such goods;
- d) Law 8661/93 and Law 9532/97, granting incentives for technological capacity building in industry (Programa de Desenvolvimento Tecnológico Industrial, PDTI) and agriculture (PDTA), revoked by Law 11196/2005 (see item f below);
- e) Law 8387/91, granting incentives for IT goods produced in the Manaus Free Zone (ZFM) similar to those granted by Law 8248/91;
- f) Law 11196/2005, revoking the legislation on PDTI/PDTA (see item d above) and granting incentives for technological innovation such as deductions from corporate income tax for technological research and innovations, reduced IPI rates on plant, equipment and instruments used for R&D, tax rebates for R&D expenditure and zero-rated sales tax for certain purchases.

50. An exhaustive recent study of state policies to develop industry and services, coordinated by Mariano Macedo for IPT in São Paulo and published by Fipe (2008), identified R&D-related incentives in at least four states (São Paulo, Santa Catarina, Rio Grande do Sul and Mato Grosso do Sul).

Box 7A – Federal tax expenditure relating to S&T

(Text and table extracted from *Desafios da Inovação, Incentivos para inovação: o que falta ao Brasil* IEDI, Feb. 2010)

Like many countries, Brazil uses a mix of instruments to support private-sector R&D, including tax incentives (indirect support) and subsidies (direct support). These incentives are designed to bolster private expenditure and support growth in competitiveness and productivity throughout the economy.

New instruments have recently been introduced in Brazil to strengthen government support for innovation and private R&D activities (Table 3.39A). These include sectoral funds, interest-rate equalisation via Fundo Verde Amarelo (2002), subsidies granted under Law 10973, known as *Lei da Inovação* (2004), and tax incentives granted under Law 11196, known as *Lei do Bem* (2005). The most significant incentives are provided by Laws 8248, 10176 and 11077, known as *Lei de Informática* (1991, 2001, 2004), accounting for some two-thirds of the incentives to private R&D activities.

Considering all the instruments in place, public support is very strong and theoretically places Brazil among the countries that offer most support to private R&D, especially through tax expenditure, as in

the case of *Lei de Informática* and *Lei do Bem*. Taking together the direct and indirect incentives available, public-sector support for private expenditure corresponds to some 0.17% of GDP, while private expenditure amounts to about 0.50% of GDP (data for 2008). This is generous by international standards, and few countries offer such substantial incentives.

However, the characteristics of the Informatics Law suggest caution. It is not so much an instrument of support for R&D as a reflection, albeit important to the nation, of the need to balance the incentives granted to the Manaus Free Zone by granting similar concessions to other regions of the country. The tax expenditure claimed to result from this law is largely an illusion, since if these incentives did not exist production would move to Manaus or be imported, increasing the sector's trade deficit.

Excluding the incentives granted by the Informatics Law, public-sector support for R&D activities in Brazil corresponds to about 0.07% of GDP (data for 2008), which is low compared with other countries, especially our main competitors, and similar only to the level found in Mexico.

Table 3.39A
Federal tax expenditure to support S&T – Brazil – 2006-2008

Type of tax expenditure	2006	2007	2008
Amounts in millions of current R\$			
Total (incentives & subsidies)	2,358	4,099	5,186
Total (incentives & subsidies, excl. IT)	368	1,340	2,003
Tax incentives	2,219	3,643	4,728
<i>Lei do Bem</i> (Law nº 11196/05)	229	884	1,545
<i>Lei de Informática</i> (Law nº 8248/91 etc.)	1,990	2,759	3,184
Subsidies	139	456	458
<i>Lei de Inovação</i> (Law nº 10973/04)	40	345	319
Interest-rate equalization (Law nº 10332/02)	66	79	90
Other subsidies (Law 10332/02 & PDTI)	33	32	50
Private R&D expenditure	11,738	13,423	15,161
GDP	2,369,797	2,661,344	3,004,881
Contribution of public support for private R&D expenditure (%)			
Total support/private R&D expenditure	20.10	30.50	34.20
Total support/private R&D expenditure (excl. IT)	3.10	10.00	13.20

Source: IEDI, *Desafios da Inovação, Incentivos para Inovação: o que falta ao Brasil* (February 2010).

