Chapter 9

Information & Communication Technology (ICT) in São Paulo State: characterization and diffusion indicators

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

1. Introduction

The profound technological changes seen in the advanced capitalist countries in the closing decades of the 20th century unfolded in an environment characterized by intense competition, integration of markets and oil price shocks, and involved a wave of innovations geared to the enhancement of efficiency in production and energy use, the development of new materials, and knowledge-intensive activities (Coutinho, 1992; Tigre, 2006).

The diffusion of information and communications technology (ICT) in a wide array of activities relates to the intense dynamism of the electronics complex, and more specifically to the development of microelectronics. ICT is used with greater or less intensity in practically every activity that involves microelectronic components, including manufacturing (e.g. in machinery and machine-tools), public services, transport, energy and communications (e.g. in air traffic control systems, management of power grids and telecommunications).

The term ICT covers a plethora of activities and industries with heterogeneous characteristics (in terms of technological intensity, for example) but which share a common technical base in terms of the storage, processing and transmission of digital information.

Thus both the pervasiveness[1] of ICT in a great many human activities and its transversality in the production chains[2] of virtually every sector[3] indicate that ICT's share in any country's gross output in direct quantitative terms is less important that its crucial role in countless areas of production, services and consumption.[4]

Given all these characteristics, it is no surprise that the makers and managers of public policy are increasingly concerned to foster the development of ICT internationally, nationally and regionally. Brazil is no exception, having implemented measures in recent decades to strengthen, develop and promote the competitiveness of the ICT industry in all its various manifestations. The main efforts in this field were the National Informatics Policy, introduced in the 1980s, the Informatics Law and the establishment of Softex in the 1990s, and the recent choice of software and semiconductors as strategic sectors by the guidelines laid down in the Industrial, Technological & Trade Policy (Pitce) and the Productive Development Policy (PDP).

Besides these federal initiatives, São Paulo has a range of incentives for ICT activities, given that a significant proportion of the industry is located in the state. Such measures include public policies to foster digital inclusion (via telecenters), education (state universities and technology colleges or Fatecs), innovation and entrepreneurship (technology parks, IPT and PIPE-FAPESP).

This chapter is structured on the basis of these considerations, presenting a set of indicators that permit advances in the characterization of ICT in São Paulo State and provide inputs for analysis and assessment of industrial and technological policy in the area.

The next section outlines the scope of the chapter and presents a characterization of ICT in Brazil and São Paulo. This is no easy task, given the aspects mentioned above: the heterogeneous nature of the activities involved requires combined treatment of data from different sources (in industry and services) to construct consolidated indicators.

Section 3 presents indicators of the São Paulo State ICT industry's external-sector performance. It is divided into two parts to facilitate comprehension: one deals with trade in manufacturing (IT and telecommunications equipment) and the other with services (software and telecom).

Section 4 proposes a still exploratory methodology to identify and gauge the size of ICT-related activities developed outside the ICT industry proper, termed secondary production in this chapter. The exercise is designed to highlight the importance of ICT-related services to some sectors in São Paulo and to estimate the economic value of such activities.

Section 5 presents the main ICT diffusion indicators for São Paulo State and compares these with national indicators based on the National Household Sample Survey (PNAD). This information serves as a basis for considerations regarding the socioeconomic determinants of access to ICT and underlines the importance of public initiatives to democratise such access.

Section 6 focuses on innovation, analyzing the ICT industry in São Paulo using information from IBGE's Survey of Technological Innovation in Industry

1. Roselino (2006, p. 3) justifies the neologism *pervasividade* in Portuguese, derived from the English word pervasive (whose root is the Latin word *pervasus*, the past participle of *pervadere*), in light of the lack of any other word in the Portuguese language capable of expressing simultaneously the dissemination and penetration of ICT.

2. A detailed discussion of the importance of transversality and pervasiveness as key elements in the consolidation of certain economic sectors as catalysts of technological revolutions, as well as an analysis of the concept of socioeconomic paradigms, can be found in Freeman & Perez (1988) and Perez (2002, 2004).

3. The term "sector" is used throughout this chapter to refer to the economic activities grouped at the two-digit level by Brazil's National Economic Activity Classification (CNAE). This is known as the CNAE division level.

4. The economic impact of ICT is highly significant and diversified, ranging from productivity growth to economies of speed, utilisation as an instrument of innovation, and geographical and social integration, among others. On this subject, see Shapiro & Varian (2003) and Romer (1986).

(PINTEC). Its performance in innovation is compared with that of the ICT industry in the rest of Brazil and differences with other industries are also highlighted.

The last section presents the chapter's conclusions in the form of a summary of each main section.

2. The ICT industry in Brazil and São Paulo State: definition of scope and general characterization

The technical and production changes mentioned in the introduction have driven penetration by ICT in various sectors, subverting their "production functions" in some cases. Traditional processes and inputs are radically modified in this process. Some products and services, such as those of the phonographic and audiovisual industries, incorporate growing amounts of informational inputs, which bring their technical base close to that of the ICT industry in a movement known as technological convergence.

The pervasiveness of information technology and the intense dynamism associated with technological convergence, which disseminates the ICT technical base to many other sectors, make delimiting the contours of the ICT industry a problematical task. The difficulty results mainly from the perception that a significant proportion of the activities geared to the development of ICT take place outside the firms that belong to the ICT industry proper.

Thus any delimitation of sectors risks being imprecise or too restricted by leaving out ICT development efforts in other industries (financial services or aerospace, for example), or too broad, including values and information for other activities that do not strictly involve IT or communications. This difficulty is not exclusive to Brazilian researchers; on the contrary, it is a general problem faced by specialists everywhere.

The most adequate option appears to be a twofold approach covering both the ICT industry proper, comprising firms whose main source of revenue is ICT goods and/or services, and ICT-related activities in all other industries or sectors. The scope of this chapter is primarily the ICT industry proper, but an exploratory analysis of ICT-related activities throughout the economy is also included (see Section 4).

The definition is based on that adopted by the Organization for Economic Cooperation & Development (OECD) as a result of an agreement among specialists from the member countries. This defines the ICT sector as a combination of manufacturing and service industries that fulfil or enable the function of information processing and communication by electronic means, including transmission and display.

By using this definition we can home in on the activities covered by four chapters of CNAE: manufacturing of electronic and IT equipment (hardware); manufacturing of telecom equipment; telecom services; and software developers and IT services (Chart 9.1).[5]

The result is a fairly heterogeneous set of activities with distinct characteristics with regard to competition, technological intensity and manpower skill levels, among other aspects. This heterogeneity sometimes hinders more general considerations on the ICT sector but it is also useful inasmuch as it transcends the traditional dichotomy between manufacturing and services by bringing together a group of activities that despite their differences have the treatment of digitally encoded information as a common substrate.

Given the scope delimited above, net operating revenue from the activities of the ICT industry nationwide is estimated to have totalled more than R$173.7 billion in 2005. Firms based in São Paulo State accounted for roughly 40%, or R$69.4 billion (Table 9.1).

The activities in São Paulo with the largest share of the total were those relating to hardware and software production and services, in which firms located in the state accounted for approximately half the national total.

In terms of net operating revenue for Brazil excluding São Paulo State, telecom equipment and services predominated in 2005, accounting for 77.5% of the ICT industry's total revenue nationwide (Figure 9.1).

5. The scope of this chapter is based on an adaptation of the OECD definition to exclude some classes of activity deemed to be less ICT-intensive. In addition, different degrees of disaggregation are used depending on data availability. The classification adopted here assures comparability with international data based on the International Standard Industrial Classification (ISIC).

Chart 9.1
Definition of ICT based on CNAE goods & services by segment

Group of segments	Definition of ICT based on CNAE goods & services
Hardware	301 - Manufacturing of office machinery and equipment
	302 - Manufacturing of equipment and machinery for electronic data processing systems
	313 - Manufacturing of insulated wires, cables & electrical conductors
Telecom equipment	321 - Manufacturing of basic electronics material
	322 - Manufacturing of telephony and radiotelephony apparatus and equipment and of television and radio transmitters
	323 - Manufacturing of television and radio receivers, and of sound and video recording, reproducing and amplifying equipment
	332 - Manufacturing of apparatus and instruments for measuring, testing and control, except industrial process equipment
	333 - Manufacturing of machinery, apparatus and equipment for electronic systems dedicated to industrial automation and process control
Telecom services	6420 – Telecommunications
Software & IT services	7210 - Hardware consulting
	7221 - Development and publishing of software ready for use
	7229 - Development of customized software and other consulting in software
	7230 - Data processing
	7240 - Database activities and online distribution of electronic content
	7250 - Maintenance and repair of office and computer equipment
	7290 - Other IT activities not elsewhere specified

Source: IBGE (CNAE).

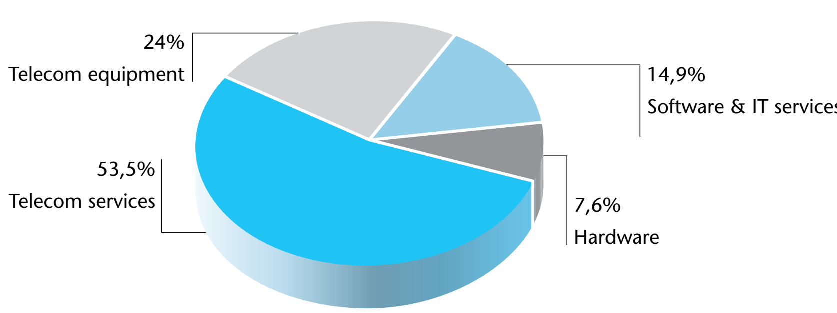
Note: Classification based on CNAE using definition proposed by OECD (2005).

Table 9.1
ICT industry net operating revenue by segment and CNAE class – Brazil & São Paulo State, 2005

Segment & CNAE class	ICT industry net operating revenue		
	Brazil (R$ 000)	São Paulo State (R$ 000)	SP / BR (%)
Total ICT	**173,785,038**	**69,418,384**	**39.9**
Hardware	**16,307,314**	**8,345,753**	**51.2**
301 - Manufacturing of office machinery and equipment	514,028	80,060	15.6
302 - Manufacturing of equipment and machinery for electronic data processing systems	9,743,908	4,164,614	42.7
313 - Manufacturing of insulated wires, cables & electrical conductors	6,049,378	4,101,078	67.8
Telecom equipment	**40,331,535**	**15,302,792**	**37.9**
321 - Manufacturing of basic electronics material	3,867,165	1,007,899	26.1
322 - Manufacturing of telephony and radiotelephony apparatus and equipment and of television and radio transmitters	23,214,993	11,112,542	47.9
323 - Manufacturing of television and radio receivers, and of sound and video recording, reproducing and amplifying equipment	9,544,446	452,624	4.7
332 - Manufacturing of apparatus and instruments for measuring, testing and control, except industrial process equipment	2,705,633	2,024,739	74.8
333 - Manufacturing of machinery, apparatus and equipment for electronic systems dedicated to industrial automation and process control	999,298	704,989	70.5
Telecom services	**86,589,077**	**30,789,952**	**35.6**
6420 - Telecommunications	86,589,077	30,789,952	35.6
Software & IT services	**30,557,112**	**14,979,887**	**49.0**
7210 - Hardware consulting	3,569,068	2,477,327	69.4
7221 - Development and publishing of software ready for use	7,328,108	2,165,714	29.6
7229 - Development of customized software and other consulting in software	10,343,515	6,106,123	59.0
7230 - Data processing	5,969,996	2,401,705	40.2
7240 - Database activities and online distribution of electronic content	232,650	172,140	74.0
7250 - Maintenance and repair of office and computer equipment	2,375,438	1,189,976	50.1
7290 - Other IT activities not elsewhere specified	738,337	466,902	63.2

Source: IBGE, PAS 2005; PIA 2005.

Figure 9.1
Breakdown of ICT industry net operating revenue by major segment – Brazil except São Paulo State, 2005



Source: IBGE, PAS 2005; PIA 2005.

Note: See Detailed Table 9.1.

