

**Production and diffusion of regional ST&I indicators:
the State of São Paulo (Brazil) experience and leadership***

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Through the analysis of a large set of data, the series “Science, Technology & Innovation Indicators in the State of São Paulo/Brazil”, published by The State of São Paulo Research Foundation (FAPESP), comprises a comprehensive portrait of the evolution of scientific and technological production in São Paulo and their contribution to national efforts in the broader context of international dynamics in the sector. These indicators are produced from a wide range of data sources. The publication also provides an in depth analysis and disseminates the major findings of new innovation surveys carried out in Brazil since 2000. The results of the last edition (2005) reports important new trends in different areas, which are not indeed associated with real ruptures, returning instead to old challenges that over recent decades have constantly hindered the development of innovation activities in Brazil. In addition to considering the central conditioning factors reinforcing this scene, this paper stresses the persistence of acute regional and local imbalances in S&T capabilities and productivity across the country. Many figures illustrate that São Paulo occupies a privileged position regionally and, in almost every dimension, accounts for the most significant portion of the S&T installed base in the country, considering the criterion of expenditure or of technical and human resources available, or the results that this infrastructure has managed to generate. Recent government measures aiming to diminishing this concentration includes an actual progress in the whole national S&T statistics system, especially concerning improvements in state level data production.

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1. INTRODUCTION

In 2005, The State of São Paulo Research Foundation (FAPESP) published the third edition of the triennial series *Science, Technology & Innovation Indicators in the State of São Paulo/Brazil*.¹ Focusing on an analysis of the recent evolution of S&T in São Paulo and their contribution to Brazilian efforts, the publication provides a comprehensive portrait of the status of scientific and technological production in the state during the period 1998-2003, in the broader context of national and international dynamics in the sector on the threshold of the 21st century. Since the first edition was published, in 1998, followed in 2001 by the second covering the period 1994-1998, the series has steadily evolved by adding more and more quantitative data, together with broader analysis and deeper interpretations of the key trends observed in the period. Furthermore, with each edition an effort is made to bring into the team new experts so as to increase the number of outside associates and mobilize a growing number of researchers, thereby gradually creating a broad and multidisciplinary collaborative network.

An important goal of the *ST&I Indicators in São Paulo* series is to provide input for public policymaking and appraisal of activities in the sector and of effectiveness of the regional research and innovation system. In this sense, it is modeled on the main international publications in this field, especially the reports issued by bodies such as OECD, UNESCO, National Science Foundation (U.S.), Observatoire des Sciences et des Techniques (FR), the Iberoamerican Network on Science & Technology Indicators (RICYT). Thus, through analytical essays and a great number of illustrations, the thematic chapters deal with different aspects and dimensions of input and output S&T indicators. For each selected theme, the data for São Paulo, which have been collected from a wide range of national and international sources, are always accompanied by comparative data for other Brazilian states, for Brazil as a whole, and wherever possible for other countries in the region and other parts of the world.

This publication is designed to be preeminently technical, for use by policymakers, as well as specialists and researchers in the sector. It gathers an ensemble of diagnostics and up-to-date information, formatted as a reference work for regular consultation. Detailed information is also provided on the statistical series from which the indicators were constructed and the methodological procedures used to collect and treat the data. This includes commenting on key limitations and gaps in the indicators presented, with recommendations ensuring correct interpretation.

Based on the results published in the last edition of FAPESP's indicators (FAPESP, 2005), the main aim of this paper is to briefly present and comment this experience carried out in São Paulo, in the broader context of the Brazilian government's new agenda concerning improvements in this sector. It provides a synthesis of the main aspects which characterized S&T production in São Paulo State and in Brazil as a whole, from the end of the 1990s to the beginning of the decade of 2000, trying to highlight the features that may be considered most decisive in the prevailing technological innovation pattern in the country. This panorama is examined under a dual perspective: first, the analysis centers on inputs available for S&T, in São Paulo and in Brazil (section 2); next, in the products which these inputs were able to produce, in the same period under examination (section 3).

The paper includes, in section 4, a brief synthesis of the main aspects as well as distinguishing features of the two major innovation surveys currently carried out in the country, at both national

¹ Available at: <<http://www.fapesp.br/english/indicators>>.

and state levels: (1) the *Industrial Survey of Technological Innovation (PINTEC)*², elaborated since 2000 by the Brazilian Institute of Geography & Statistics (IBGE), publisher of the first national indicators of the innovation activities developed in the Brazilian industrial firms; (2) the *Survey of Economic Activity in São Paulo State (PAEP)*³, produced by the State Data Analysis System Foundation (SEADE), which covers a larger spectrum of firms located in São Paulo, including the service sector. The construction of such indicators, based on international methodological standards, contributes to a better understanding of the process of technological innovation in the Brazilian industry, ensuring its comparability with data from other countries.

Finally, with the aim of stimulating debate and drawing attention to the countless difficulties that remain to be overcome for the periodic elaboration of diagnostics of this kind, in section 5 a brief critical appreciation is undertaken with respect to the weakness and limits of existing sources of S&T information available for this purpose. Special emphasis is put on the formalization, in 2004, by the Ministry of Science and Technology, of an implementing plan of an integrated “national system of S&T indicators”, involving, among other coordination measures, technical and financial support for decentralization or “regionalization” of S&T data production. By promoting the adoption of a common conceptual and methodological framework, such a system would facilitate a deeper understanding and monitoring of the ST&I performance in the 26 Brazilian states.

2. CONTRASTS AND REGIONAL IMBALANCES IN BRAZIL’S SCIENTIFIC AND TECHNOLOGICAL INSTALLED BASE

The Brazilian Public System of Science and Technology, such as it is currently structured, is relatively young when compared to that of other significant intermediary economies. However, it was gradually constructed over the course of some decades, out of research institutions already in existence but dispersed - a few even emerged in the nineteenth century - and others which were being created with specific objectives and geared to the development of areas considered to be of priority.

A good part of the research institutes, higher education institutions and funding agencies in existence in Brazil today emerged from the 1950s onwards. But it is only in the mid-1980s that there began to take shape and consolidate a complex and multi-institutional structure embracing the functions of coordination, implementation and promotion of governmental actions on S&T. The Ministry of Science & Technology (MCT), which went on to become the central organ of the then created National System of Scientific and Technological Development (SNDCT), began to operate only in 1985.

The logic of this new institutionalization process was centered, nevertheless, almost exclusively on the federal unit. The federal government took upon itself this responsibility for articulation and created structures capable of supporting a national project of scientific and technological development, incorporating the needs and specificities of the socio-economic reality of the different regions of the country. In this sense, the initiative to set up the so-called “State Systems of S&T”, in the 1980s, appeared and lasted throughout the decade more as an initiative of the federal government, than as a necessity of the states of the Federation themselves (SICSÚ & LIMA, 2001). The regional treatment had a centralized planning, without the desirable participation of the local institutions and without taking into account the specificities of the

² The survey’s description, methodology and detailed results are available at: < <http://www.pintec.ibge.gov.br/>>.

³ Available at: < <http://www.seade.gov.br/produtos/paep/index.php>>.

regions. Furthermore, there not having occurred an effective restructuring of the entire existing institutional framework nor a real articulation between the different coordinating and funding agencies for this national project, the policy of S&T, right from the moment of its birth, emerged isolated from the rest of public policies (BARROS, 1999).

With the Federal Constitution of 1988, encouraging the decentralization and spatial diffusion, the strategies of regional development take on a new and greater impulse. This permits the states to link budgetary resources directly to the funding of research and development activities, by means of the definition of a fixed percentage to be effected annually by the state governments. Thus, specific mechanisms stimulated the creation of state funding agencies known as Research Support Foundations (FAPs). This evolution generated a strong mobilization of researchers and local governors in almost all the Brazilian states, which managed to link in their Constitutions – as in the example of the system already in operation in São Paulo State – a portion of specific resources destined to the S&T sector (see Chart 1, attached).