7. International overview

The key reference for comparisons has been the OECD, which collects data on national R&D expenditure frequently and with a well-defined methodology. The main aggregate used in international comparisons is gross expenditure on research and development (GERD), which refers to total current and capital expenditure on R&D by resident companies, research institutions, university laboratories and governments, and by convention excludes R&D expenditure effected abroad by domestic firms.

The OECD's R&D statistics are compiled in accordance with the recommendations of the *Frascati Manual*. The editors draw attention to the fact that several countries featured in the available time series have improved their coverage of R&D activities.⁵¹ In the specific case of Brazil, they say its statistics do not entirely comply with the aforementioned recommendations but are compiled from domestic sources, concluding that Brazil's R&D expenditure indicators are underestimated, like those of India and South Africa (as well as China before 2000).

R&D expenditure is considered a key indicator for governmental and private efforts to evaluate the level of competitiveness in S&T as well as the production system in each country. It can also be used as an indicator domestically to compare regions of a given country with each other. While there are problems of comparability with the data from several countries, due to conceptual and methodological differences in data collection, comparisons are nonetheless useful to appraise the level of an individual country or of a group of countries compared with the rest as far as R&D efforts are concerned. The analysis, of course, must always

take into consideration such factors as the differences in economic and social development.

According to *Science, Technology & Industry Outlook 2008* (OECD, 2008) and *Science, Technology & Industry Scoreboard 2007* (OECD, 2007),⁵² until the ongoing financial crisis broke out and intensified, investment in ST&I benefited from a positive macroeconomic outlook. In the period 2001-06, gross expenditure on R&D (GERD) in OECD countries rose 2.5% per year in real terms, reaching US\$818 billion at current prices in 2006. The U.S. accounted for 41% of the total, Europe for 30% and Japan for 17%. In the major developing economies, especially the BRICs (Brazil, Russia, India and China), the leader was China, where R&D expenditure grew very rapidly, rising 19% per year in real terms in the period.

R&D expenditure in São Paulo State corresponded to 1.52% of GDP in 2008, well above the efforts of Latin American countries (Brazil 1.14%, Argentina 0.51%, Mexico 0.38%, Chile 0.67%) but well below countries such as Israel, Sweden, Finland, Japan and South Korea, all of which invested more than 3% of GDP in R&D (Figure 3.16A). The intensity of total R&D expenditure in São Paulo also lagged behind the OECD average, which was 2.28% of GDP, although it outperformed all of the BRICs including China.⁵³