Telecom also predominated in São Paulo, albeit less emphatically. Activities relating to IT (hardware, software and services) had a larger share of the ICT industry's total revenue in the state, accounting in aggregate for 33.6%, compared with 22.5% for the rest of the country (Figure 9.2).

This difference in the composition of the ICT industry in São Paulo and the rest of Brazil derives mainly from the fact that telecom service providers are geographically more dispersed throughout the country, not least as a result of the institutional aspects of the privatisation process that took place in the late 1990s.

The relative importance of IT-related activities in São Paulo is probably due to a combination of two factors: proximity to a significant part of the corporate market, especially for custom software and other IT services; and a sufficient supply of labor with the qualifications required for these activities.

As shown in Table 9.2, São Paulo's share of employment in the ICT industry is proportional to its share of net operating revenue. The state accounted for 40% of formal jobs in ICT firms nationwide in 2005. Hardware manufacturing was the largest source of such jobs, with a share of 56%.

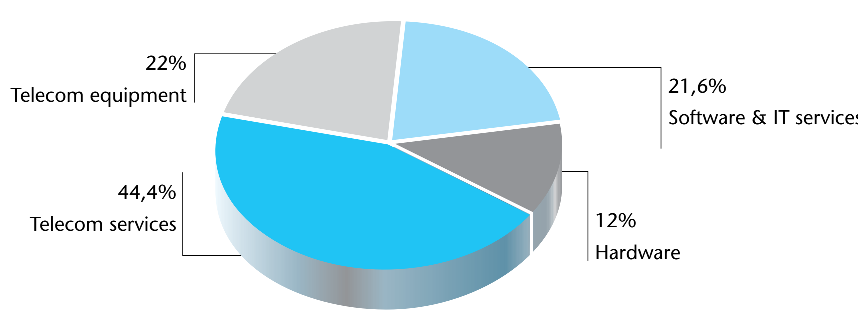
It is also worth noting the importance of telecom services, software development and IT services in creating ICT-related jobs: these services accounted for 64.3% of the ICT workforce in São Paulo State and 69.7% in Brazil.

The labor-intensive nature of many ICT activities makes the fostering of such activities an especially important element of policy measures designed to stimulate job creation.

The heterogeneity of ICT segments is evidenced by significant disparities in average firm size measured in terms of workforce (Table 9.3). The largest firms on average are manufacturers of office and computer equipment (CNAE 301 and 302), hardware consultants, and firms engaged in database activities and online distribution of electronic content (CNAE 7210 and 7240).

On the other hand, it is worth focusing for a moment on the average employment data for firms engaged in development of customized software (CNAE 7229), data processing (CNAE 7230), and maintenance and repair of office and computer equipment (CNAE 7250). These numbers reflect not only important differences in the profiles of ICT firms but also the different formal employment relations involved. A significant proportion of the ICT industry workforce consists not of directly em-

Figure 9.2
Breakdown of ICT industry net operating revenue by major segment – São Paulo State, 2005



Source: IBGE, PAS 2005; PIA 2005.

Note: See Detailed Table 9.2.

Table 9.2
Formal employment in ICT firms by segment and CNAE class – Brazil & São Paulo State, 2005

Segment & CNAE class	Formal employment in ICT firms		
	Brazil (abs. nos.)	São Paulo State (abs. nos.)	SP / BR (%)
Total ICT	**484,060**	**193,163**	**39.9**
Hardware	**52,250**	**29,249**	**56.0**
301 - Manufacturing of office machinery and equipment	4,229	2,851	67.4
302 - Manufacturing of equipment and machinery for electronic data processing systems	29,489	14,964	50.7
313 - Manufacturing of insulated wires, cables & electrical conductors	18,532	11,434	61.7
Telecom equipment	**94,409**	**39,659**	**42.0**
321 - Manufacturing of basic electronics material	37,735	14,814	39.3
322 - Manufacturing of telephony and radiotelephony apparatus and equipment and of television and radio transmitters	21,287	9,752	45.8
323 - Manufacturing of television and radio receivers, and of sound and video recording, reproducing and amplifying equipment	20,479	5,031	24.6
332 - Manufacturing of apparatus and instruments for measuring, testing and control, except industrial process equipment	7,728	5,574	72.1
333 - Manufacturing of machinery, apparatus and equipment for electronic systems dedicated to industrial automation and process control	7,180	4,488	62.5
Telecom services	**118,080**	**42,228**	**35.8**
6420 - Telecommunications	118,080	42,228	35.8
Software & IT services	**219,321**	**82,027**	**37.4**
7210 - Hardware consulting	32,770	14,478	44.2
7221 - Development and publishing of software ready for use	8,193	3,125	38.1
7229 - Development of customized software and other consulting in software	26,511	9,729	36.7
7230 - Data processing	73,672	24,267	32.9
7240 - Database activities and online distribution of electronic content	6,099	2,216	36.3
7250 - Maintenance and repair of office and computer equipment	22,097	8,214	37.2
7290 - Other IT activities not elsewhere specified	49,979	19,998	40.0

Source: MTE, RAIS (2005).

Table 9.3
Formal employees and local units of ICT firms by CNAE class – São Paulo State, 2005

Activities by CNAE class	ICT firms		
	Formal employees (abs. nos.)	Local units (abs. nos.)	Employees per firm (abs. nos)
301 - Manufacturing of office machinery and equipment	2,851	24	118.8
302 - Manufacturing of equipment and machinery for electronic data processing systems	14,964	57	95.3
313 - Manufacturing of insulated wires, cables & electrical conductors	11,434	172	66.5
321 - Manufacturing of basic electronics material	14,814	373	39.7
322 - Manufacturing of telephony and radiotelephony apparatus and equipment and of television and radio transmitters	9,752	118	82.6
323 - Manufacturing of television and radio receivers, and of sound and video recording, reproducing and amplifying equipment	5,031	97	51.9
332 - Manufacturing of apparatus and instruments for measuring, testing and control, except industrial process equipment	5,574	291	19.2
333 - Manufacturing of machinery, apparatus and equipment for electronic systems dedicated to industrial automation and process control	4,488	101	44.4
6420 - Telecommunications	42,228	840	50.3
7210 - Hardware consulting	14,478	86	168.3
7221 - Development and publishing of software ready for use	3,125	261	12.0
7229 - Development of customized software and other consulting in software	9,729	12,707	0.8
7230 - Data processing	24,267	9,980	2.4
7240 - Database activities and online distribution of electronic content	2,216	12	184.7
7250 - Maintenance and repair of office and computer equipment	8,214	1,798	4.6
7290 - Other IT activities not elsewhere specified	19,998	292	68.5

Source: MTE, RAIS (2005).

ployed staff but of independent contractors with their own firms, in an arrangement designed to minimize payroll taxes, which are very high in Brazil. This at least partly explains the fact that firms classified in CNAE 7229 have less than 1 employee on average. The vast majority of these firms are sole proprietorships, small businesses or co-ops. Many will have been set up as part of an outsourcing strategy by large ICT firms.

The ratio of net operating revenue to formal jobs also varies significantly across the ICT industry (Table 9.4). While this cannot be considered a precise indicator of productivity (which should be based on value added rather than revenue), the stark contrast between types of activity is worth examining.

The activity with the highest ratio of NOR to jobs is CNAE 322 (telephone equipment and TV and radio transmitters). This is may be at least partly explained by the fact that manufacturers in this segment mainly assemble products from imported components, as noted in Section 3 below.

In ICT services the highest ratios are in CNAE 6420 (telecom services), 7221 (software ready for use) and 7229 (customized software and other consulting in software). In the first two cases, the reason seems to be significant economies of scale, which are characteristic of both activities. In the third, high revenue per employee may be due to a combination of two distinct factors: scale gains in the production of custom soft-

Table 9.4
Net operating revenue per formal employee in ICT firms by CNAE class – São Paulo State, 2005

CNAE class	Net operating revenue per formal employee in ICT firms (R$)
301 - Manufacturing of office machinery and equipment	28,081
302 - Manufacturing of equipment and machinery for electronic data processing systems	278,309
313 - Manufacturing of insulated wires, cables & electrical conductors	358,674
321 - Manufacturing of basic electronics material	68,037
322 - Manufacturing of telephony and radiotelephony apparatus and equipment and of television and radio transmitters	1,139,514
323 - Manufacturing of television and radio receivers, and of sound and video recording, reproducing and amplifying equipment	89,967
332 - Manufacturing of apparatus and instruments for measuring, testing and control, except industrial process equipment	363,247
333 - Manufacturing of machinery, apparatus and equipment for electronic systems dedicated to industrial automation and process control	157,083
6420 - Telecommunications	729,136
7210 - Hardware consulting	171,110
7221 - Development and publishing of software ready for use	693,028
7229 - Development of customized software and other consulting in software	627,621
7230 - Data processing	98,970
7240 - Database activities and online distribution of electronic content	77,681
7250 - Maintenance and repair of office and computer equipment	144,872
7290 - Other IT activities not elsewhere specified	23,347

Source: MTE, RAIS (2005); IBGE. PAS 2005; PIA 2005.

ware due to increasing modularization and reuse, and the prevalence of outsourcing, as already mentioned.

Finally, indicators of concentration for São Paulo State's 63 microregions in 2005 are presented in order to analyze ICT distribution in the state. The methodology (see Methodological Annex, item 1) uses the concepts of location quotient (LQ) and horizontal clustering (HC)[6] based on recommendations widely accepted in the specialized literature (see for example Suzigan et al., 2004).

These indicators show that ICT activities are highly concentrated in certain microregions of São Paulo State (Tables 9.5 and 9.6, and Maps 9.1 and 9.2). Based on LQ, only six microregions can be classed as specialized in ICT, i.e. with LQs of more than 1 (Osasco, São Paulo, Piedade, Itapecerica da Serra, Campinas and São José dos Campos). As for HC, the rank order is different, with the São Paulo microregion so far in the lead that it has 42,282 more ICT jobs than it would have if it were not specialized, i.e. if its LQ were 1 or less. This striking difference is due to the microregion's production structure, which involves far more workers than the rest.

The situation with regard to specialization matches the findings of Diegues & Roselino (2008), for whom "a pronounced feature of ICT activities in the international sphere is the tendency to concentrate in certain geographical areas, such as Silicon Valley in the U.S.,

6. First presented in Fingleton, Igliori & Moore (2004).

Table 9.5
Location quotients (LQs) of jobs in ICT firms for selected microregions – São Paulo State, 2005

Selected microregions	LQs of jobs in ICT firms
Osasco	2.28
São Paulo	1.70
Piedade	1.48
Itapecerica da Serra	1.19
Campinas	1.18
São José dos Campos	1.13

Source: MTE, RAIS (2005).

Note: See Methodological Annex.

Table 9.6
Horizontal clustering (HC) of ICT jobs for selected microregions – São Paulo State, 2005

Selected microregions	HC of jobs in ICT firms
São Paulo	42,282
Osasco	9,920
Campinas	2,995
São José dos Campos	974
Itapecerica da Serra	754
Piedade	134

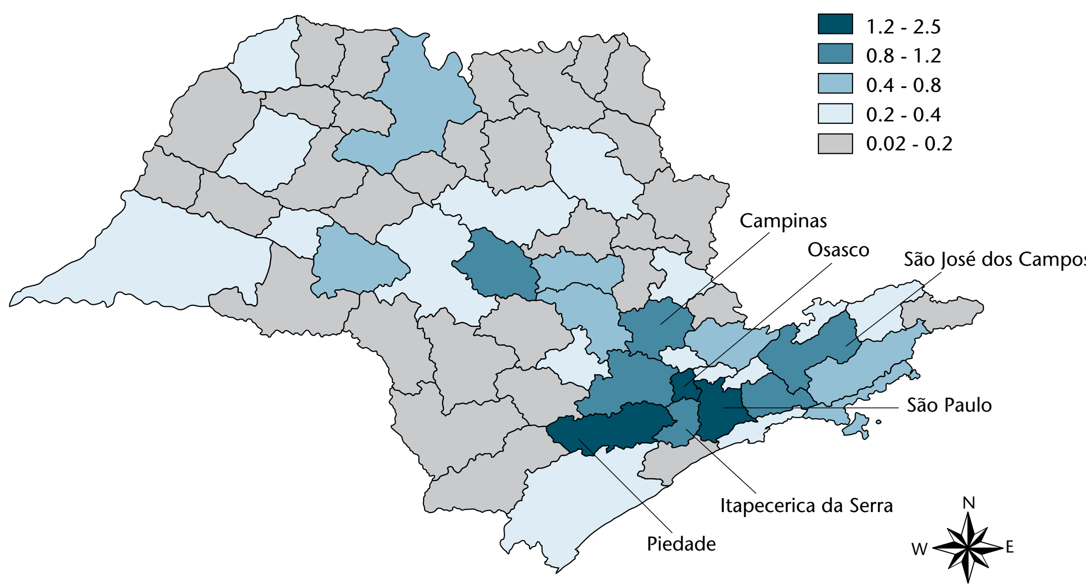
Source: MTE, RAIS (2005).