During the decade of the 1990s the states then continued structuring their FAPs which, gradually, came to legitimize themselves as enabling mechanisms for specific vocations, through the implementation of programs and actions which take into account the existing heterogeneity, the different agents and scenarios in regional development (MELLO, 1992; DIAS *et al.*, 2000).

At the core of this movement, State Secretariats for Science & Technology were also created in different states, with the role of formulating policy and managing the sector. This institutional evolution led to the creation of representative forums, such as the National Council of State Secretaries for ST&I Affairs (CONSECTI) and the National Council of State Research Funding Agencies (CONFAP). To a large extent, these initiatives may be taken as a way of overcoming the historic lack of tradition of the state governments in Brazil in the promotion and support of scientific and technological development.

In short, despite significant deficiencies and discontinuities, Brazil managed to construct in its trajectory a robust and diversified system of S&T, which today places it in an outstanding position in Latin America. In this context, the state of São Paulo occupies a leading position regionally and, in almost every dimension, accounts for the most significant portion of the S&T base installed in the country, either by the criterion of expenditure and the infrastructure of human and technical resources available, or by the results that this infrastructure has managed to generate (see Chart 2, attached). In this sense, the São Paulo system plays an important role in the improvement of S&T infrastructure of other Brazilian states, as is well illustrated by the indicators relating to the post-graduate enrollments and awardees in São Paulo's universities, which embrace quite a large quota of students coming from other regions.

The São Paulo public system of S&T, just like that of the other units of the Federation, embraces teaching and research institutions, funding bodies and regulatory units, from both spheres, federal and state. However, São Paulo is the only Brazilian state where the local system of S&T – either in terms of size, in the number of institutions, in financial resources allocated or in human resources and laboratories available – outstrips the federal one in the state of São Paulo.

Besides having three out of the ten major Brazilian universities, São Paulo also possesses the largest network of research institutes in the country, geared fundamentally to applied research and technological development, and with a sectoral vocation. The current 18 research institutes in the state, which were created over the course of many decades, involve different state secretariats, the areas of agriculture and health being the most prominent. In addition, São Paulo is headquarter to seven federal institutions, linked to four different ministries. The majority of these federal institutes are associated with strategic areas, most notably the aerospace defense sector -

such is the case of the National Institute for Space Research (INPE) and the Aerospace Technical Center (CTA). It should be noted that these seven institutes occupy an outstanding place in the São Paulo scenario and account for 49% of total federal R&D expenditure applied in the state.

The two central organs of the state of São Paulo S&T system are the Secretariat for Science, Technology and Economic Development (SCTDE), with the role of formulating the state policy on S&T and the management of the system as a whole, and the State of São Paulo Research Foundation (FAPESP), dedicated to the promotion of research and training of human resources qualified for S&T activities. FAPESP was created in 1962, establishing a mold for those that were being created throughout the national territory. Since its creation it has continued to enjoy a rather privileged situation when compared to the other state funding agencies, both in terms of volume of available financial resources (see Chart 1, attached) and in terms of institutional and functional stability from which it has always benefited. By way of illustration, in the year 2005, its total receipts reached the lofty figure of R\$592 million (or US\$240 million)⁴, R\$416 million of which derived from transfers from the state's Treasury, distributed among its three principal lines of action: *Regular Line* (scholarships and financial awards for research, in all areas of knowledge); *Special Programs* (such as media science) and *Technological Innovation Programs* (innovation at SMEs, industry-university partnership for innovation, among others).

The high regional concentration of S&T infrastructure installed in Brazil, with the respective concentration of resources and opportunities in the Southeast region of the country, has been the object of many reflections and debates between different actors. Various studies point to the existence of a clear association between the flow of financial resources allocated in the states and the S&T installed base (ALBUQUERQUE *et al.*, 1996; BARROS, 1999; ROCHA, 2005; FAGUNDES *et al.*, 2005). This association suggests a cumulative process in which the interstate inequalities in S&T in the country would seem to obey a self-reinforcing mechanism: the conditions of infrastructure available influence the allocation of resources deriving from the government agencies; these resources are incorporated into the very existing infrastructure, leading to an incitement of the differentials of competitiveness among the states as regards the capacity to secure public resources.

In sum, in a context predominantly marked by financing S&T activities based on public tenders, the distribution of the resources in a given period is directly related to the available S&T infrastructure in the immediately prior period.

This would thus appear to constitute a vicious circle, which ultimately perpetuates a situation of imbalance among the regions: the states that are more developed states and possess a larger and more diversified S&T installed capacity are the ones that attract the greater part of government investments; at the same time, they are the ones that have the best conditions for making investments with their own budgetary resources.

Concentration of financial resources allocated to R&D activities

According to data published by FAPESP (2005), total expenditure on R&D activities in the state of São Paulo reached, in 2000, around R\$4 billion (US\$2.2 billion dollars at today's rate), representing more than 36% of national disbursement in the sector.⁵ As previously stated, the wide variation in the regional distribution of expenditure on S&T prevalent in Brazil can be

⁴ Conversion at the average annual exchange rate.

⁵ This percentage is scarcely a little higher than that of the participation of the state of São Paulo in the Brazilian GDP (33.7%, in 2000).

explained, in large part, by the historic and high concentration of S&T infrastructure available in the country, especially in the states in the Southeast region.

When analyzed as a share of GDP, R&D spending showed real growth compared to previous years: it was 1.07% of São Paulo's GDP, in 2000 and 0.98% in the period 1994-1998 (FAPESP, 2002). The R&D effort in São Paulo was proportionally greater than in Brazil as a whole, where expenditure in the sector did not exceed 1.00% of GDP in 2000. These findings put São Paulo in a position of leadership, comparable to advanced industrialized countries such as Italy and ahead of countries such as Spain and Portugal, although in absolute terms the diagnostics remained much less favorable.

Taking into account merely the public expenditure on R&D in the state, it was found that, between 1998 and 2002, it always exceeded R\$2.3 billion annually. In addition to involving significantly higher amounts, the pattern of public spending which prevails in São Paulo is the inverse of that in all the other Brazilian states, that's to say, the greater proportion of public expenditure on R&D comes from the state and not from the federal government (around 60% against 40%, respectively). This prevalence of the state sphere in relation to the federal sphere is the first and most striking distinctive element of the state of São Paulo S&T system when compared to that of the remaining units of the Federation.

As regards funding agencies for R&D, the state agency FAPESP again took the lead by spending more than any other in every year of the period examined and consistently accounting for over 56% of the total (R\$508 million per year on average). For the sake of illustration, the three biggest federal agencies – CAPES, CNPq and FINEP⁶ – together invested in São Paulo not more than R\$387 million per year, on average, in the same period.

The estimates of expenditure on post-graduate R&D in the state of São Paulo totaled, on average in the period 1998-2002, R\$863 million per year, of which 84% effected by the three large state universities (USP, UNICAMP and UNESP)⁷ alone. It is to be noted here that this situation is also the inverse of that which prevails in all the other Brazilian states, where the most important universities belong to the federal network. In this sense, the second main distinctive feature of the São Paulo S&T system in relation to the other states is the fact that the public university sector is dominated by state rather than federal universities.