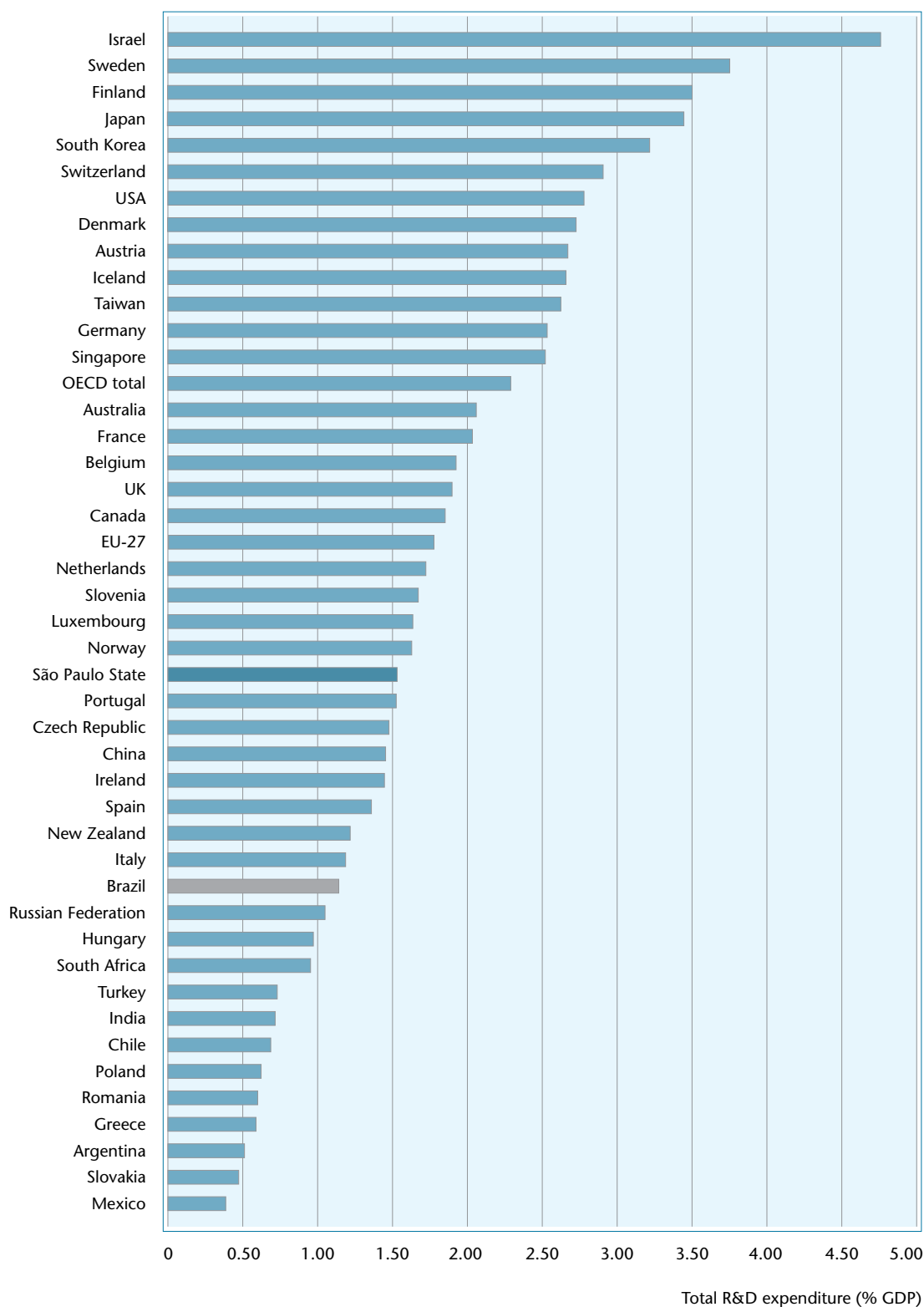
The disparity between the intensity of total R&D expenditure in São Paulo and Brazil and the OECD can be better understood if it is divided into two components, one corresponding to the intensity of business expenditure on R&D (BERD) and the other to non-business expenditure. The latter component consists mainly of government expenditure and expenditure by HEIs. In a few cases there may be a third element comprising R&D expenditure using foreign funds.

51. Some countries have included the service sector (Japan, Netherlands, Norway, U.S.) and higher education (Finland, Greece, Japan, Netherlands, Spain and the U.S.), while others (Italy, Japan, Sweden) have endeavoured to enhance the international comparability of their data. Thus some of the alterations to time series discussed here reflect these methodological improvements. The following methodological differences are noteworthy: in S. Korea, human and social sciences are excluded from the R&D expenditure database; in the U.S., capital expenditure is excluded.

52. Summaries of these reports in Portuguese can be found in Carta IEDI, issues 296, 344 and 347. For more information, go to <<http://www.iedi.org.br/>>.

53. China's R&D expenditure rose much faster than GDP, resulting in rapid growth of R&D expenditure intensity, which rose from 0.9% in 2000 to 1.4% in 2006. It set a target of 2% for 2010 and 2.5% for 2020. Considering its strong GDP growth, achieving these targets will require an increase in R&D expenditure of 10%-15% per year in the period.

Figure 3.16A
Total R&D expenditure in proportion to respective GDP – Brazil, São Paulo State & selected countries – 2008 (1)



Source: OECD, *Main Science & Technology Indicators (MSTI) 2009*, v.1. (1) or most recent year with available data.

Notes: 1. São Paulo State as calculated for this chapter.
 2. See Table 3.16A.

Figure 3.17A1 shows that the main cause of the disparity in total R&D expenditure is due to the low intensity of BERD. This is 1.58% of GDP for the OECD, or 70% more than in São Paulo (0.94%) and over three times more than in Brazil (0.49%).

From Figure 3.17A2 it can be seen that the disparity in non-business R&D expenditure is far smaller. This component consists largely of government expenditure, with HEIs also contributing to a lesser extent. The intensity of non-business R&D expenditure in São Paulo is 0.58% of GDP, very similar to Brazil's (0.60%). The OECD average is 0.69%, only 15% more than Brazil's.