Note: See Methodological Annex.

Dublin, Ireland, and Bangalore, India. ICT activities in these areas develop with the support of strong local institutions and linkages with other high-tech activities".

These elements help explain the importance of ICT activities in the São Paulo, Osasco, Campinas and São José dos Campos microregions. Besides complex production structures, these microregions also display a high concentration of innovation inputs. In other words, the leading position of these microregions reflects the outstanding innovative dynamism of ICT activities and in particular, as noted by Feldmann (1993), a local concentration of innovation inputs such as university-based R&D, industrial R&D, the presence of related industries and the presence of specialized service providers.

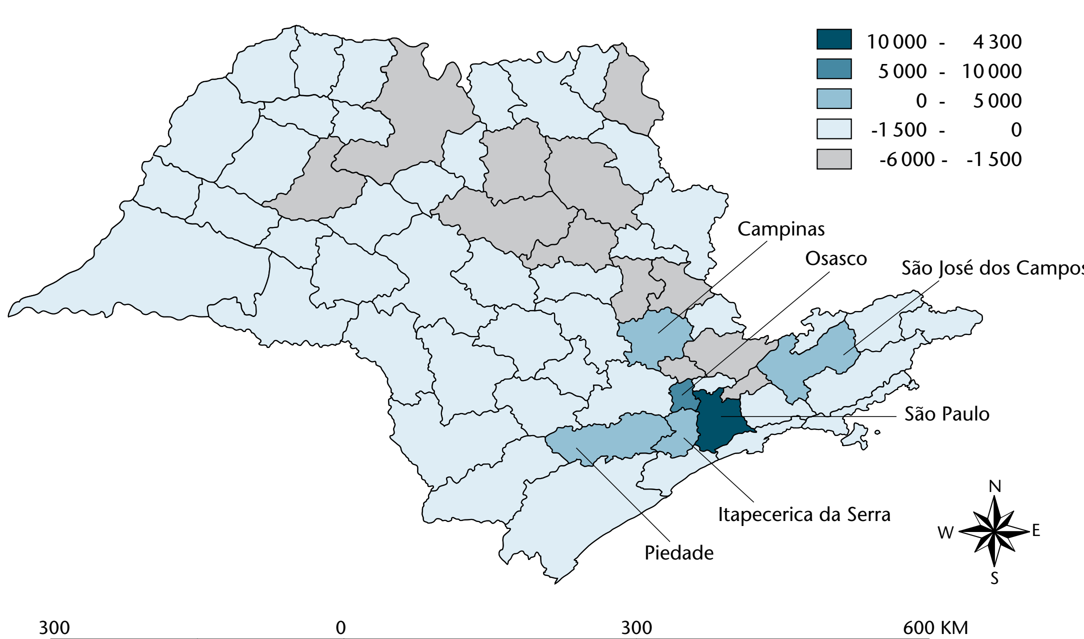
Map 9.1
Location quotients (LQs) for ICT jobs by microregion – São Paulo State, 2005



Source: MTE, RAIS (2005).

Note: See Methodological Annex.

Map 9.2
Horizontal clustering (HC) of ICT jobs – São Paulo State, 2005



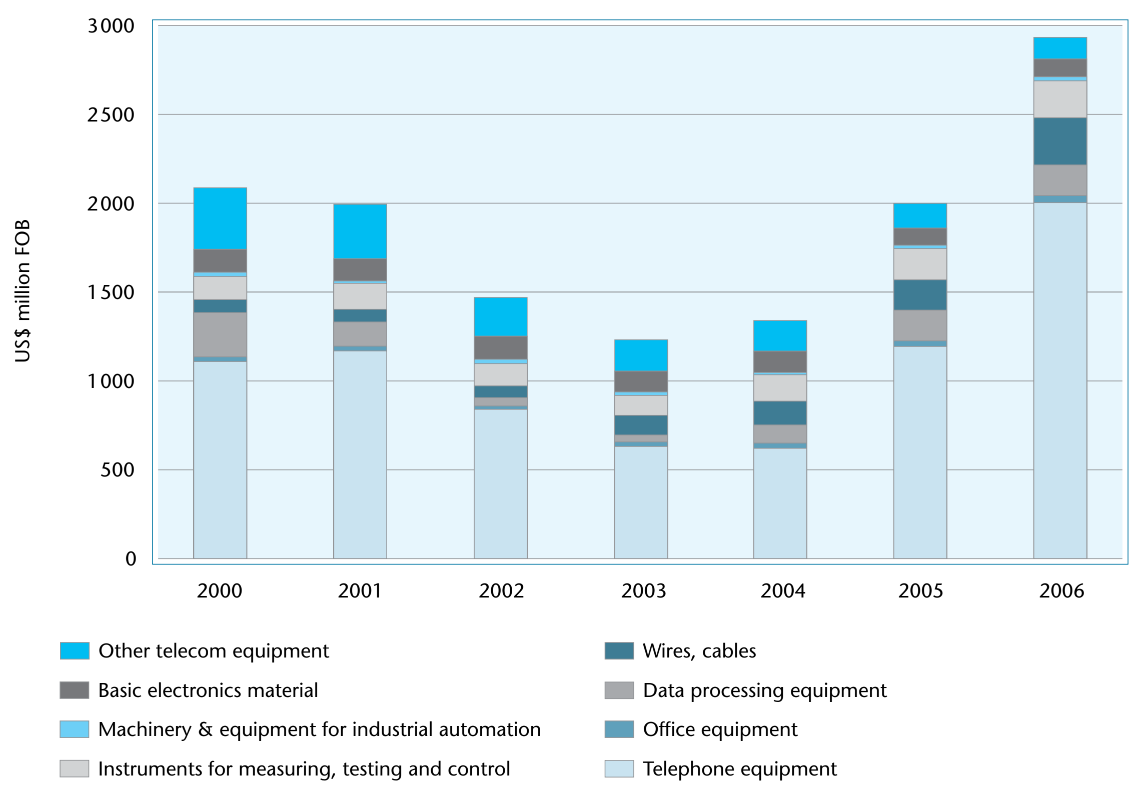
Source: MTE, RAIS (2005).

Note: See Methodological Annex.

3. Participation in international trade by the ICT industry in São Paulo State[7]

The trade performance of São Paulo State's ICT industry[8] has fluctuated sharply in recent years in terms of both exports and imports, largely in response to international trends that affect the sector. Both exports and imports fell 40% in the period 2000-03, influenced by the global economic slowdown, a reduction in the intensity of U.S. growth, and perceived excess capacity mainly in the telecom equipment industry (Figures 9.3 and 9.4; Detailed tables 9.3 and 9.4). Thus after a period of vigorous global growth fuelled by (i) expansion of fixed and mobile telecom networks, (ii) exponential growth in internet use and (iii) growth in sales by manufacturers of infrastructure equipment and home appliances, the impact of the global contrac-

Figure 9.3
ICT exports by segment – São Paulo State, 2000-2006



Source: MDIC. Secex.

Note: See Detailed Table 9.3.

7. It is important to stress that this section discusses trade in ICT goods and not international trading by ICT firms. This is because the trade statistics analyzed in the section were obtained by aggregating exports and imports for each of the main product groups in specific ICT segments (see item 2 of the Methodological Annex for more details). Thus if a computer is imported by a large retail chain, it will be booked in the trade balance as data processing equipment because statistically it is recognized as part of an ICT activity rather than a product of the ICT manufacturing industry. This methodological option is justified by its capacity to produce a more detailed and complete portrait of the external-sector dimension of ICT activities in São Paulo.

8. The ICT industry as defined for present purposes does not include software development and telecom services, owing to problems with the measurement of exports and especially imports. Despite significant recent progress by IBGE in measuring the software industry's export revenue, the import statistics currently available are still not adequate for the purposes of precise measurement or analyzing trade with specific countries and regions. For this reason, statistical information on exports by these segments is presented separately at the end of this section. It is worth noting that the Department of Commerce & Services at the Ministry of Development, Industry & Trade (MDIC) has worked hard to transcend these limitations by implementing a new integrated system for the registration of foreign trade in services called Siscoserv, scheduled to go live in 2009.

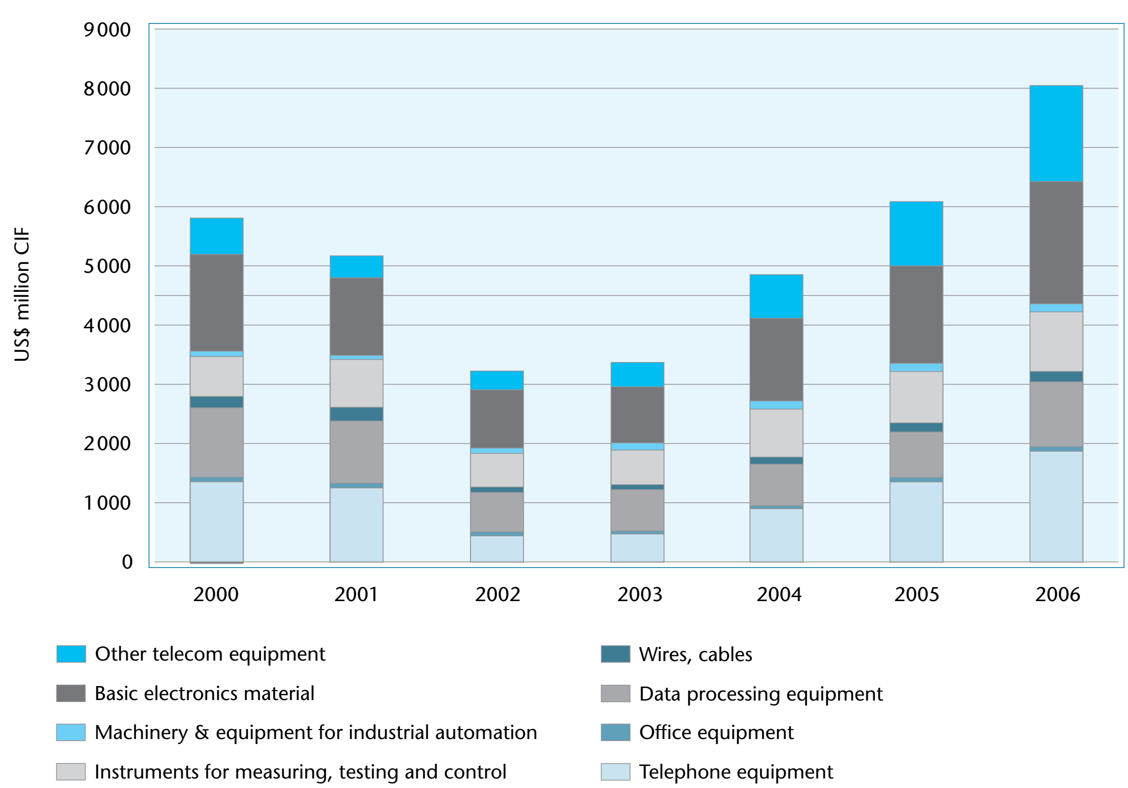
tion in the ICT industry affected the trade performance of ICT firms in São Paulo.