In relation to expenditure on R&D undertaken by the business sector, the picture of high concentration in the state of São Paulo is even more flagrant when compared to the other Brazilian states: in 2002, the São Paulo business sector already accounted for 56.7% of total R&D expenditure undertaken by the country's entire business enterprises, a percentage similar to that of the number of businesses located in the state, out of all those that undertook internal R&D activities in the same period.⁸

These indicators highlight a third distinctive feature of the state of São Paulo system compared to the other states, namely, that business expenditure on R&D exceeds governmental expenditure. In 2000, they accounted for around 54% of the São Paulo effort (R\$2.2 billion), as opposed to 46%

⁶ Coordination for the Improvement of Higher Education Personnel (CAPES), of the Ministry of Education; National Council for Scientific and Technological Development (CNPq) and the National Technology and Innovation Investment Agency (FINEP), of the Ministry of Science & Technology.

⁷ The University of São Paulo (USP), the State University of Campinas (UNICAMP) and the State University of São Paulo (UNESP).

⁸ These aggregated indicators were elaborated only for the year 2000, when for the first time robust and reliable data was made available on R&D expenditure undertaken by the business sector. These data were provided by the first *Industrial Survey of Technological Innovation (PINTEC 2000)*, carried out by the Brazilian Institute of Geography and Statistics (IBGE, 2002). The section 4 discusses this experience and comments its main results.

from the public sector. In an inverse situation, for Brazil as a whole, public expenditure accounted for, in the same year, 58% of total expenditure, compared to not more than 42% from the business sector. These profiles of sectoral distribution reveal that business participation in the aggregated R&D expenditure for São Paulo, while still fairly limited in contrast to a large number of countries, draws closer to the pattern observed in the most dynamic industrial economies, in which the participation of businesses rises, on average, to around 70% of total expenditure.

To conclude, despite the increase in expenditure in recent years, the goal of narrowing the still considerable gap between Brazil's R&D efforts and those of the most advanced economies, in terms not only of the amount invested but, above all, of the structure of spending by sector, is a longstanding challenge that will have to be surmounted if the nation is to enhance the competitiveness of its industry. Aiming to bridging this gap, the formalization of a *National Industrial, Technological & Foreign Trade Policy (PITCE)*⁹ that concurrently fosters productive efficiency, foreign trade, innovation and technological development as dynamic vectors of industrial activity should have highly positive effects in the medium to long term (BRAZIL, 2003).

In the short run the new *Innovation Act* signed by the President of Brazil on December 2, 2004 should also play a central role in efforts to reverse this trend, since it is designed to facilitate and foster cooperation between the academic and business sectors. Organized around three axes – “creating an environment favorable to strategic partnerships between the academic community and private enterprise”, “stimulating participation by S&T institutions in the innovation process” and “encouraging business organizations to innovate” – the new legislation should boost investment in R&D by both the public and private sectors. As such, it serves as a legal foundation for implementation of the new industrial and trade policy above-mentioned (PITCE), having as one of its central guidelines “promoting institutional and entrepreneurial interactions and close articulation with educational systems and research centers with the aim of cultivating a new industrial climate of cooperation” (BRASIL, 2003).

Profile of higher education (undergraduate and post-graduate)

Data from the National Institute for Educational Studies and Research (INEP) for the period 1998-2002 show a clear acceleration in the growth of enrolments at high education institutions (HEIs) throughout Brazil, compared to the period 1995-98, adding over 1.3 million students to the system. This acceleration was largely driven by a sharp increase in the number of secondary school graduates, but also reflected steady expansion of the system into the interior of Brazil, associated with institutional diversification and greater flexibility in the provision of courses by existing HEIs.

Generally speaking, the higher education system seems to have continued evolving in recent years along the same lines as in the previous period (FAPESP, 2002). Enrolments, courses and HEIs in the state of São Paulo expanded 46%, 89% and 40% respectively between 1998-2002. But growth was even more pronounced in Brazil overall, where the same categories expanded 64%, 107% and 68% respectively.

Within the context of the new governmental measures concerning deconcentration of the S&T installed base in the country, the most recent figures also show a clear dislocation of the undergraduate system outside of capitals and outside of the Southeast and South regions, which is called by some specialists a “threefold movement of spatial diffusion” (FAPESP, 2005). More

⁹ See BRAZIL (2003).

specifically, these trends consist of: (a) deconcentration of enrolments in São Paulo and growth in other states of the Southeast region, alongside expansion into the interior; (b) deconcentration of enrolments in the Southeast and growth in less developed Brazilian regions; and (c) “interiorization” of enrolments, courses and institutions, as cities other than state capitals increase their share of supply by both public and private HEIs.

First, intraregional and interregional deconcentration were evidenced by differences in the pace of growth in enrolments, which rose 46% in São Paulo State and 61% in the Southeast excluding São Paulo, in the period 1998-2002. At the same time, these rates rose much less in the Southeast and South than in all other Brazilian regions. In the North and Centre-West, which have fewer HEIs than the rest of Brazil, enrolments rose 123% and 98%, respectively.

Conversely, the data shows that post-graduate studies remain highly concentrated in the state of São Paulo, with only some variations: in numbers of entrants São Paulo’s share was 33% of Brazilian master’s students and 51% of doctoral students in 2002; in degrees awarded they were 36% and 59%, respectively.

Taking the Southeast region as a whole, in 2002, it was responsible for 60% of all masters degrees and for 81% of doctoral degrees awarded in the country.¹⁰ In other words, three out of four Brazilian PhDs concluded their doctoral studies in universities located in the states of São Paulo, Rio de Janeiro or Minas Gerais. It is important to remember, nevertheless, that a good proportion of these degree-holders come from other regions of the country, who see themselves obliged to seek a more select qualification in the Southeast.

Finally, although still very heavily concentrated in São Paulo, some figures show that the take-up of post-graduate studies is greatly expanding throughout Brazil, as are undergraduate studies, albeit at a slower pace. The positive expansion verified between 1998 and 2002, but accentuated at doctorate level, is doubly confirmed: (1) in student registrations, an increase of 62% for the other Brazilian states, compared to 26% for São Paulo; (2) in the number of degrees awarded, 113% compared to 55%, respectively.

Stock of human resources available for S&T

In 2001, the human resources available in the S&T sector (HRST), measured in accordance with the guidelines laid down in the *Canberra Manual* (OECD) and from the standpoint of education and occupation, totaled 11.2 million in Brazil, with the state of São Paulo accounting for 3.6 million. According to the OECD’s statistics Brazil’s HRST are comparable in absolute terms to those of such important European economies as France or the United Kingdom, while São Paulo is comparable on this criterion with the Netherlands and well ahead of countries such as Belgium or Switzerland (OECD, 2003).

As a proportion of the workforce, however, the HRST situation in Brazil and São Paulo is entirely different and unfavorable in both cases. In 1999, for example, Brazil’s HRST accounted for only 12% of the economically active population (EAP), lagging far behind European countries. The proportion for São Paulo was 17% in the same year.

These findings underscore the very low weight of more qualified occupations in the occupational structure of Brazil and São Paulo. Thus, over and above encouraging the education and training of qualified human resources, which has been done with relative success in recent years, the

¹⁰ When these findings are added to the data obtained from the South region, the percentages rise to 79% and 89%, respectively.

creation of more qualified jobs is an essential component of any serious endeavor to increase the stock of HRST in the country. For the sake of illustration, it is worth stressing that although the stock of HRST grew 12% in Brazil as a whole and 18% in São Paulo State between 1999 and 2001, levels of educational attainment and numbers of university degrees awarded grew significantly faster. Thus, the positive results of the efforts made to expand the educational system are not yet reflected in the same proportions by growth in the stock of available HRST. This is one of the many challenges that will have to be faced by the new *National Industrial, Technological & Foreign Trade Policy (PITCE)*, mentioned in the introduction, if it is to achieve its goal of fostering the acquisition of capabilities that enable firms to become more innovative.