An analysis of the funding pattern shows that on average industry is the principal source of domestic gross expenditure on R&D in the OECD, accounting in 2008 for 70% of the total. Industry's share varies strikingly from one country to another, however: while industry's share of funding in 2008 was 78% in Japan (and rising), in the U.S. 73% (and declining) and in the EU 65% (stable), in some countries the main source of funding was government, especially Russia (61%), Portugal (50%), Poland (69%) and Turkey (59%). The main exception was China, where industry's share was 72%, although of course many firms are directly or indirectly controlled by the government.

Table 3.40A lists total R&D expenditure (expressed in purchasing power parity dollars) for OECD countries plus Argentina, China, Israel, Romania, Rus-

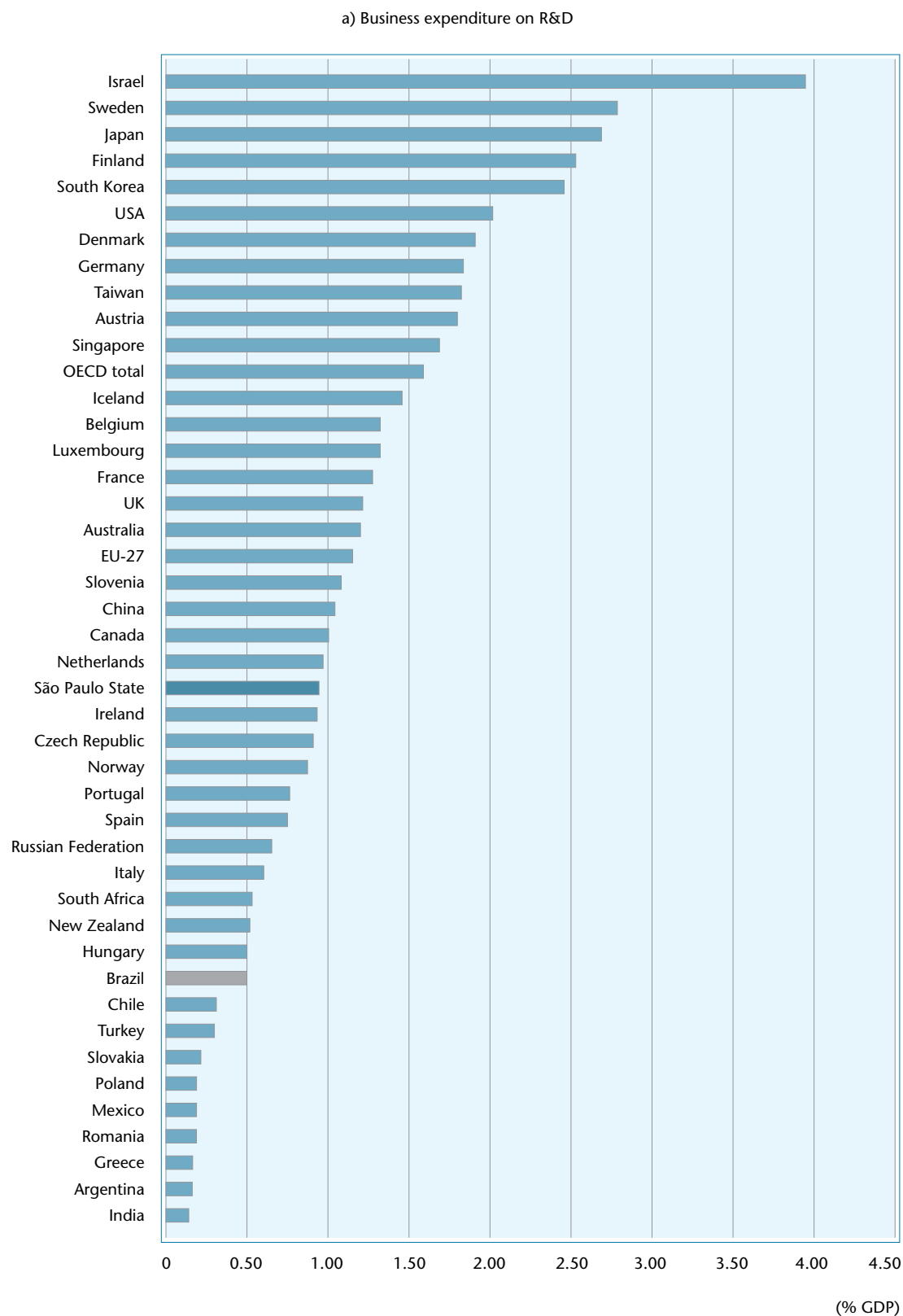
sia, Singapore, Slovenia, South Africa, Taiwan and Brazil (source: MCT indicators and recalculations in this chapter), as well as São Paulo (source: this chapter).