The first dimension of this impact, as shown in Figure 9.3, was the sharp contraction in exports by ICT firms in São Paulo between 2000 and 2003, especially in telecom and data processing: exports of telephone equipment fell 42%, exports of other telecom equipment fell 45%, and exports of data processing equipment fell more than 80%, reflecting global saturation of demand as perceived by players in the sector.

Another dimension was the sharp drop in São Paulo's ICT imports in the same period, especially in telecom, as shown in Figure 9.4. At first glance the drop in imports can be understood as a reflection of the economic slowdown and hence of falling domestic demand. However, the drop in imports can also be understood as due to the drop in exports. This is because of the organization of ICT firms in global production networks (Ernst, 2004, 2006; Ernst & Kim, 2002) and the low level of local content in the inputs used by hardware manufacturers in São Paulo (and indeed throughout Brazil), so that any growth in exports by ICT firms in São Paulo leads to an increase in demand for part and components, most of which are produced in Asia. In other words, as can be seen from the trajectories of exports and imports in Figure 9.5, strong dependency on Asian inputs links the level of production and exports by São Paulo's ICT industry to the level of demand for imported inputs.

U.S. economic growth and the increase in global liquidity driven by expansionary fiscal and monetary policy in the U.S. led to a period of accelerating global economic growth after 2003, with world demand for ICT-intensive goods rising strongly. This increase in demand was reflected in rising exports by ICT firms in São Paulo between 2003 and 2006. It is important to note that the Brazilian real appreciated continuously against the U.S. dollar during this period of growth (Figure 9.6), favouring imports but not exports. This points to the probability that the effect of the exchange rate on competitiveness was less important to the export performance of São Paulo's ICT firms than other

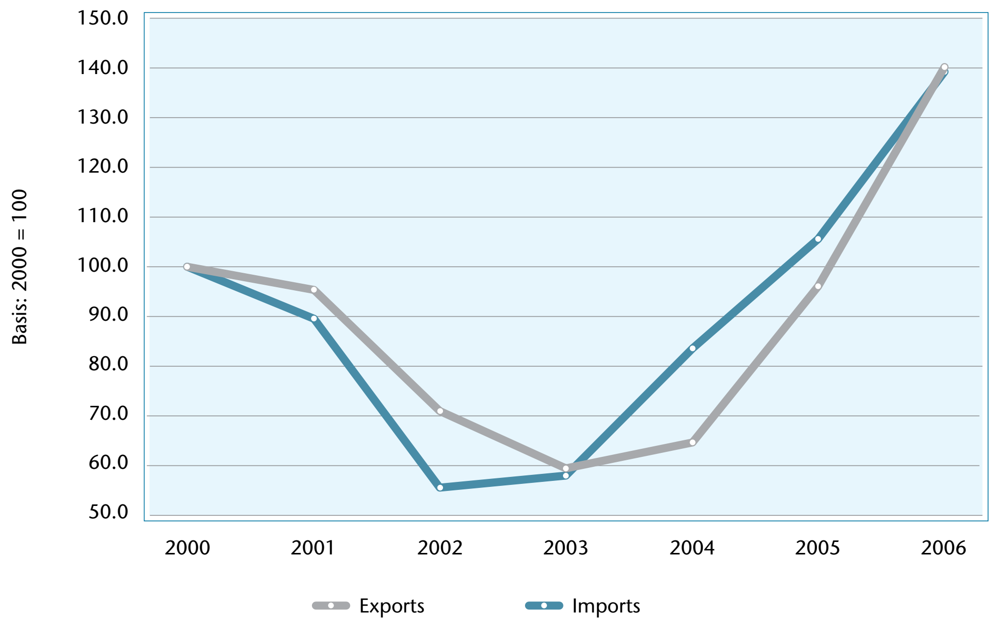
Figure 9.4
ICT imports by segment – São Paulo State, 2000-2006



Source: MDIC, Secex.

Note: See Detailed Table 9.4.

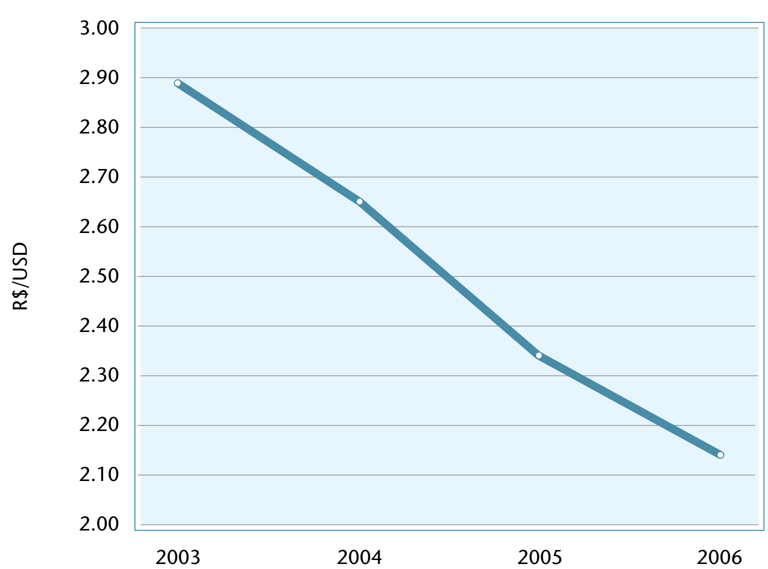
Figure 9.5
ICT exports and imports as indices – São Paulo State, 2000-2006



Source: MDIC, Secex.

Note: See Detailed Table 9.5.

Figure 9.6
Exchange rate – Brazil, 2003-2006



Source: Central Bank of Brazil.

Note: 1. End-of-period exchange rate calculated by Central Bank (PTAX).
2. See Detailed Table 9.6.

factors, such as global location strategies for manufacturing activities adopted by transnational firms.

Alongside export growth, São Paulo's ICT imports rose 140.3% in the period, reaching US$8 billion in 2006 (according to calculations based on Detailed Table 9.4). It can be argued that this rise in imports was influenced not just by domestic economic growth, local currency appreciation and hence falling dollar prices of ICT equipment, but also by the growth in exports, which reached 136.5% in the period (Detailed Table 9.3).

Despite these quantitative fluctuations in the period 2000-06, the composition of both export and imports remained relatively unchanged.

These statistics show that export growth in the period was due almost entirely to expanding sales of telephone equipment (as can be seen by examining Figure 9.3). Besides accelerating global economic growth, another factor that may have driven export growth in this segment is increasing demand for mobile phones, due to expansion of the segment's capacity to offer integrated multimedia solutions (such as digital cameras, scheduling and other personal applications), and solutions associated with increased mobility (e.g. mobile banking, email and content).

Imports by ICT firms in São Paulo also rose in the period, possibly owing to a growing need for inputs for the manufacturing of exports, as well as growth in domestic demand. It should also be stressed that despite the substantial growth in imports in the period 2003-06, this growth does not yet fully reflect the explosion of demand for personal computers (PCs) in Brazil, which intensified from 2007 as a result of a combination of the following factors: (i) local currency appreciation, (ii) greater availability of credit, and (iii) the implementation of public policy incentives for the purchase of PCs (see Box 1: The Computers For All Program).[9]

Box 1: The Computers For All Program

Besides the Informatics Law (Law 10176, enacted in 2001), another important instrument designed to promote the development of the Brazilian IT equipment industry is the Computers For All Program. Included in a package of tax incentives known as "MP do Bem"[10] and associated with the federal government's digital inclusion program, Computers For All establishes incentives for the production and marketing of PCs. The main incentives are exemption from PIS-Pasep and Cofins tax at 9.25% for end-users on PCs costing up to R$ 4,000 each and special lines of credit to finance the purchase of PCs costing up to R$ 1,400 each. These lines can be extended directly to consumers via public-sector banks or indirectly via onlending to retailers under a special program run by BNDES, the national development bank.

To qualify for the program, computers must be produced in accordance with the requirements of the Basic Production Process[11] and comply with a number of technical specifications for hardware and software, such as internet connectivity and installation of at least 26 open source software programs with certain functionalities and other required features.

In response to the effects of these measures, combined with the fall in international prices of computer equipment and local currency appreciation to third-quarter 2008, the Brazilian PC market has displayed significant growth, alongside a reduction in the "grey market" relative to the total. According to the Brazilian Electronics & Electrical Industry Association (Abinee), sales of PCs grew 46% to 8.3% million units in 2006. In first-half 2007, sales of desktop computers rose 20% year over year (reaching 4.3 million units), while sales of laptops or notebooks rose 146% (to 167,000). According to International Data Corporation (IDC), the share of contraband or pirated products fell from 70% in 2005 to about 55% in 2007.

10. On November 21, 2005, Brazil's President signed Law 11,196 containing provisions originally part of Provisional Measures (MP) 252/2005 and 255/2005 (MP do Bem) including tax incentives for software and IT equipment, digital inclusion projects and technological innovation.

11. PPB in Portuguese. This is a requirement of the Informatics Law and Manaus Free Trade Zone legislation specifying the minimum stages of manufacturing a company must complete in order to qualify for tax breaks.

9. For a more detailed discussion of the PC market's performance in Brazil and São Paulo, see Igliori & Diegues (2008), available at <www.desenvolvimento.sp.gov.br>.

Besides the sharp swings seen in the period 2000-06, another element worth highlighting in the analysis of São Paulo's ICT exports and imports is the striking difference in their composition. Imports were far more diversified in terms of ICT segments than exports, in which telephone equipment predominated.

The main reason for which telephone equipment accounted for some 70% of São Paulo's ICT exports is the presence of subsidiaries of large multinationals that operate in the segment. These subsidiaries are typically integrated in a global network, and the São Paulo ICT industry's participation in international trade is strongly conditioned by the parent companies that command their respective supply chains. Firms in São Paulo are part of these chains, acting as net importers of parts and components for assembly of finished products, which they then export. Hence the large share of telecom equipment in exports and the greater diversification of imports.

Notwithstanding the vigorous growth in exports and imports by São Paulo's ICT firms, their share of Brazilian trade flows fell during the period. In exports, São Paulo's ICT firms accounted for 73.2% of the Brazilian total in 2000 and 58.2% in 2006 (recovering from 43.7% in 2005). The fall was shallower in imports, with São Paulo accounting for 57.8% in 2000 and 52.3% in 2006 (Figure 9.7).

The main reason for the fall in exports was deconcentration in the segments "telephone equipment" and "other telecom equipment". São Paulo's exports fell as a share of the Brazilian total for these segments from 95.3% to 64.3% and from 63.1% to 36% respectively between 2000 and 2006 (MDIC, 2007).

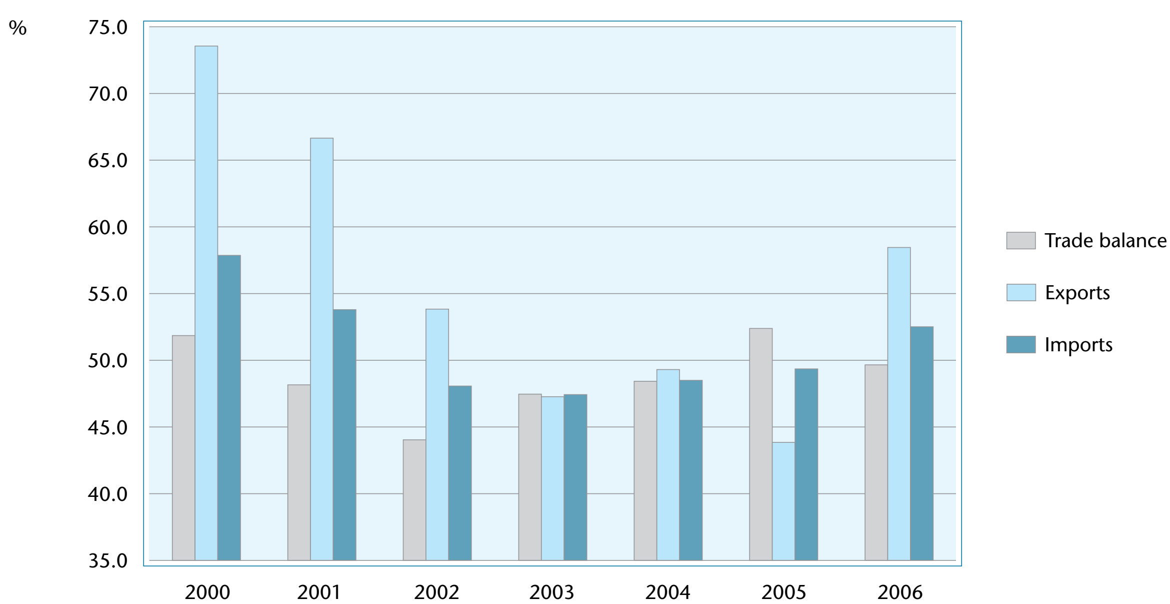
As for imports, deconcentration was less significant in the period and occurred mainly in data processing and basic electronics material. São Paulo's share of ICT imports in these segments fell from 67% to 44% and from 56% also to 44% respectively.