With regard to R&D personnel in the industrial sector, according to the data from the *Industrial Survey of Technological Innovation (PINTEC 2000)*¹¹, the more than 8,600 industrial firms that introduced innovations in São Paulo State in 2000 employed only 22,300 people in R&D activities: 11,600 of these employees were university graduates, 7,300 were secondary school graduates, and 3,400 had other levels of education. These estimates place São Paulo clearly in the lead compared to all other Brazilian states, albeit well behind the levels observed for the most industrialized countries.

3. REGIONAL CONCENTRATION OF NATIONAL SCIENTIFIC AND TECHNOLOGICAL PRODUCTION

Based on indicators constructed on the basis of scientific papers by residents in the country published in indexed periodicals in the main international bibliographical databases, it is possible to affirm that scientific production in Brazil, such as that of the state of São Paulo has continued to maintain continuous growth over time, at a pace that far exceeds that of world production as a whole.

According to the Science Citation Index Expanded (SCIE) database, published by the Institute for Scientific Information (ISI), Brazil's output grew 54% from 10,279 indexed articles, in 1998, to 15,846, in 2002. World scientific output measured by the same criterion expanded less than 9% in the same period. Brazil's share of the world total therefore rose from 1.1%, in 1998, to 1.5%, in 2002, and Brazil remained ahead of the rest of Latin America in this regard. Several other countries in the region, such as Argentina, Chile and Mexico, also achieved significant growth in the period, but even so their scientific output expanded less than Brazil's in every case.

Maintaining the historical pattern of concentration confirmed by various different studies (FAPESP, 2002; Viotti & Macedo, 2003), São Paulo accounted on average for 52% of the national effort in the period observed, but its scientific output expanded more than Brazil's at 63%. In 2002, São Paulo's scientific output (8,538 articles) corresponded to 0.8% of the world total indexed by SCIE.

Confirming that Brazil's scientific output is almost entirely of academic origin, the figures show that 17 of the top 20 institutions in publications indexed by SCIE for the period 1998-2002 were federal and state HEIs. Five of the top eight were located in São Paulo State. The University of São Paulo (USP) alone accounted for 26% of Brazilian scientific output in the period, UNICAMP for 11%, and the Federal University of Rio de Janeiro (UFRJ) for 9%, the latter two consistently ranking either second or third.

Other states apart from São Paulo increased their shares of Brazilian scientific output, however, reinforcing the already mentioned observation regarding deconcentration of S&T efforts

¹¹ See footnote 2.

evidenced by different families of indicators. Despite the clear dominance of the Southeast region, which accounted for 77% of total output in the period, other regions such as the South and Northeast increased their output with even higher growth rates. This trend was certainly associated to a significant extent with expansion of post-graduate studies in the less developed states, especially the numbers of degrees awarded, as previously illustrated.

Nevertheless, as abundantly discussed in the reference literature, this strong growth in Brazil's and São Paulo's scientific output in the last 15 years does not yet seem to have had a real impact on technological production or innovation by private enterprises. The last edition of *Science, Technology & Innovation Indicators in the State of São Paulo/Brazil*, whose main findings are commented in this paper, is set out to develop a more detailed picture of this situation and in particular to identify the limits of the weak articulation between scientific development and technological innovation in Brazil.¹²

The United States Patents & Trademark Office (USPTO) patent granted statistics for the period 1999-2001 show Brazil's share rising moderately but steadily to 0.07% of the world total in 2001. São Paulo accounted for about 50% of the Brazilian total on average in the period. This percentage was similar to the state's share of patent applications filed with the National Industrial Property Institute (INPI) between 1990 and 2001. Different sets of FAPESP's indicators highlight São Paulo's solid lead over the rest of Brazil, and consequently, its key role in determining the nation's technological profile. The indicators constructed on the basis of USPTO statistics show particularly clearly that São Paulo is largely responsible for Brazil's specialization in the international context.

A salient feature revealed by the data is the very significant share of patent applications filed with INPI by individuals (over 70%) as opposed to firms, both for Brazil and for São Paulo. As is well-known, a prevalence of individual patents is associated with backwardness and underdevelopment. However, in the case of Brazil and São Paulo, there is an evident need to verify the true nature and origin of patent applications and those responsible for filing them in order to delimit the contours of the two categories more accurately. More in-depth research may show that applicants for patents, in those cases, are often on the borderline between corporate executives and entrepreneurs or small business proprietors and between the public and private sectors.

Despite the similarity of these proportions for Brazil and São Paulo, it is important to note that the share of corporate patents was slightly larger in the latter case for the entire period in question. Corporate patents accounted for 26% in the state and 23% in Brazil, suggesting a more favorable or less technologically backward position for São Paulo than for Brazil as a whole.

The situation evidenced by INPI statistics was reversed internationally, with USPTO statistics showing that individual patents accounted for only 26% of the total for São Paulo in the period 1981-2002. A significant proportion of the corporate patents granted by USPTO (74%) went to multinationals: taking residents and non-residents together, these accounted for 55% of the total, whereas for Brazil the proportion of multinational patentees was only 41%. These findings show that technological activities by multinationals located in São Paulo State generated more USPTO patents than those of Brazilian-owned firms.

With reference to leading firms in patenting activities in Brazil and in São Paulo, significant differences were noted when comparing INPI and USPTO statistics. With regard to INPI, seven

¹² The main sources of data used for this purpose were patent applications filed with the National Industrial Property Institute (INPI) by Brazilian residents between 1990 and 2001, and patents granted by the United States Patents & Trademark Office (USPTO) between 1981 and 2002 (see FAPESP, 2005).

of the top 20 corporate patentees in the period 1990-2001 were located in the state of São Paulo. The weight of HEIs and research institutions was found to be substantial: two of the seven were universities and three were research institutions. It is important to note, however, that these five institutions, which ranked among the top 20 INPI patentees, were not among the leading USPTO patentees, suggesting that patenting activities by these research and higher education institutions were limited basically to Brazil. More research needs to be done to verify the real extent and significance of this trend.

Lastly, in FAPESP's indicators report, the analysis of the diversification of innovative activities in São Paulo State, in terms of technological domains and sub-domains, is based on different systems for classifying patents and economic activities. In every case, the top four sub-domains in INPI patents for both São Paulo and Brazil all corresponded to relatively traditional, medium-technology or low-technology economic activities. In contrast, the bottom six sub-domains were relatively advanced or high-tech, including biotechnology, macromolecular chemistry and semiconductors, among others. It is also important to note signs of technological stagnation in the absence of significant change in the front-ranking domains for INPI patent filings between 1990 and 2001, as reflected in São Paulo's and indeed Brazil's unfavorable international position on this criterion.

Regarding data on international trade in products with technological content, both Brazil and São Paulo State ranked alongside a group of countries (Mexico, Canada, China, Spain, Italy and Poland) with the following characteristics: (1) high-tech goods accounting for between 20% and 30% of exports and 25-45% of imports; (2) medium-tech goods accounting for about 70% of exports and 50-60% of imports. Thus, the technological balance of payments for all these countries is fundamentally defined by a deficit in high-tech goods.

The state of São Paulo leadership in Brazilian overall innovation performance is corroborated by its equally large contribution to Brazilian trade: the state accounted for 33% of exports and 42% of imports in 2002. Moreover, high-tech goods accounted for 25-30% of São Paulo's exports in the period 1998-2002, compared to 15-20% for total exports by Brazil.¹³

One of the most important trends revealed by the FAPESP's indicators report, however, relates to recent changes in the pattern of trade by product category. More specifically, the relative positions of São Paulo and Brazil with regard to high-tech goods changed considerably in the period covered by the study. While São Paulo's exports of high-tech goods remained practically unchanged overall at around US\$4.8 billion, exports of high-tech goods by other Brazilian states almost doubled, reaching some US\$6 billion in 2002. Low-tech goods also increased their share, leading to a decrease in the overall level of technological content of São Paulo's total exports.