Total R&D expenditure in São Paulo State ranks 18th and in Brazil 9th for the year in question. Brazil's total R&D expenditure exceeds those of Canada, Italy, Russia, Spain and Taiwan. São Paulo's exceeds those of Israel, Belgium, Argentina and Finland.

Per capita R&D expenditure in São Paulo State ranks 29th and Brazil's 33rd in this list of 41 countries. The average for all 41 countries is US\$606 purchasing power parity (PPP), so that São Paulo's and Brazil's per capita R&D expenditures are 44% and 21% of the average, respectively.

OECD in Figures 2008 shows that public R&D expenditure continues to grow in several countries despite budget constraints and gradual cuts in government spending. This growth reflects national targets for R&D, such as the EU's goal of raising R&D expenditure to 3% of GDP by 2010. The report also highlights a tendency for direct public funding of R&D activities to be replaced by indirect funding, mainly in the form of tax incentives. In addition to the growth in these benefits, which have become increasingly generous over the years in many countries, such as Canada, France, the U.S. and Mexico, the number of member countries that grant tax incentives for private R&D rose from 12 in 1996 to 21 in 2008.

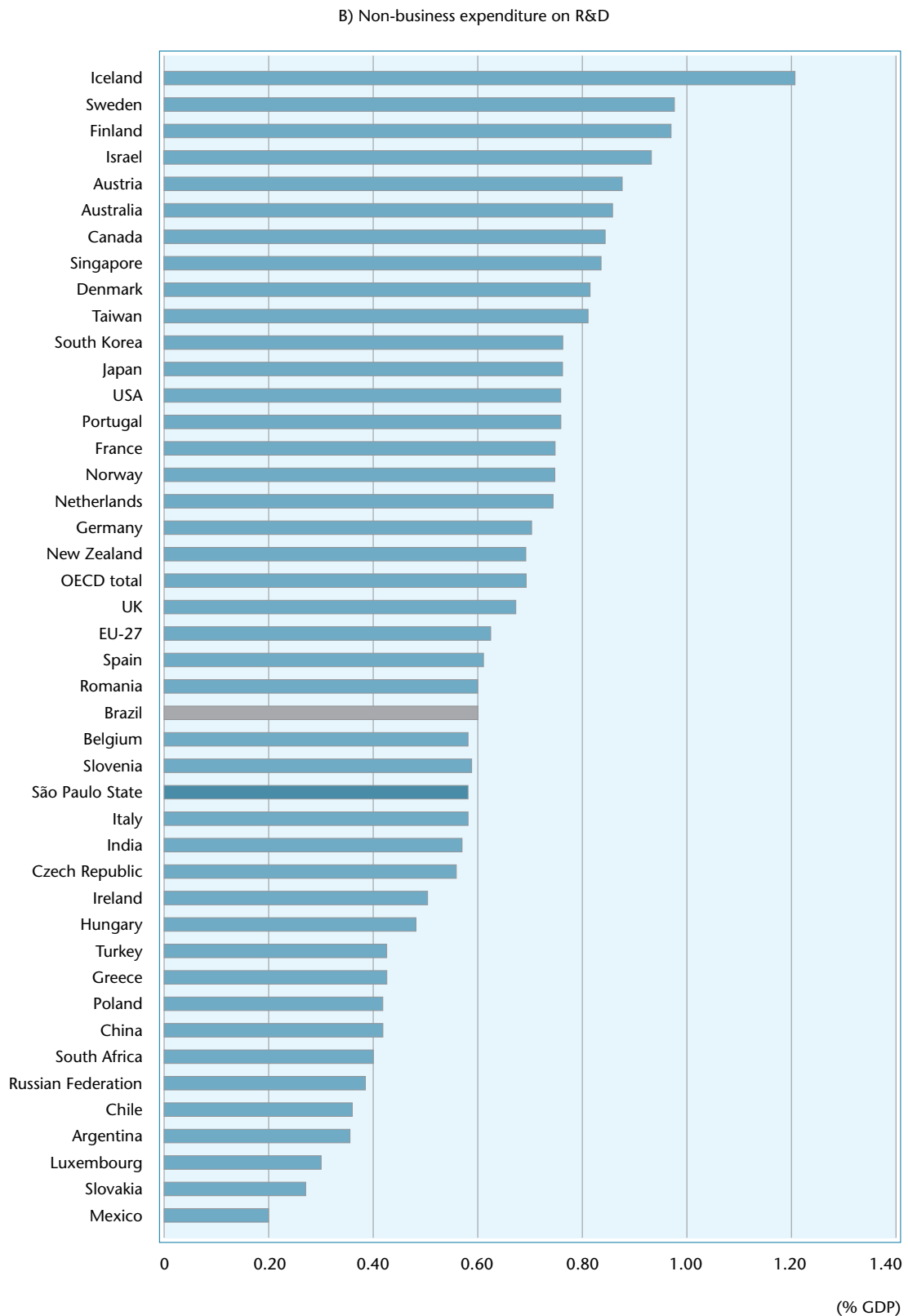
Figure 3.17A (a)
Business expenditure (a) and non-business expenditure (b) on R&D in proportion to respective GDP –
Brazil, São Paulo State & selected countries – 2008 (1)