In data processing equipment, this deconcentration was basically due to the entry of new players with a growing share of the national market, including Positivo in Paraná and firms in the Ilhéus/Itabuna area of Bahia, such as Leadership and Novadata.

In the segment "basic electronics material", which consists mainly of inputs for production of a wide range of electronics goods, the primary explanation for São Paulo's loss of share is geographical deconcentration of IT equipment manufacturing, alongside the rise of other centers of telecom equipment and mobile phone production, especially the Manaus Free Trade Zone.

As a result of this concomitant reduction in São Paulo's contribution to Brazilian ICT exports and imports, its share of the national ICT trade balance remained relatively constant throughout the period (Figure 9.7).

Figure 9.7
Participation of São Paulo State in Brazil's ICT trade deficit, exports and imports – 2000-2006



Source: MDIC, Secex.

Note: See Detailed Table 9.7.

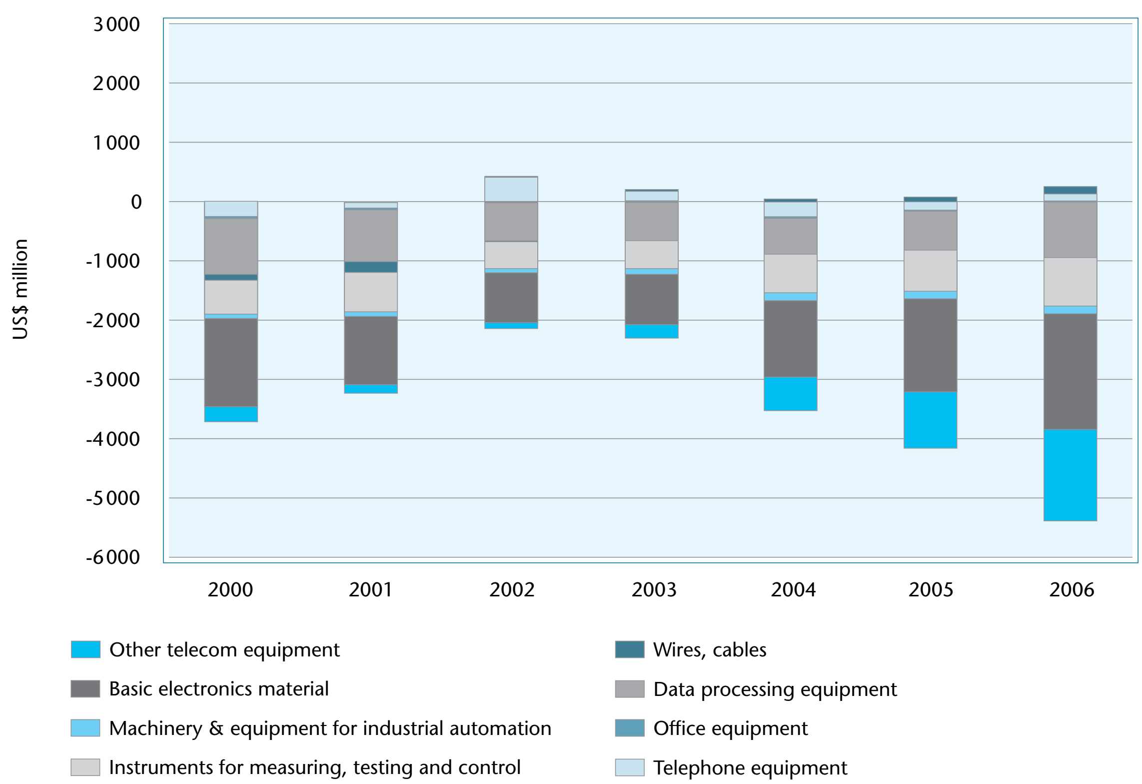
It is important to note the large and growing trade deficit displayed by ICT activities in São Paulo (as well as Brazil), exceeding US$5 billion in 2006 (Figure 9.8). This reflects the structure of the ICT industry in the state (and in Brazil), as well as the adoption of a global segmentation strategy by multinational corporations in accordance with their typical network paradigm.

Assuming that the ICT industry's trade performance can offer some elements for an understanding of its competitiveness and potential technological development, an analysis of the ICT trade balance in São Paulo points to several structural features of the industry.

The first of these features is the industry's inability to produce a trade surplus even in the context of vigorous export growth. The network paradigm is a useful analytical tool to identify the reasons for the positive correlation between ICT export and import flows in São Paulo. The explanation is that exports consist mostly of communications equipment whose production mainly requires parts and components not produced locally, so that export growth necessarily entails import growth. Thus because of the ICT industry's structural characteristics with regard to the production of parts and components, the sector was consistently unable to produce a trade surplus despite the substantial rise in exports in the period 2003-06.

Another characteristic, which derives from the first, is the apparent inability of ICT firms in São Paulo to position themselves in the global marketplace based on capabilities and expertise that differentiate them in the context of the sector's competitive and innovation-related dynamics.[12] In other words, ICT firms in São Paulo appear to occupy a hierarchically inferior position in the global value chain since their capacity to add value is relatively small. This positioning of São Paulo's ICT activities in the global value chain can be

Figure 9.8
ICT industry trade balance by segment – São Paulo State, 2000-2006



Source: MDIC, Secex.

Note: See Detailed Table 9.8.

12. For a discussion of the core features of competition and innovation dynamics in the ICT sector, see Diegues (2007).

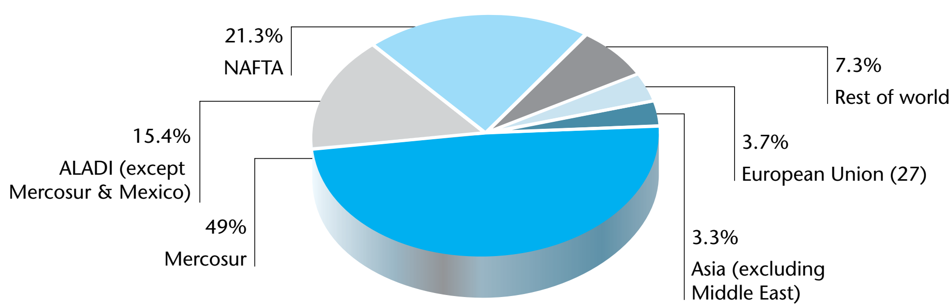
evidenced more clearly by an analysis of the segmentation of exports and imports by destination and origin.

With regard to exports, the superior competitiveness of ICT firms in São Paulo (and Brazil) compared to those of other Latin American countries and the strategy pursued by multinationals to transform their subsidiaries in São Paulo (and Brazil) into platforms for exporting to the rest of the region (and the rest of the Americas) means that the member countries of Mercosur,[13] NAFTA[14] and ALADI[15] are the main destinations for São Paulo's ICT exports, accounting for 49%, 21.3% and 15.4% of the total respectively (Figure 9.9).

As for imports, Asia is the origin of practically two-thirds of São Paulo's ICT imports, reflecting almost complete domination of the global supply of ICT parts and components by Asian countries (Figure 9.10).

Notwithstanding Asia's emergence as a major center for ICT exports, especially parts and components, U.S.-based multinationals still control techno-

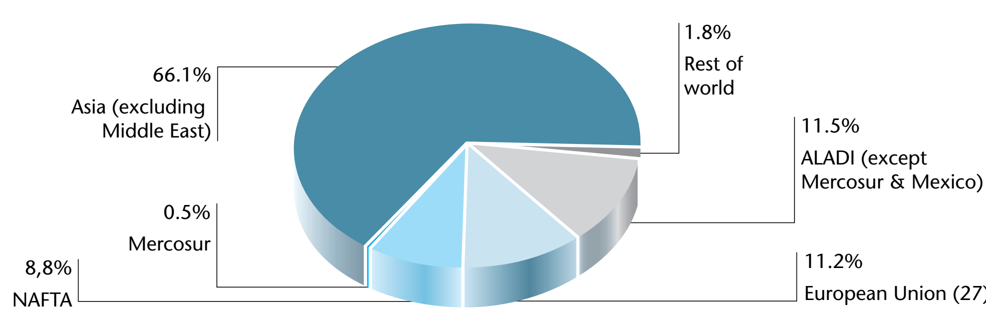
Figure 9.9
ICT exports by destination – São Paulo State, 2006



Source: MDIC, Secex.

Note: See Detailed Table 9.9.

Figure 9.10
ICT imports by origin – São Paulo State, 2006



Source: MDIC, Secex.

Note: See Detailed Table 9.10.

13. Common Market of the South, South America's largest trading bloc. Full members are Argentina, Brazil, Paraguay and Uruguay.
14. North American Free Trade Agreement, signed by Canada, the United States and Mexico to form a trilateral trading area in North America.
15. Latin American Integration Association (also known as LAIA), created by Argentina, Bolivia, Brazil, Chile, Colombia, Cuba, Ecuador, Mexico, Paraguay, Peru, Uruguay and Venezuela.

logical development and innovation in the global ICT value chain. These firms control the establishment and evolution of technological paradigms, which are "the most important structural elements for the consolidation of the sector's dominant technological platforms", and these platforms in turn are "the main factors that determine the dynamics of competition and innovation in these activities" because they enable their controllers to "appropriate privately the benefits of the externalities that characterise *ICT*" (Diegues 2007, p. 140),

Thus although Asia is the origin for a significant proportion of São Paulo's ICT imports, the importance of this continent is largely due to the supply of parts and components, which are increasingly commoditized products. With software taking over from hardware as the main driver of innovation in ICT, software development and production increasingly accounts for the hierarchically superior functions of the ICT industry.

Unlike trade in tangible goods, trade in software and telecom services is difficult to measure. The available consolidated trade statistics are limited to transactions involving tangible merchandise classified according to the Mercosur Common Nomenclature (NCM), which is consistent with the Harmonised System (HS). Equivalent information is not available for trade in ICT services including telecom services as well as software and IT services. As a result, it is not possible to present the trade balance in services either for Brazil or for São Paulo, despite the important contribution of services to both GDP and foreign trade.

However, IBGE's Annual Survey of Services (PAS) can be used to estimate the value of exports by some of the firms classified as providers of ICT services in Brazil and São Paulo. These data show that São Paulo State accounts for the lion's share of Brazilian service exports by value (Table 9.7).

Calculations based on Table 9.7 show that firms in São Paulo account for 78% of total Brazilian ICT service exports, for 69.5% of exports of telecom services and for 90% of exports of software and IT services.

Exports account for a very small share of total revenue for ICT service firms in São Paulo. As shown in Table 9.8, only 4% of these firms' net operating revenue came from service exports in 2005.

The data indicate that ICT service firms in São Paulo focus on the domestic market. This focus results from the history of the ICT service sector's development in Brazil, and particularly in São Paulo. ICT service firms were originally established, and have since grown, with organic links to a complex and diversified production structure.