Thus, the specialization profile of São Paulo's exports, characterized throughout the 1990s by a growing proportion of high-tech goods, shifted in the next period towards low-tech and medium-tech goods. As a result of this change, the state's share of Brazilian high-tech exports fell from 62% to 32% between 1998 and 2002. This may point to a significant improvement from the technological standpoint for the nation as a whole (FAPESP, 2005).

On the other hand, the state's imports contracted overall, with high-tech goods falling more than any other category (20%). Imports of high-tech goods totaled US\$10.2 billion in 2002,

¹³ In 1998 Brazilian exports remained strongly concentrated in medium-tech goods, especially those produced by scale-intensive industries, primary agricultural goods and agro-industrial goods, accounting for approximately 50% of total exports. The figures for São Paulo, in contrast, show high-tech goods accounting for 27% of its exports, compared to 15% for Brazil.

accounting for 50% of the total. Brazilian imports also fell during the period, albeit less intensely than São Paulo's.

In sum, the declining deficit in high-tech goods and growing surplus in medium-tech goods in the period 1998-2002, both due to falling imports and rising exports, progressively shifted Brazil's trade balance towards the US\$20 billion surplus produced in 2003. Thus the figures suggest that Brazil's and São Paulo's technological capabilities, classified at an intermediate level among the countries analyzed when measured in terms of trade, are currently less weak than they were at the end of the 1990s. However, both nationally and for São Paulo alone international trade is strongly asymmetrical from the standpoint of technology, considering the origins and destinations of trade flows, and industry remains highly dependent on technology produced abroad.

4. NOTES ON INNOVATION SURVEYS EXPERIENCES AND RESULTS IN BRAZIL

In Latin America, particularly in Brazil, the elaboration of methodologies and the construction of historical series of S&T indicators based on the application of innovation surveys were rarely explored in statistical research activities until the decade of the 1990s. Sectoral case studies available up to this time, although decisive in highlighting the incremental nature of the technological capability of national companies, broached a limited number of sectors and did not allow for generalizations or comparisons.

From the second half of the decade of the 1990s onwards, some significant initiatives regarding innovation surveys in the industrial sector were implemented. This section offers a brief synthesis on the main aspects as well as distinguishing features of the two major innovation surveys currently produced in the country, at both national and state levels: (1) the *Survey of Economic Activity in the State of São Paulo (PAEP)*, produced by the State Data Analysis System Foundation (SEADE), which covers a larger spectrum of firms, including the service sector; and (2) the *Industrial Survey of Technological Innovation (PINTEC)*, elaborated since 2000 by the Brazilian Institute of Geography & Statistics (IBGE), which represents a pioneer experience in producing technological innovation indicators for the Brazilian industrial firms as a whole. This survey is statistically representative for the main geographic regions of Brazil and for São Paulo State.

The construction of such indicators, based on international methodological standards, contributes to a better understanding of the innovation efforts and activities in the Brazilian industry, ensuring its comparability with data from other countries. Nevertheless, as emphasized below, significant methodological and conceptual differences between PINTEC and PAEP surveys make the innovation indicators for São Paulo not directly comparable, despite the efforts made by the agencies to overcome these differences.

Survey of Economic Activity in São Paulo State (PAEP)

In Brazil, the measurement of the innovative process in industrial firms began in the state of São Paulo with the design of PAEP, in the middle of 1990s. At the time, the SEADE Foundation, responsible for the accomplishment of this survey, aimed to create a new methodology capable of capturing transformations occurring in the economic and innovative processes, and their impact on São Paulo State's productive structure in particular, which until then was little known due to the absence of specific information and quantitative data.

The first PAEP (base-year 1996) represented, then, the first innovation survey in the state ambit carried out in Brazil, adopting the conceptual and methodological frame recommended by the Oslo Manual¹⁴ and by the Community Innovation Survey (CIS1), as well as other thematic surveys conducted by the OECD and by Canada.

This first edition of PAEP focused on the industrial firms located in the state of São Paulo and combined consolidated economic variables from structural surveys with quantitative and qualitative variables related to technology diffusion. Complementing the investigation of these variables, the survey also focused on styles of production management, industrial automation and the diffusion of new information and communication technologies, enabling the assessment of the size and the extent of the technological and informational base of the surveyed enterprises.

The PAEP second edition (2001), whose period of reference was 1999-2001, had a significantly broader scope with the aggregation of the service sector. This contribution proved to be an additional methodological challenge owing to the difficulties in classifying the activities of the service sector, requiring differentiation in the instruments for data collection.

A more accurate sampling design, especially for the regions of the interior of the state of São Paulo, was another important advance achieved in this second edition. The firms from the 5 examined sectors (industry, commerce, services, banks and financial institutions, and civil construction)¹⁵ were grouped in eight administrative macro-regions of the state, according to the locality of their headquarters. This classification allowed for the regionalization of the collected data and permitted to better identify and evaluate local specificities in the innovation efforts of the state of São Paulo economy.

Generally, in both PAEP editions (1996 and 2001) the sectoral statistics for technological innovation were constructed on the basis of four central perspectives: (1) the innovation efforts of firms; (2) use and diffusion of new technologies; (3) the origin of the new technologies adopted; and (4) the impact of innovative activities. This range of information, combined with the economic variables (demand and lack of technical workforce, industrial location, production management techniques, outsourcing techniques, origin and composition of capital, etc.), allowed for the construction of multiple indicators, in a variety of themes and according to a diversity of analytical approaches.

As for the most striking results, in the 2001 edition (BERNARDES, 2003; SEADE, 2002), from a universe of 41 thousand industrial firms surveyed, 4% (1,656) declared that they had introduced a new product into the national market in the period 1999-2001. The segments that displayed the best performances – between 20% and 32% – were those of greater technology intensity (information technology, medical and optical equipments, high-precision and industrial automation instruments, electronic and communications materials). The lowest innovation rates, below 4%, were observed for the more traditional industrial branches (textiles, pulp and paper, rubber, metallic products, food and beverages, etc.)

In the commerce sector, out of 11 thousand enterprises, the innovation rate was lower than that of industry, of around 3%. In contrast, in the service sector (within a universe of 21 thousand enterprises) the innovation rate attained 5%. In this case, the information and knowledge-

¹⁴ The use of this manual for innovation surveys in developing countries has given rise to critical discussions regarding the suitability of the adoption of methodologies developed in advanced economies for recent industrialized countries, which exhibit a different pattern of technical change.

¹⁵ The PAEP sampling includes headquarters and local units from 47 branches: 21 from industry; 4 from civil construction; 9 from commerce, 13 from service, and banks. With regard to the size of firms investigated, the strata vary according to the sector and headquarter location (5-29, 30-99, 100 or more employees).

intensive branches, such as IT (30%) and telecommunications (15%) were outstanding. Finally, among the banks investigated (60, in total), around 18% declared that they had introduced technologically new or improved financial products and/or services into the national market, a rate well above other sectors of economic activity in the state of São Paulo.

Because of its regional approach, one of the main phenomenon that the PAEP survey allowed for clearly identify was the correlation between the location of the innovative activities and the geographical potential of inputs for innovation. By way of illustration, in 2001, 61% of the innovative firms were concentrated in the Metropolitan Region of São Paulo, where the largest portion of the physical infrastructure and human resources in the S&T sector is to be found.

In conclusion, the PAEP survey represented an advance in the dissemination of previously unavailable information on São Paulo's regional economy, enabling, through the disaggregated analysis of a broad set of variables, a more detailed and integrated vision of the economic and technological innovation performance in each region of the state.