Source: OECD. *Main Science and Technology Indicators (MSTI) 2009*. v.1. (1) or most recent year with available data.

Notes: 1. São Paulo State as calculated for this chapter.
 2. See Table 3.16A

Figure 3.17A (b)
Business expenditure (a) and non-business expenditure (b) on R&D in proportion to respective GDP –
Brazil, São Paulo State & selected countries – 2008 (1)



Source: OECD. *Main Science and Technology Indicators (MSTI) 2009*. v.1. (1) or most recent year with available data.

Notes: 1. São Paulo State as calculated for this chapter.
 2. See Table 3.16A.

Table 3.40A
Total and per capita R&D expenditure – Brazil, São Paulo State & selected countries – 2008 (1)

Country / region	Total R&D exp. (million US\$ PPP)	Population (million inhab.)	Per capita R&D exp. (US\$ PPP)
USA	398,086	301	1,321
EU-27	263,582	498	530
Japan	147,801	128	1,157
China	102,331	1,339	76
Germany	71,789	82	873
France	42,757	62	690
South Korea	41,742	48	861
UK	41,448	61	680
Brazil	24,086	190	127
Canada	23,962	33	728
Russian Federation	23,408	140	167
Italy	21,859	59	371
Spain	19,547	45	436
Taiwan	18,275	23	795
Australia	15,279	21	725
Sweden	12,901	9.2	1,410
Netherlands	11,018	16	673
São Paulo State	10,905	41	265
Israel	9,921	7.2	1,372
Austria	8,418	8.3	1,012
Belgium	7,197	11	678
Turkey	6,830	71	97
Finland	6,551	5.3	1,239
Singapore	5,814	4.7	1,248
Mexico	5,567	106	53
Denmark	5,444	5.5	998
Norway	4,497	4.7	955
South Africa	4,101	49	84
Poland	4,079	38	107
Czech Republic	3,763	10	364
Portugal	3,719	11	351
Ireland	2,664	4.3	614
Argentina	2,656	41	65
Greece	1,828	11	163
Hungary	1,823	10	181
Romania	1,790	22	81
New Zealand	1,384	4.2	327
Slovenia	936	2.0	466
Luxembourg	660	0.48	1,387
Slovakia	561	5.4	104
Iceland	312	0.31	1,002

Source: OECD. *Main Science and Technology Indicators (MSTI) 2009*. v.1.

(1) or most recent year with available data.

US\$ PPP: purchasing power parity dollars.

Notes: 1. São Paulo State as calculated for this chapter.