Thus the low export coefficient does not necessarily mean fragility or even lack of competitiveness. This is a characteristic that distinguishes the Brazilian model of development of ICT services, especially software, from other successful cases of development of these activities in non-central economies.[16]

Table 9.7
Exports of ICT services by main activity – Brazil & São Paulo State, 2005

Main activity	Exports of ICT services		
	Brazil (R$)	São Paulo State (R$)	SP/BR (%)
Total	**911,665,129**	**707,971,329**	**77.7**
6420 - Telecommunications	546,155,931	379,504,673	69.5
7210 - Hardware consulting	88,557,408	85,437,336	96.5
7221 - Development and publishing of software ready for use	136,083,279	120,036,958	88.2
7229 - Development of customized software and other consulting in software	130,898,489	114,892,001	87.8
7230 - Data processing	5,712,057	3,913,026	68.5
7240 - Database activities and online distribution of electronic content	0	0	-
7250 - Maintenance and repair of office and computer equipment	3,448,587	3,448,587	100.0
7290 - Other IT activities not elsewhere specified	809,379	738,748	91.3

Source: IBGE, PAS 2005; PIA 2005.

16. For a discussion of this aspect of the Brazilian software industry, see Roselino (2006).

Table 9.8
Shares of domestic and foreign markets in ICT service firms' net operating revenue by main activity - São Paulo State, 2005

Main activity	Net operating revenue from		Exports/net operating revenue (%)
	Domestic market (R$ 000)	Foreign market (R$ 000)	
Total	**44,045,787**	**1,724,052**	**3.9**
6420 - Telecommunications	29,865,782	924,170	3.1
7210 - Hardware consulting	2,269,270	208,057	9.2
7221 - Development and publishing of software ready for use	1,873,400	292,314	15.6
7229 - Development of customized software and other consulting in software	5,826,338	279,785	4.8
7230 - Data processing	2,392,176	9,529	0.4
7240 - Database activities and online distribution of electronic content	172,140	0	0.0
7250 - Maintenance and repair of office and computer equipment	1,181,578	8,398	0.7
7290 - Other IT activities not elsewhere specified	465,103	1,799	0.4

Source: IBGE, PAS 2005; PIA 2005.

As can be seen from Table 9.7, telecom services account for the largest proportion of export value among the activities listed. Even so their share of net operating revenue is only 3.1%, whereas the largest contribution comes from exports of software ready for use, which account for 15.6% of NOR (Table 9.8).

4. The secondary dimension of ICT firms' software activities and related services in São Paulo[17]

The purpose of this section is to put forward a methodology capable of measuring the secondary dimension of software and related services in São Paulo. The secondary dimension concept used in this chapter refers to software activities and related services performed outside the software industry. In other words, this dimension encompasses the development, production, commercialization and maintenance of software and related services not performed by firms classified as belonging to the software sector.[18]

Among the main configurations of these activities in the industry's secondary dimension are their presence as onboard components and inputs for the production process. Another important part of this secondary dimension is the production and commercialization of software by firms for which these activities are not the main source of revenue.

In order to circumvent the statistical limitations to the measurement of the secondary dimension of software activities and related services, while at the same time producing information with a high degree of international comparability, the methodology is based on a reference framework proposed by the OECD. It should be stressed that this concern with international comparability is justified by the global lack of statistical information capable of measuring the secondary dimension of ICT, a lack which is currently being addressed by several national statistics offices as well as the OECD. The task is complex and international

17. The methodology briefly outlined in this chapter and its main conclusions are among the results of research by Roselino and Diegues conducted as part of a broader research project executed under the coordination of Softex. Known as the Softex Observatory, this project aims to design and implement an information system for the Brazilian software and IT service industry and to establish a national and international framework of indicators and concepts for the sector. The application of this methodology to Brazil is presented in Diegues & Roselino (2009). The researchers were assisted while designing the methodology by valuable comments from several members of the Softex Observatory, especially Virgínia Duarte, Antonio Carlos de Junqueira Botelho and José Vidal, to whom thanks are due.

18. Firms classified as belonging to the software sector comprise the primary dimension of software activities and related services.

efforts to develop an acceptably reliable methodology have so far produced fairly incipient results.

As noted in Section 2 above, ICT activities have specificities that greatly hinder their measurement. These difficulties largely derive from three intrinsic features of ICT activities, namely: (i) the fact that production of ICT goods and services takes place in a wide array of economic sectors; (ii) the transversality and pervasiveness of these activities; and (iii) their immateriality.

The OECD has worked hard to overcome these difficulties and make progress in measuring ICT. Its systematic research efforts in this field aim above all to "ensure the continued improvement of the methodology for the collection of internationally comparable data for measuring ICT supply and demand" (OECD, 2007). These efforts are coordinated by the Working Party on Indicators for the Information Society (WPIIS), set up in 1998, and since then the OECD has become the focus for international initiatives to measure ICT activities.

Among the results of these efforts it is worth highlighting substantial advances in the definition of ICT activities, their aggregation in economic sectors based on the International Standard Industrial Classification (ISIC), and the definition of ICT goods.[19] Thanks to these efforts a methodological framework has been established for ICT industry measurement with a high degree of precision and international comparability.

However, as discussed in Section 2 above, only some ICT activities take place in the ICT industry proper. In other words, ICT activities take place in a wide array of different economic sectors because of the particularities of ICT, especially its transversality and pervasiveness.

The main component of ICT's transversality is its use as a technological or production input in many activities and economic sectors, embodied in ICT goods and services produced internally by firms for their own consumption (e.g. management systems developed solely for use by a specific firm for use in the production process and hence not commercialized) or as onboard components of other goods. Direct measurement of the transversal dimension of these activities is incompatible with the traditional statistical instruments used internationally in economic research.

With regard to the production of goods and services for onboard components of other goods, the limitation derives mainly from the difficulty of constructing methodologies capable of measuring the value added by ICT activities. The perception of value for end-users is associated with a complete set of functionalities (when a purchase is materialized in a physical good) or with the ability to provide a given solution (when ICT services are acquired). A good example of this methodological difficulty is the impossibility of segregating the values of software and hardware components in mobile phones and telecom equipment generally. Despite the tendency for hardware to become commoditized (Galina, 2003) and for software to be increasingly responsible for differentiation of these products, neither consumers nor producers are able to separate out the value attributed to each of these components. Ultimately this limitation derives from the technological characteristics of the sector, since the materialization of a given ICT product occurs only when the hardware and software are integrated. Thus, as noted by Steinmueller (1995, p. 2), "every application of information technology has required complementary 'software' – computer instructions that transform the tabula rasa of computer hardware into machines that perform useful functions".

With regard to in-house production of ICT goods and services for own consumption, the main difficulty with statistical measurement resides in the level of aggregation used by economic surveys. Owing to methodological limitations, most such surveys are unable to capture data with sufficient disaggregation to identify, classify and measure the value of countless ICT products, services and solutions used in the production processes of the companies surveyed. Because ICT activities are embodied in a broad array of goods and services with short life cycles, it would be very expensive to increase the level of statistical disaggregation. Moreover, the statistics have to be constantly updated to keep up with the constant changes in ICT products and services, making the maintenance of international comparability and above all of standardized time series especially difficult when high levels of disaggregation are used.

In addition to all these limitations, the value of ICT activities for own consumption is as hard to estimate as that of onboard components. This occurs because goods and services for own consumption are not exposed to the market selection environment and any attempt at valuation must therefore be highly arbitrary. In other words, the value attributed to ICT activities for own consumption depends to a significant extent on the user's perception of the value of the full set of solutions they are designed to execute, so that estimating reference prices based on the average market prices for final goods and services may produce highly inconsistent results.

19. A detailed discussion of the limitations and methodological advances in the measurement of ICT activities is presented by Mendes (2007).

Another important element that contributes to the difficulty of measuring ICT is the fact that firms not classified as part of the ICT industry (because their revenue comes mainly from other activities) produce a significant proportion of ICT goods and services.

Because statistical surveys classify firms according to their main source of revenue, they aggregate and measure a firm's entire revenue as if it all came that core business even when revenue from secondary activities is included. Thus the revenue earned from sales of software and ICT services by firms of acknowledged importance in these activities, such as banks, are not booked under the software industry but included in the aggregate revenue of the industry concerned, such as financial services in the case of banks.

In sum, while international research efforts based on the OECD framework have advanced on several fronts in measuring the economic value of ICT production and commercialization (i.e. the primary dimension), little progress had been made towards measuring ICT services in other sectors (i.e. the secondary dimension).

The intrinsic characteristics of software activities and related services, such as immateriality and the impossibility of delimiting precisely and in a standardized manner a very large universe of diversified activities that are undergoing constant qualitative changes, make defining a standard "list" of ICT services with a high degree of representativity an extremely arduous task.

The methodology proposed in this section for the measurement of the secondary dimension of software activities and related ICT services is divided into five general stages (Chart 9.2).

In the first stage, which consists of a scope definition, the first step is to delimit the geographical dimension (in this case São Paulo State) and time horizon (2005).[20] The next step entails delimiting the scope of the activities to be measured. Using the OECD framework, this measurement effort is confined to software activities and related services (whose primary dimension is classified under CNAE Division 72).

Concluding the first stage of the methodology, the scope definition identifies the economic sectors to which the effort to measure the secondary dimension of software activities and related services will be applied. For the purposes of this chapter, the methodology was applied to the measurement of the secondary dimension of all economic activities in São Paulo State, corresponding to CNAE Divisions 1-99. One of the main advantages of the proposed methodology is the possibility of applying it at very high levels of disaggregation (both sectoral and geographical). Thus, for example, it is possible to measure the secondary dimension of software activities and related services for a given municipality at the maximum level of sectoral disaggregation.[21]

The second stage of the methodology consists of identifying the types of occupation present in the software industry and related services (Table 9.9). This involved using the Ministry of Labor's Annual Employee Register (RAIS) to identify the main occupations present in the industry based on the Brazilian Classification of Occupations (CBO).[22] The RAIS database was chosen as the main source for this purpose for the following reasons, among others: (i) all the variables it contains are internationally comparable; (ii) several variables are highly disaggregated (e.g. sectors,[23] location and occupations, among many others); (iii) data can be cross-referenced in many ways; (iv) it is an official source with standardized time series; and (v) many

Chart 9.2
Stages in measuring the secondary dimension of software activities and related ICT services

Stages in measuring the secondary dimension of software activities & related ICT services
1) Scope definition
2) Identification of all different types of occupation present in software industry and related services
3) Segmentation of occupations in software industry and related services into qualitatively distinct groups
4) Calculation of value added coefficient (VAC) for each occupation
5) Measurement of secondary dimension of software activities and related services

20. The justification for choosing 2005 as the base year is that at the time of writing this was the most recent year for which all the information required to produce the methodology was available from the various databases involved.

21. At the maximum level of sectoral disaggregation it is possible to identify CNAE classes to four digits.

22. The Brazilian Classification of Occupations (Classificação Brasileira de Ocupações, CBO) was established in 1977 in accordance with guidelines issued by the International Labor Organization (ILO) as part of Human Resources Planning Project BRA/70/550 and based on the 1968 International Standard Classification of Occupations (ISCO-68).

23. It is worth noting that RAIS covers all sectors of economic activity in Brazil, including all units of direct and indirect public administration in the public sector.

variables are available, including pay, educational attainment, firm size and type, and job turnover, among others. Alongside these positive points, the RAIS database also has a number of limitations, such as self-declaring, possible distortions in the data collected for multiunit firms, and coverage of only formal employment.[24]

An analysis of the occupational structure of São Paulo's software and related services industry (SPSS) in 2005 shows systems analysts and clerical workers in the majority, accounting for some 40% of a total amounting to over 82,000 employees (Table 9.9). As in other industries, there were significantly more employees classified as support workers and assistants than there were employees classified in the occupations intrinsic to the activities carried out by the industry.

The third stage consists of selecting the occupations in software activities and related services, and segmenting them into qualitatively distinct groups. The criterion used here was to select only occupations strictly and almost exclusively linked to software activities and related services.

This selection was made by means of a detailed examination of the Labor Ministry's description of all jobs (based on the international classification used by the ILO) for each of the occupational families found in the SPSS. This entailed exclusion of jobs that may involve performance of these activities in some cases but are mostly associated with a broad set of activities that do not relate to software production and related services.