However, the PAEP findings are not, currently, the exclusive source of information regarding the state-of-the-art of São Paulo innovation process. As shown below, with the PINTEC national survey, accomplished every two years, a set of more robust, comparable and disaggregated data become available for systematic monitoring and analysis of regional and national performances.

Industrial Survey of Technological Innovation (PINTEC)

By launching of PINTEC, in 2000, the Brazilian Institute of Geography and Statistics (IBGE) produced the first national indicators regarding technological innovation activities developed by the Brazilian industrial firms, articulated with other economic statistics and structural surveys regularly produced by the Institute, thus allowing for researchers to have access, for the first time, to detailed information on innovation process in Brazilian industry. The construction of these indicators is based on international methodological standards permitting its comparability with data from other countries.

The first edition of PINTEC (2000), covering the period 1998-2000, was based on the same methodological foundation of the third round of the Community Innovation Survey (CIS3), and adopted a questionnaire compatible with European surveys.¹⁶ The survey 2000 referred to a universe of 72 thousand industrial firms employing ten or more persons¹⁷. The high response rate to the questionnaires (94%) corroborated the successfulness of this first round. The second edition (PINTEC 2003), referring to 2001-2003, was based on an equivalent universe of 84 thousand firms around the country.

The third edition (2005), which is in process¹⁸, brings an important improvement: the survey scope will be enlarged and, in addition to the industrial sector, will contemplate the high technology intensive services (telecommunications, IT and R&D). Thus, the PINTEC 2005, covering the period 2003-2005, will survey 96 thousand industrial firms and 4.3 thousand service enterprises. Another significant change in this last edition refers to the reduction of the survey's frequency, from three to two years.

¹⁶ The questionnaire was basically the one proposed by the EUROSTAT to the European economies, with some additions and minor adaptations that did not hamper the most important comparisons. The analysis was restricted to the manufacturing activities, which are common to these surveys.

¹⁷ The survey's unit of analysis is the firm; hence, for firms having more than one address, the innovative activities carried out in all the different local units are considered, and its impacts are measured for the firm as whole.

¹⁸ See <<http://www.pintec.ibge.gov.br>>.

PINTEC focuses on the analysis of factors influencing the innovative behavior of Brazilian firms and their innovation strategies, efforts, outputs, incentives and obstacles. A brief comparative analysis of the results of the first two editions of the PINTEC (2000 and 2003)¹⁹ (IBGE, 2002; 2005), in the following paragraphs, makes it possible to highlight the main aspects that characterized the innovative performance of the Brazilian industrial sector in recent years.

Initially, between 2000 and 2003 surveys, the number of firms that implemented technologically new or improved product, in Brazil, grew from 22.7 thousand to 28 thousand. This evolution corresponded to a rise in the general innovation rate of 31.5% to 33.3%. Owing to the absence of relevant structural transformations in Brazilian industry, the levels of innovation rates between the two periods examined did not experience significant changes. In other words, from 1998 to 2003, only a third of Brazilian industrial firms introduced at least one new or improved product or process. This is a low rate in comparison to that of the leading innovative European economies (Germany, Belgium, Netherlands and Denmark), where the innovation rates range from 49% to 60% (EUROSTAT, 2004).

Among the reasons for this phenomenon, it is important not to underestimate the difficult economic conditions of that period in Brazil, but there are also two structural factors whose influence on the gap between Brazilian's rate and those of the other countries mentioned deserve to be investigated in greater depth. First, technology-intensive branches according to the OECD classification carry much more weight in the industrial structures of the most developed countries than in those of Brazil; they are precisely the branches with the highest innovation rates. Secondly, in the industrialized European countries firms tend to be larger on average than in Brazil in most branches of industry. As is well known, the larger the firm, the greater its propensity to innovate.

In fact, according to the results of the PINTEC's last edition (2003), the slight growth in the Brazilian rate was essentially due to the activities undertaken by enterprises employing between 10 and 49 persons, which mainly develop product and process innovations new to the firm, and imitative in nature. Bearing in mind that they represented 79.9% of the surveyed universe, their activities are those that most affected the national innovation rate.

In Brazil, process innovations remain predominant in inovative industrial firms: 25.2% of the total effort, in 2001, and 26.9% in 2003. Nevertheless, in the same period, the most significant growth was observed in product innovations, whose rate increased from 17.6% to 20.3%. This increase was associated, however, to products new to the firm (from 14.4% to 18.1%) to the detriment of products new to the market. This suggests, as argued in specialized literature, that innovations imitative in nature prevail in Brazilian industry.

Concerning the information sources that give rise to innovation in industry, PINTEC 2003 reveled an increase in the number of firms attributing high or medium importance to the acquisition of machinery and equipment (from 77%, in 2001, to 80%, in 2003), and a net decrease in all other activities. This result joins such referring to the growth in innovation rate for small firms, especially in traditional sectors, whose access to technological knowledge is usually done by the acquisition of these capital goods.

Focusing on disaggregated results²⁰, the state of São Paulo's innovation rate, in the period 1998-2000 (32.6%) was very similar to the Brazilian rate (31.5%), and both were about 25% below the European average according to CIS3 (EUROSTAT, 2005). When broken down by type of innovation, São Paulo's performance was also close to Brazil's: 7.5% of manufacturing firms in

¹⁹ See VIOTTI *et al.*, 2005.

²⁰ The comments made hereafter concerns the results published in the survey's first edition (PINTEC 2000).

the state implemented only product innovations in the period (6.3% for Brazil) and 13.2% introduced only process innovations (13.9% for Brazil), while 11.8% innovated in both products and processes (11.3% for Brazil). If the firms with product innovations only were added to those with product and process innovations, São Paulo's product innovation rate (19.3%) would more clearly be superior to the overall rate for Brazil (17.6%). This result can be explained by the fact that the proportion of innovative industrial firms belonging to the most high-tech and medium-tech branches of manufacturing, where product innovation rates are higher than process innovation ones, was higher in São Paulo than in Brazil (FAPESP, 2005).

In fact, as is widely known, the branch of industry to which firms belong is another attribute with significant explanatory power regarding technological activities and innovation performance. The innovation rates in São Paulo broken down by branch of industry were similar to those of the country as a whole, albeit with some important differences. The innovation rate for manufacturers of instrumentation, medical and hospital equipment and automation equipment in São Paulo, for instance, was 68.3% between 1998 and 2000. For "other transport equipment" the rate was 54.2%. Nevertheless, these rates do not apply to Brazil as a whole (58.9% and 43.5%, respectively). In fact, most of the leading manufacturers of transport equipment are located in São Paulo, as the aircraft industry, which is one of the main drivers of innovation in this category.

In sum, two main trends can be discerned from a comparison of innovation rates for industry in the state of São Paulo and Brazil. First, São Paulo innovation performance is higher than the national average in high and medium-technology sectors. Second, the reverse applies to low-technology sectors. Thus, the sectoral dispersion of innovation rates is greater for São Paulo than for Brazil as a whole. This could be partially explained by the São Paulo's greater sectoral specialization, compared to the other states, in the spatial location of Brazilian industry.

Finally, it is important to observe that, regarding the difficulties and obstacles for introducing technological innovations, of the 28 thousand firms setting up innovations between 2001-2003, 45% stated having encountered difficulties slowing down or making unfeasible the development of certain projects (54.7% between 1998 and 2000). Within this group of firms, 80% pointed out high innovation costs as an influencing factor for those difficulties, 75% excessive economic risks and 57% scarcity of funding sources. Similar results were obtained for firms located in São Paulo.