2. See Table 3.16A and Detailed Table 3.1A

8. Closing remarks

This chapter discusses the evolution of R&D expenditure in São Paulo State since 1995. The authors believe this is the longest series detailing R&D expenditure ever produced in Brazil.

The methodology was designed to follow the recommendations of the *Frascati Manual*, except in cases where the data had to be estimated in other ways owing to the complete absence of reliable sources and records. Business expenditure R&D (BERD) is the main case in point. A specific methodology was developed for BERD using gross fixed capital formation (GFCF) as a proxy. The analysis demonstrates that this GFCF series is a good proxy, citing 24 other countries for which statistical series exist covering both GFCF and BERD.

The survey of R&D expenditure by public and private HEIs followed the *Frascati Manual's* recommendations very closely, with one alteration compared with the practice of MCT: instead of using the number of academics registered by CAPES to quantify R&D efforts in higher education, the chapter used data supplied by public (state and federal) universities located in São Paulo State (or extracted from INEP's Census of Higher Education) for the total number of academics and the number of academics with PhDs employed full-time. This change assured more accurate estimates and enabled the statistical series to be produced more rapidly and effectively. The case of private HEIs deserves further analysis to obtain more precise data, since full-time employment by private HEIs does not automatically entail involvement in research activities.

In order to permit certain comparisons between the situation in São Paulo State and Brazil, national R&D expenditure in the period 2000-08 was recalculated using the same methodology as for the state. In the case of HEIs, the values changed very little. The use of GFCF to estimate BERD resulted in more significant alterations, tending to increase values for national expenditure compared with those estimated by MCT.⁵⁴

In the case of public research institutions, it is extremely difficult to obtain data on R&D expenditure from public accounting records. For this reason a request for the budget execution series since 1995 was submitted to each of the institutions located in São Paulo (with a few exceptions, where data were obtained in other ways, e.g. from existing publications).

It is desirable that progress should be made in public finance, from budget preparation to account-

ing and management, so that R&D expenditure can be properly measured. Meanwhile, measuring R&D expenditure and calculating the respective indicators remains a highly complex task and the results remain full of gaps. It is undeniable that surveys of expenditure suffer from limitations in sources of information and databases. The specific case of measuring R&D expenditure, moreover, is still a relatively recent effort, undertaken and analyzed by few in Brazil. The systematization of increasingly up-to-date and detailed information, and above all a constructive critique of the indicators, will contribute to steady gains in quality.

The results obtained can be summarized as follows:

- a) R&D expenditure in São Paulo reached R\$ 15.5 billion in 2008, for an intensity equivalent to 1.52% of the state's GDP. Calculated using the same methodology, national R&D expenditure reached R\$ 34.2 billion in 2008, for an intensity of 1.14%. Both expanded in the last two years of the period. Despite this growth, it appears unlikely that national R&D expenditure will reach the target of 1.5% of GDP in 2010 (modest in comparison with OECD countries, which already spend 2.26% of GDP) set by MCT in the "Science Action Plan for 2007-2010;"
- b) In São Paulo, private R&D expenditure (BERD plus private HEIs) accounted for 63% of total R&D expenditure in 2008. In Brazil, it accounted for 49%;
- c) In São Paulo, public R&D expenditure accounted for 37% of the total in 2008 (0.57% of the state's GDP), with a federal share of 13% and a state share of 24%. In Brazil, public R&D expenditure accounted for 51% of the total (0.58% of GDP), with a federal share of 36% and a state share of 15%;
- d) For São Paulo, the decade that began in 2011 consisted of two quite distinct phases: the intensity of R&D expenditure was 1.37% in 2001, fell until 2003, reaching 1.23%, and then rose again, reaching 1.42% in 2007. For Brazil the trend was similar but weaker: after peaking at 1.03% in 2001, intensity rose again only in 2007, when it reached 1.09%;
- e) Recent growth of R&D expenditure in both São Paulo and Brazil appears to be associated with the sustained resumption of economic growth, which was interrupted in late 2008. This means total R&D expenditure, and especially BERD, may well have fallen in 2009.

54. The method used by MCT, at least until Feb. 22, 2010, to estimate BERD based on a geometric mean for growth in the period 2000-05 is considered open to criticism because values in current *reais* were used to calculate the geometric mean, so that the variations caused by inflation certainly distorted the results obtained.

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