The best example is the occupational family "Electronics technicians", which ranked fourth in the SPSS by number of employees, accounting for 4.3% of the total (Table 9.9), but cannot be said to be strictly and

Table 9.9
Employees in software and related services industry (primary dimension) by CNAE class and occupational family – São Paulo State, 2005

CNAE class & occupational family	Employees in software & related services industry	
	Abs. nos.	%
All occupational families	**82,027**	**100.0**
2124 - Computer systems analysts	16,141	19.7
4110 - Clerical workers in general, agents, administrative assistants	15,956	19.5
4223 - Telemarketing operators	5,251	6.4
3132 - Electronics technicians	3,514	4.3
3171 - Systems & applications development technicians	3,389	4.1
3172 - Computer operating & monitoring technicians	3,109	3.8
4121 - Data entry & transmission equipment operators	2,381	2.9
3133 - Telecom technicians	1,764	2.2
4131 - Accounting assistants	1,599	1.9
4221 - Receptionists	1,375	1.7
1423 - Sales, marketing & communication managers	1,257	1.5
3541 - Specialized sales technicians	1,147	1.4
5142 - Building/street conservation & maintenance workers	1,037	1.3
1421 - Administrative, financial & risk managers	1,036	1.3
4122 - Office boys	965	1.2
4101 - Administrative supervisors	944	1.2
1425 - IT managers	897	1.1
Other	20,265	24.7

Source: MTE, RAIS (2005).

24. Given this limitation, and the fact that some segments of the software industry employ informal workers or contractors engaged as legal entities, RAIS underestimates the total number of people employed in the industry.

almost exclusively linked to software production and related services. Thus although some electronics technicians potentially perform activities that can be classified under software production and related services, the majority perform activities far closer to those of the hardware industry.

This process led to the selection of 11 occupational families comprising a total of more than 34,000 employees, or 41.7% of the overall workforce in the SPSS. Outstanding among these families were "Computer systems analysts", which accounted for 47% of the total selected, and "Telemarketing operators", which accounted for 15.3%. Although jobs were classified on the basis of the activities actually performed in the firm and not necessarily in accordance with the formal job title, it should be noted that the activities performed by individuals in any given occupation family may differ qualitatively. Thus, for example, the activities performed by a systems analyst in a large telecom company and an analyst responsible for IT in a small supermarket obviously involve different levels of complexity, intensities of technical and tacit knowledge and up-to-date technology skills.

The next step following selection of the 11 occupational families was to group them into three qualitatively distinct segments based on factors such as proximity to software development activities, technological intensity, innovation potential, work complexity, the need for highly specific formal or tacit knowledge, and the capacity to add value. The resulting groups were as follows: SW1 – Software industry workers (directors of IT services, IT managers, computer engineers, computer systems analysts, systems and applications development technicians, including programmers); SW2 – Software and related services workers (network administrators, systems administrators, database administrators, computer operating and monitoring technicians, network operators, data entry and related equipment operators); and SW3 – Workers indirectly linked to the software industry (telecom technicians, telemarketing operators).

An analysis of the distribution of these groups in the SPSS (Table 9.10) shows a clear predominance of SW1, which accounted in 2005 for more than 60% of the employees in occupations linked to software activities and related services. It is worth noting that this

Table 9.10
Employees in software and related services industry (primary dimension) in proportion to total for São Paulo software and related services industry (SPSS) and selected occupations – São Paulo State, 2005

Selected occupational families	Employees in software and related services industry		
	Total (Abs. nos.)	% total SPSS	% selected occupations
Total software industry	**82,027**	**100.0**	
Total occupational families	**34,222**	**41.7**	**100.0**
Software industry workers (SW1)			
1236 - Directors of IT services	90	0.1	0.3
1425 - IT managers	897	1.1	2.6
2122 - Computer engineers	389	0.5	1.1
2124 - Computer systems analysts	16,141	19.7	47.2
3171 - Systems & applications development technicians	3,389	4.1	9.9
Software & related services workers (SW2)			
2123 - Network, systems & database administrators	731	0.9	2.1
3172 - Computer operating & monitoring technicians	3,109	3.8	9.1
3722 - Network operators, related equipment operators	80	0.1	0.2
4121 - Data entry & transmission equipment operators	2,381	2.9	7.0
Workers indirectly linked to the software industry (SW3)			
3133 - Telecom technicians	1,764	2.2	5.2
4223 - Telemarketing operators	5,251	6.4	15.3

Source: MTE, RAIS (2005).

group comprises most of the occupations associated with high-tech and potentially more innovative activities, i.e. the activities most directly associated with what can generically be considered software development and fundamental to analysis, design and specification.

When the analysis shifts to software activities and related services performed outside the SPSS, i.e. the secondary dimension, substantial quantitative and qualitative differences are observed. The first point to highlight is that the total number of employees in secondary-dimension software activities and related services in 2005 (218,100) was almost 6.5 times more than the number of employees in the first dimension (34,222), as can be seen by comparing Tables 9.10 and 9.11. The numbers for Brazil were 554,931 and 90,640 respectively, or 6.1 times (Detailed Tables 9.11 and 9.12). This confirms the transversality and pervasiveness of software activities, which play a key role in organization, management and competitiveness for a growing array of economic sectors.

However, the quantitative superiority of the secondary-dimension workforce varied in inverse proportion to technological complexity and innovation potential. For example, the number of telemarketing operators in the secondary dimension was more than 22 times the number in the primary dimension, while the multiples for systems analysts and computer engineers were only 2.5 times and 1.7 times respectively. All told, the distribution of occupations among secondary-dimension groups was practically a mirror image of the primary dimension, with SW1 and SW3 accounting respectively for roughly 60% and 20% of the primary dimension and about 26% and 61% of the secondary dimension.

Besides the impact of the burgeoning telemarketing sector in São Paulo on the structure of occupations in the secondary dimension, another element that explains this inversion is the fact that a significant proportion of the software activities and related services performed by firms that do not belong to the primary dimension reflect the use of software as a production input, mainly for management and control of the production process. These activities are technologically much less complex inasmuch as they involve the application of software as a tool to control routine tasks rather than software design and development, as evidenced by the smaller number of employees in the first group of occupational families (SW1).

Table 9.11
Employees in occupations linked to software activities throughout São Paulo's economy except software industry (secondary dimension) for selected occupational families – São Paulo State, 2005

Selected occupational families	Employees in occupations linked to software activities	
	Total (abs. nos.)	%
Total	**218,100**	**100.0**
Software industry workers (SW1)		
1236 - Directors of IT services	384	0.2
1425 - IT managers	5,226	2.4
2122 - Computer engineers	645	0.3
2124 - Computer systems analysts	40,046	18.4
3171 - Systems & applications development technicians	9,742	4.5
Software & related services workers (SW2)		
2123 - Network, systems & database administrators	2,470	1.1
3172 - Computer operating & monitoring technicians	13,865	6.4
3722 - Network operators, related equipment operators	1,614	0.7
4121 - Data entry & transmission equipment operators	11,385	5.2
Workers indirectly linked to the software industry (SW3)		
3133 - Telecom technicians	14,186	6.5
4223 - Telemarketing operators	118,537	54.3

Source: MTE, RAIS (2005).

The distribution of secondary-dimension occupational groups across economic sectors (Table 9.12) evidences the sectors with the most employees in software-related activities and offers an important indication of technological density in key areas of the economy. The findings of many surveys and qualitative investigations of this dimension are corroborated here, in terms of both the key economic sectors in the secondary dimension of software activities and the technological profile of the relevant occupations in these sectors.

Thus by far the largest sector for the secondary dimension in terms of the numbers employed is corporate services, with 45.9% of the total, followed by retail commerce (9.8%), postal services and telecom (6.7%), financial intermediation (6.3%) and wholesale commerce (3.5%).

The significance of corporate services, in which practically three times more people are employed than in the SPSS, is largely due to telemarketing, and this explains the preponderance of SW3. In addition, this sector also includes activities such as consulting and more routine jobs relating to ICT maintenance and administration services provided to large firms by contractors.

Another activity that stands out in the secondary dimension is commerce, both retail and wholesale, with some 29,000 employees in the selected occupations, or 13.4% of the total secondary-dimension workforce. There are two main reasons for the importance of commerce. The first is the influence of software on competitiveness in the sector, given the key role played by integrated processes for managing inventories, sales and distribution in the context of low profit margins. The second is the growing importance of electronic commerce to business strategies, both for supply-chain management and as an instrument for sales to end-customers.

With regard to the distribution of occupational groups in the commerce sector, it is worth noting that while SW3 is preponderant, accounting for roughly 45% of the total according to calculations based on Table 9.12, for both wholesale and retail, employment is more evenly distributed across all three categories than in other sectoral groups, pointing to the coexistence of some development functions, albeit not especially intense, with more routine management and control activities.

Financial intermediation is another important sector, accounting for 6.3% of total employment in

Table 9.12
Employees in occupational families linked to software activities (secondary dimension) by CNAE division except software industry – São Paulo State, 2005

CNAE divisions	Employees in occupational families linked to software activities				
	Total		Software industry workers (SW1)	Software & related services workers (SW2)	Workers indirectly linked to the software industry (SW3)
	Abs. nos	%			
Total	**218,100**		**56,043**	**29,334**	**132,723**
Total (%)		**100.0**	**25.7**	**13.4**	**60.9**
74 - Services mainly provided to business enterprises	100,065	45.9	8,636	6,219	85,210
52 - Retail commerce & repair of personal or household objects	21,443	9.8	6,932	4,697	9,814
64 - Postal services, telecom	14,609	6.7	2,228	576	11,805
65 - Financial intermediation	13,658	6.3	7,616	2,456	3,586
51 - Wholesale commerce, sales representatives or agents	7,675	3.5	2,998	1,190	3,487
85 - Healthcare & social services	5,931	2.7	1,182	1,656	3,093
91 - Associative activities	5,776	2.6	1,246	1,443	3,087
75 - Public administration, defence, social security	4,530	2.1	2,214	2,188	128
80 - Education	4,157	1.9	2,025	1,388	744
45 - Construction	3,438	1.6	539	391	2,508
30 - Manufacturing of office machinery & IT equipment	3,240	1.5	2,730	342	168
66 - Insurance, private pensions	3,114	1.4	1,040	371	1,703
Other	30,464	14.0	16,657	6,417	7,390

Source: MTE, RAIS (2005).

the selected groups. In this sector SW1 accounts for 55.8% of the software-related workforce in the sector, reflecting the technological density of its software activities and related services. This predominance of skilled labor reflects the prevalence of technology-intensive activities associated with software production, such as analysis and specification of requirements and engineering. The employment of a large permanent workforce in these activities is justified by the importance of ICT to various core elements of the business models commonly pursued in the financial services industry, not to mention the need for integration and constant evolution of the industry's ICT infrastructure to keep pace with change. Such elements include (i) the development of internet banking, mobile banking and information security solutions; (ii) real-time interconnection between the systems used by banks to manage financial transactions and terminals of various kinds (such as in-branch cash dispensers and ATMs that use electronic funds transfer or ETF solutions); and (iii) the performance of a vast and highly complex array of financial transactions involving countless domestic and foreign assets, securities and instruments.

Telecom is another leader of the secondary dimension, with 6.7% of total employment in the selected groups. There are two reasons for this, once again. The first is the outstanding importance of telemarketing, as evidenced by the fact that over 80% of jobs in the selected groups are SW3. The second is the strategic role played by software in the dynamics of innovation in telecom, given the growing commoditisation of hardware components in this industry (Galina, 2003; Suzigan et al., 2001, among others).

A breakdown of the total workforce employed in software activities and related services, cross-tabulated against firm size measured by the number of employees, shows telecom, R&D, IT equipment, retail commerce and corporate services in the lead (Table 9.13). In all these sectors, the numbers employed in software activities and related services by firms with 1,000 or more employees exceed 20% of the total workforce, with the proportion reaching 45.2% in the case of R&D and 32.7% in telecom.