5. INSUFFICIENCY AND FRAGILITIES OF THE BRAZILIAN INFRASTRUCTURE OF S&T INFORMATION

As the previous sections suggest, the beginning of the 21st century marks the emergence of a new paradigm of S&T in Brazil. The national structure of ST&I began to experience significant changes – at programmatic and institutional levels – enhancing the installed capacities and establishing a new dynamic in the whole sector. Amongst the most significant shifts, the establishment of new instruments for financing R&D, the structuring of national and regional networks for supporting innovation, the support for enterprise incubation and venture capital, and the emphasis on prospective studies and new structures for R&D evaluation can be mentioned. At the legal level, the sanction of the new *Innovation Act* delivers new facilitating mechanisms for cooperation between the academic and business sectors. More recently, the formalization of a *National Industrial, Technological & Foreign Trade Policy (PITCE)* can be considered a definitive step, simultaneously linking the stimulus for efficient production, foreign trade, innovation and technological development as dynamic vectors of the country's economic activity.

However, this advance has not been accompanied by a process of amelioration of the S&T information infrastructure and statistics available in the country, something indispensable for the accompaniment and monitoring of the transformations underway. Government sectors, both at federal and state levels, even more active in various aspects, have still not managed to establish a systematic execution of support and promotion of information for technological innovation. Unlike other countries at a comparable stage of scientific and technological development, Brazil does not yet have multifunctional agencies fully dedicated to the management of information relating to S&T activities and the systematic production of regional data in this sector (GUSMÃO, 2005). Despite the efforts made and the progress achieved in a relatively short period of time (BRASIL 2004; 2006), it is still a long way from the functionality and adequacy of the systems already in use in most developed countries.

An important shortfall of the Brazilian S&T statistics refers to the available data sources, which vary considerably in coverage and comprehensiveness. Many official databases are very poorly systematized and standardized, impairing comparability. In addition, it is quite difficult to obtain up-to-date and reliable data for all regions, states or municipalities. These difficulties are largely a direct consequence of the lack of articulation among the institutions producing primary data, and of the resulting difficulty relating the adoption of common references. Furthermore, these producers do not interact with the end-users of the data they provide, hindering the transmission of new demands and making improvements less likely.

More precisely, six major obstacles can be highlighted:

- the absence of uniform criteria of cover, selection of content, aggregation and classification of data from the numerous available sources;
- the absence of common terminology and shared concepts;
- the different time cycles in the updating routines of existing databases;
- discontinuity and inconsistency in the adoption of the same procedures for the storage and classification of data each time they are updated;
- unavailability and/or disparate nature of the quality of disaggregated data (by geographical areas, industrial sectors, disciplines, etc.);
- an inadequate and widely-varying infrastructure and competencies for the production of S&T statistics within the ambit of the state systems.

In other words, Brazil now has numerous sources of S&T information and differentiated databases. The greatest challenge lies in the systemization and in the judicious and “intelligent” treatment of the data that can be marshaled, and not in the creation of new and more complex systems.

In this sense, FAPESP’s recent efforts in producing and diffusing regional S&T indicators represents a pioneer experience in Brazil, which already provides some revealing impacts on other Brazilian states. Such endeavor includes the periodic production and publishing of ST&I indicators for the state of São Paulo, from which many of the data examined in the previous sections were taken, and the launching and maintaining of an integrated information system that facilitates access to a large array of institutional and documental sources of S&T data – FAPESP.INDICA. This online system, which can be accessed via FAPESP’s website²¹, is designed to be an important tool for new research on the sector and also to meet the specialized information needs of public-sector administrators, experts and the scientific community in

²¹ See <<http://www.fapesp.br/indicadores>>.

general and help them find and directly access the data sources that are indispensable to the production of ST&I indicators.

Grounded in the selection and systematization of such data, FAPESP.INDICA gives access to an integrated system comprising three reference databases: (1) institutional sources of information on ST&I indicators (organisations, programmes, portals and online retrieval services that produce, process and/or disseminate information in a national and international level); (2) documental sources of information (official publications, methodological documents, surveys and online databases, published in Brazil and abroad); (3) a selection of ST&I indicators (preformatted consolidated tabulations relating to the main ST&I indicators for São Paulo, Brazil and some international comparisons indexed by a range of variables). The portal currently contains over 4,500 records for Brazil, for the Latin American countries and the main OECD member states, encompassing: links to over 2,800 organisations; links to some 1,100 documental sources; viewing of some 900 tables and figures relating to key Brazilian ST&I indicators, some many international comparisons.

In the same direction, new important initiatives have also been established by the federal agencies in the last years. In fact, at the present stage in the production of ST&I indicators, these agencies are convinced of the need to transcend national borders and enable analyses of regional and local spheres (inter and intra-regional comparisons).

In 2002, the Ministry of Science and Technology proposed the institutionalization of a “national system of indicators”, with the aim to consolidate a databank of Brazilian indicators, built on a coordination of efforts to assemble primary data producers in each state of the country.

In this process, entities such as the National Council of State Secretaries for ST&I Affairs and the recently created National Council of State Research Funding Agencies, have, without doubt, an important and central role to play. In fact, they recently have promoted the creation of specialized indicators units within the structure of the State Secretariats for Science and Technology, with the aim of systematic production of municipal and state S&T data. Above all, these initiatives reflect a preoccupation with the “regionalization” of the national S&T indicators, safeguarding the adoption of a common conceptual and methodological framework, as well as the comparability among the statistics produced in different states.

6. CONCLUSION

When compared to those relating to the first half of the 1990s, the main findings for the last ten years regarding scientific and technological production in the state of São Paulo and their place in the national and international contexts indicate important new trends in various different areas. However, they also suggest that these trends are not always associated with real ruptures, returning instead to old challenges that over recent decades have constantly hindered the strengthening of the S&T system and the development of innovation efforts in Brazil.

Thus, although the advances observed in the most recent period – such as inversion of the downtrend in government spending on R&D activities; increased business participation in total R&D expenditure; faster growth of higher education throughout the country; a moderate improvement in the profile of technology-related trade – a number of major barriers or constraints still persist. The fundamental point here is the contrast between progress in terms of scientific capabilities and production and relative stagnation of the capacity to generate

technological innovations, not to mention the limited performance of private enterprise in R&D, and hence, the prevalence of heavy dependency on foreign technology.

Nevertheless, two other central conditioning factors must be added: on the one hand, the weak and incipient interaction between the academic and business sectors in the development of innovative activities, compared to international standards; on the other hand, the persistence of acute regional and local imbalances in S&T capabilities across the country, which was taken as the primary focus of this paper.

In the last few years, several specialists have pointed out the need to adopt affirmative S&T regional policies which might permit a reversal in the tendency to amplify these inter-regional and intra-regional inequalities. But in Brazil, the articulation between S&T policies and national development programs, particularly in the case of industrial policy, have remained historically weak, intermittent and totally at the mercy of circumstantial factors.

This strategy presupposes actions which contemplate, on the one hand, a broadening of the S&T installed base, through direct investments in laboratorial infrastructure, human resources and support for R&D activities in the least favored regions. On the other hand, it also requires the adoption of a management model of resources allocated to S&T based on partnerships between the state and the federal governments, adopting differentiated contribution criteria for the states, as well as the definition of specific regional agendas (MELLO, 1992; SICSÚ & LIMA, 2001; ALBUQUERQUE & ROCHA NETO, 2005). The policy of articulation with the states remains a slow process; however, the strategy of regional action through the development of these partnerships between the state and federal spheres has shown itself to be, according to different authors, the surest and most suitable way to proceed.

In this sense, one of the main important aspects of such articulation concerns the strengthening of the state systems of S&T information and the “regionalization” of national data, whose production is still totally centralized in federal organisms. It requires the implementation, within the different S&T agencies throughout Brazil, of a more complete and compatible S&T information system. By promoting the adoption of a common conceptual and methodological framework, such “national system of statistics” would facilitate more systematic production of standardized S&T data compatible with the methodologies adopted internationally.

However, international experiences reveal that the development and implementation of such “national system of indicators” imply, among other aspects, the consolidation of an efficient dynamic of storage, processing and dissemination of data originating from various sources and the adoption of a technical infrastructure which allows for the gradual evolution of these databases, in terms of range and level of complexity, compatible with international standards. An evolution of this kind, in Brazil, presupposes the establishment of a “platform”, involving the maintenance of a set of disparate sources, capabilities of advanced treatment, infrastructure and qualified human resources inside the state agencies, many of which currently lack such facilities. In other words, it’s a matter of going beyond the periodic publication of bulky reports of S&T indicators, such as those edited by FAPESP, but rather to allow the different institutions involved to use this “platform” to produce new indicators which correspond to their specific needs, so as to make feasible a process of permanent measurement and monitoring of their action programs.

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Chart 1
Brazilian States R&D expenditure, 2004

(in current US\$ 000)

Region / State	State GDP (2003)	State expenditure on S&T sector*	State Research Foundation expenditure	Research Foundation expenditure / State tax revenue (%) (According to State Constitution**)
Southeast	279,613,995	443,695	184,097	
Minas Gerais	47,066,140	36,466	14,286	3.0
Rio de Janeiro	61,992,252	61,509	25,867	2.0
Sao Paulo	161,119,344	343,162	143,944	1.0
Espírito Santo	9,436,259	2,559	-	n.e.
South	94,185,436	123,502	13,626	
Parana	32,235,922	87,119	-	2.0
Santa Catarina	20,257,739	12,236	6,494	2.0
Rio Gde do Sul	41,691,775	24,147	7,132	1.5
Northeast	69,876,542	100,695	26,948	
Maranhao	4,553,353	2,284	1,726	0.5
Paraiba	4,464,496	3,091	679	2.5
Pernambuco	13,760,843	17,072	3,469	1.0
Ceara	9,255,698	16,810	9,201	2.0
Bahia	23,824,196	50,729	8,821	1.5
Alagoas	3,362,283	3,587	2,779	2.0
Others	10,655,673	7,122	273	-
Centre-West	37,827,621	19,371	6,421	
Distrito Federal	12,292,878	3,982	2,766	2.0
Mato Grosso	7,363,854	9,697	2,653	2.0
Mato Grosso Sul	6,176,779	2,701	1,002	0.5
Goias	11,994,110	2,991	-	3.0
North	25,214,479	13,793	6,507	
Acre	884,414	2,488	642	n.e.
Amazonas	9,137,646	8,027	5,831	3.0
Others	15,192,420	3,278	33	-
Total Brazil	506,718,073	701,057	237,599	

n.e.: not specified in State Constitution.

* Except expenditure on tertiary-level education. Data were calculated according to the methodology adopted by the Ministry of Science and Technology (MCT). See <http://www.mct.gov.br/index.php/content/view/8842.html>.

** Generally, this fixed percentage to be effected annually by the state governments to the state R&D funding agencies refers to the state tax revenues. But in some cases (5 States) it refers to the total current revenue.

Source: Brazilian Department of the Treasury (STN); Brazilian Institute of Geography & Statistics (IBGE); Central Bank of Brazil; Ministry of Science and Technology; State Constitutions (1989).

Chart 2

São Paulo State contribution to Brazil's global efforts in the S&T sector

INPUT INDICATORS	São Paulo	Brazil	SP/BR (%)
R&D EXPENDITURE			
Total R&D expenditure (R\$ million, 2000)	3,980	10,970	36.3
Public R&D expenditure (R\$ million, 2000)	1,825	6,409	28.5
Business R&D expenditure (R\$ million, PINTEC 2000/IBGE)	2,121	3,742	56.7
UNDERGRADUATE SYSTEM			
Undergraduate places offered (total, 2002)	555,152	1,773,087	31.3
Undergraduate enrolments (total, 2002)	988,696	3,479,913	28.4
First degree graduates (total, 2002)	160,051	466,260	34.3
Teaching functions in higher education (total, 2002)	63,863	227,844	28.0
Ph.D holder teaching functions in higher education (total, 2002)	18,153	49,287	36.8
Ph.D holder teaching functions in higher education (state HEI network, 2002)	8,695	12,609	69.0
POST-GRADUATE SYSTEM			
No. of master's courses (2004)	548	1,787	30.7
No. of doctoral courses (2004)	411	988	41.6
Enrolments in master's degree courses (2003)	23,900	63,791	37.5
Enrolments in doctoral degree courses (2003)	19,898	37,795	52.6
No. of master degrees awarded (2002)	8,501	23,359	36.4
No. of doctoral degrees awarded (2002)	4,055	6,893	58.8
HUMAN RESOURCES IN S&T			
People in research groups (CNPq, 2002)	43,130	146,209	29.5
R&D personnel in industrial firms (PINTEC 2000/IBGE)	22,301	41,467	53.8

(Cont. Chart 2)

OUTPUT INDICATORS	São Paulo	Brazil	SP/BR (%)
SCIENTIFIC PRODUCTION			
Publications indexed by SCIE/ISI (2002)	8,538	15,846	53.9
Growth rate (% , 2002/2001)	19.2	15.6	...
SCIE/ISI-indexed Brazilian public. in collaboration with other countries (2002).....	2,356	4,793	49.2
PATENTING ACTIVITY IN BRAZIL			
INPI patents filled by first-named inventors residing in Brazil (total, 2001)	2,811	5,501	51.1
Nr. of corporate patents filed with INPI (2001)	774	1,379	56.1
Nr. of individual patents filed with INPI (2001)	2,037	4,122	49.4
% of municipalities with patent applications filed with INPI (1999-2001)	39.8	16.0	...
PATENTING ACTIVITY ABROAD			
Patents granted by USPTO (total, 2002)	55	112	49.1
Corporate patents granted by USPTO (total, 2002)	48	96	50.0
Corporate patents granted by USPTO (transnationals subsidiaries, 1981-2002)	81	84	96.4
TECHNOLOGY BALANCE OF PAYMENTS			
Total exports of the "R&D-intensive industry" (CTP category, US\$ million, 2003)	1,830	4,140	44.2
Total imports of the "R&D-intensive industry" (CTP category, US\$ million, 2003)	4,076	7,379	55.2
Total exports of "high technology products" (US\$ million, 2003)	4,715	9,317	50.6
Total imports of "high technology products" (US\$ million, 2003)	8,158	15,685	52.0
Average export value of the "R&D-intensive industry" (US\$, 2003)	8.14	7.54	...
Average import value of the "R&D-intensive industry" (US\$, 2003)	14.80	13.50	...
Average export value of the "high technology products" (US\$, 2003)	6.75	5.73	...
Average import value of the "high technology products" (US\$, 2003)	15.84	14.05	...
TECHNOLOGY INNOVATION BY INDUSTRY			
Nr. of innovative firms (PINTEC 2000/IBGE)	8,664	22,698	38.2
Nr. of firms conducting R&D activities (PINTEC 2000/IBGE)	3,373	7,412	45.5
R&D expenditure by innovative firms (R\$ million, PINTEC 2000/IBGE)	2,121	3,742	56.7
Innovation rates in industry (nr. innovative firms/total firms, %)	32.6	31.5	...
R&D effort intensity of the innovative firms (R&D expenditure/net sales, 2000)	0.8	0.6	...
Innovative effort intensity of innovative firms (innovation expenditure/net sales, 2000)	4.2	3.8	...

Elaborated by the authors.

Source: Science, Technology & Innovation Indicators in the State of São Paulo 2004 (FAPESP, 2005).