This observation reinforces still further the above considerations regarding the importance of software activities to these sectors, since the ratios between the selected occupations and the total workforce for each sector are very close to those seen in the primary dimension of the industry. It can therefore be concluded from the data presented in Table 9.13 that the numbers employed in software activities and re-

Table 9.13
Employees in occupational families linked to software activities (secondary dimension) as percentage of workforce by CNAE division (except software industry) and firm size – São Paulo State, 2005

CNAE divisions	Firm size (no. of employees)	Employees in occupational families linked to software activities (%)
73 - Research & development	1,000 or more	45.2
64 - Postal services, telecom	1,000 or more	32.7
64 - Postal services, telecom	500 -999	31.1
30 - Manufacturing of office machinery & IT equipment	1,000 or more	26.6
52 - Retail commerce & repair of personal or household objects	1,000 or more	26.1
74 - Services mainly provided to business enterprises	1,000 or more	20.9
64 - Postal services, telecom	250 -499	19.5
65 - Financial intermediation	1,000 or more	18.9
66 - Insurance, private pensions	1,000 or more	18.4
65 - Financial intermediation	500 -999	18.2
30 - Manufacturing of office machinery & IT equipment (1)	-	18.2
64 - Postal services, telecom (1)	-	18.0
67 - Ancillary activities in financial intermediation, insurance & private pensions	250 -499	16.8
73 - Research & development (1)	-	16.0

Source: MTE, RAIS (2005).

(1) Considering all firms in sector regardless of size.

lated services by large firms, especially in telecom and R&D, are proportionally very similar to (or, in the case of R&D, greater than) the intensity seen in São Paulo's software industry, where they account for 41.7% of total employment in the selected occupational families (Table 9.10). However, it should be noted that this intensity (41.7% of the total) refers to all firms in the SPSS and not only to firms with 1,000 or more employees.

Secondary-dimension software activities are concentrated above all in large firms, especially those with 1,000 or more employees, which account for more than 50% of total employment in software activities and related services in the secondary dimension (Table 9.14). This observation suggests that despite the strong diffusion of ICT activities toward smaller firms, the use of ICT by large firms is still more intense.

This concentration tendency, however, varies from one group to another and is more pronounced in SW3 and less so in SW2. These differences are intrinsically related to the dynamics of competition in the sectors in which these jobs are concentrated, as SW3 are concentrated in telemarketing firms, most of them large, i.e. with 1,000 or more employees.

Similarly, because SW1 are concentrated in activities associated with software design and development, and because the competitive logic of these activities requires significant economies of scale, they naturally predominate in firms with 1,000 or more employees, albeit less intensely so than is the case for SW3.

Conversely, the competitive advantages leveraged by SW2 are often associated not with scale economies but with extensive geographical coverage and proximity to customers, since software activities and related services typically require customized solutions that are incompatible with componentisation and reuse. Thus jobs in this group are relatively evenly distributed among firms of different sizes compared with SW1 and SW3.

Having analyzed in detail the distribution of occupations in the primary and secondary dimensions of software activities and related services by economic sector and firm size, the methodology moves on to stage four, which entails calculating the value added coefficient (VAC) for each occupation.

The first step in calculating VAC consists of measuring average monthly pay in each of the 11 selected occupations in the SPSS. Next, average monthly pay is multiplied by the total number of employees in these occupations throughout the SPSS to obtain an estimate of the total monthly wage bill for these occupations in the SPSS (Table 9.15).

Table 9.14
Employees in secondary-dimension software activities by occupational family and firm size – São Paulo State, 2005

Size of workforce	Employees in secondary-dimension software activities by occupational family				
	Total		Software industry workers (SW1)	Software & related services workers (SW2)	Workers indirectly linked to the software industry (SW3)
	Abs. nos.	%			
Total workforce	**218,100**		**56,043**	**29,334**	**132,723**
Total	**218,100**	**100.0**	**100.0**	**100.0**	**100.0**
0-4	3,806	1.7	2.3	5.2	0.7
5-9	4,975	2.3	3.0	6.1	1.1
10-19	7,445	3.4	4.5	7.0	2.2
20-49	13,685	6.3	8.9	11.6	4.0
50-99	13,517	6.2	9.3	9.9	4.1
100-249	20,641	9.5	14.4	15.1	6.2
250-499	18,179	8.3	12.6	12.4	5.6
500-999	25,812	11.8	10.8	11.2	12.4
1,000 or more	110,040	50.5	34.2	21.5	63.7

Source: MTE, RAIS 2005.

Table 9.15
Employees in São Paulo software and related services industry (SPSS), average monthly pay and primary-dimension wage bill by occupational family – São Paulo State, 2005

Occupational families	Employees in SPSS			
	Abs. nos.	Average monthly pay (R$)	Monthly wage bill (R$)	% total wage bill
Software industry workers (SW1)				
1236 - Directors of IT services	90	5,202.50	468,225	0.6
1425 - IT managers	897	4,950.50	4,440,600	5.7
2122 - Computer engineers	389	4,599.87	1,789,350	2.3
2124 - Computer systems analysts	16,141	2,953.01	47,664,525	61.6
3171 - Systems & applications development technicians	3,389	2,081.01	7,052,550	9.1
Software & related services workers (SW2)				
2123 - Network, systems & database administrators	731	3,573.53	2,612,250	3.4
3172 - Computer operating & monitoring technicians	3,109	1,598.30	4,969,125	6.4
3722 - Network operators, related equipment operators	80	1,756.88	140,550	0.2
4121 - Data entry & transmission equipment operators	2,381	757.56	1,803,750	2.3
Workers indirectly linked to the software industry (SW3)				
3133 - Telecom technicians	1,764	1,604.97	2,831,175	3.7
4223 - Telemarketing operators	5,251	689.84	3,622,350	4.7

Source: MTE, RAIS 2005.

The wage bills for all occupations in the SPSS are then obtained from RAIS in order to determine the share of software activities and related services in the total wage bill for the SPSS (Table 9.16).

Once the share of occupations linked to software activities and related services in the total wage bill for the SPSS has been calculated, it is assumed that this share is equivalent to the relative contribution of software-related occupations to net operating revenue (NOR) in the SPSS. In other words, given that the wage bill for these occupations corresponds to 50.2% of the total wage bill for the SPSS, it is assumed that these occupations account for the same percentage of the industry's NOR.

Based on this hypothesis, it can be seen that the contribution of employees classified in the 11 selected occupations to total NOR in the SPSS was R$ 7.5 billion, or 50.2%, in 2005 (Table 9.17).

Table 9.16
Average monthly wage bill in São Paulo software and related services industry (SPSS) – São Paulo State, 2005

Occupations	Average monthly wage bill In SPSS	
	R$	%
Total	**154,295,155**	**100.0**
Selected occupations	77,394,450	50.2
Other occupations in SPSS	76,900,705	49.8

Source: MTE, RAIS 2005.

Table 9.17
Inputs to calculation of value added coefficient (VAC) based on wage bill in São Paulo software and related services industry (SPSS) – São Paulo State, 2005

Indicators	Inputs to calculation of VAC
Wage bill for software occupations/total wage bill for SPSS (%)	50.2
Net operating revenue of SPSS (R$)	14,979,887,000
Total contribution of software occupations to NOR of SPSS (R$)	7,513,169,011

Source: IBGE, PAS 2005; PIA 2005.

Table 9.18
Contributions of selected occupations to net operating revenue of São Paulo primary-dimension software and related services industry (SPSS) by occupational family – São Paulo State, 2005

Occupational families	Contributions of selected occupations to net operating revenue of SPSS (R$)
Total	**7,513,169,011**
Software industry workers (SW1)	
1236 - Directors of IT services	45,453,564
1425 - IT managers	431,077,142
2122 - Computer engineers	173,703,527
2124 - Computer systems analysts	4,627,097,061
3171 - Systems & applications development technicians	684,635,657
Software & related services workers (SW2)	
2123 - Network, systems & database administrators	253,587,638
3172 - Computer operating & monitoring technicians	482,384,408
3722 - Network operators, related equipment operators	13,644,078
4121 - Data entry & transmission equipment operators	175,101,426
Workers indirectly linked to the software industry (SW3)	
3133 - Telecom technicians	274,840,073
4223 - Telemarketing operators	351,644,437

Source: MTE, RAIS 2005; IBGE, PAS 2005.

Table 9.19
Annual value added coefficient (VAC) per employee (secondary dimension) by selected occupation family – São Paulo State, 2005

Occupational families	VAC (R$)	Employees (Abs. nos.)
Software industry workers (SW1)		
1236 - Directors of IT services	505,040	384
1425 - IT managers	480,576	5,226
2122 - Computer engineers	446,539	645
2124 - Computer systems analysts	286,667	40,046
3171 - Systems & applications development technicians	202,017	9,742
Software & related services workers (SW2)		
2123 - Network, systems & database administrators	346,905	2,470
3172 - Computer operating & monitoring technicians	155,157	13,865
3722 - Network operators, related equipment operators	170,551	1,614
4121 - Data entry & transmission equipment operators	73,541	11,385
Workers indirectly linked to the software industry (SW3)		
3133 - Telecom technicians	155,805	14,186
4223 - Telemarketing operators	66,967	118,537

Source: MTE., RAIS 2005; IBGE, PAS 2005.

The next step is to calculate the share of each of the 11 selected occupations in the total wage bill for the SPSS. Thus, for example, using the data in Table 9.15 it can be seen that computer systems analysts accounted in 2005 for 61.6% of the total wage bill for the selected occupations.

Each occupation's share of the wage bill is then multiplied by the São Paulo software industry's NOR to find its contribution to NOR. For example, in the case of systems analysts, their share of the wage bill is 61.6% and their contribution to the industry's NOR of R$ 7.5 billion is therefore R$ 4.6 billion (Table 9.18).

The contribution of each of the 11 selected occupations is then divided by the number of employees in each occupation to find its value added coefficient (VAC). The results are shown in Table 9.19. To take the same example, the contribution of systems analysts to NOR (R$ 4.6 billion) divided by 16,141 employees (Table 9.15) equals R$ 286,700 and this was their VAC in 2005.

In mathematical terms, VAC is calculated as follows:

$$VAC_i = [(WB_i / WBSS) * TCSS] / NE_i$$

Where:

VAC_i is the value added coefficient for occupation i

WB_i is the wage bill for occupation i

WBSS is the wage bill for the occupations linked to software activities and related services (SPSS)

TCSS is the total contribution in reais (R$) by the software-related occupations to the net operating revenue (NOR) of the SPSS

NE_I is the number of employees in occupation i.

The values of WBSS and TCSS for 2005 are R$ 77.4 million and R$ 7.5 billion respectively. The other values used to calculate VAC vary according to the occupation concerned.

Next it is assumed that VAC for each occupation in the SPSS is the same as VAC for the same occupation outside the SPSS, i.e. in the secondary dimension. The fifth and last stage of the methodology for each occupation entails multiplying the respective value of VAC by the number of wage or salary earners in the secondary dimension. Returning to the example of systems analysts once again, their VAC of R$ 286,700 is multiplied by the number of systems analysts employed in the secondary dimension, which is 40,046, as shown in Table 9.19. Finally, the SW1 dimension is the sum of the results of this multiplication for all the occupations comprised by this dimension, and the same procedure is repeated for SW2 and SW3.

Thus:

$$SW1 = \sum_{i=1}^{5} VAC_i * NE_i$$

$$SW2 = \sum_{i=6}^{9} VAC_i * NE_i$$

$$SW3 = \sum_{i=10}^{11} VAC_i * NE_i$$

Where
VAC_i is the value added coefficient for occupation i
NE_i is the number of employees in occupation i.

Thus it can be concluded that in São Paulo State the value added by the software activities of firms not part of the software industry is greater than that added by the activities of the industry itself. This is also true of the secondary dimension for Brazil, with value added of R$ 35.3 billion for SW1, R$ 11.5 billion for SW2 and R$ 16.6 billion for SW3 (Table 9.20).

Assuming that SW1 is the best proxy for the software industry proper, it can be said that in 2005, according to the estimate proposed in this chapter, software activities and related services in São Paulo State generated net operating revenue of R$ 31.4 billion, of which R$ 15 billion was generated in the primary dimension (Table 9.1) and R$ 16.4 billion in the secondary dimension. In addition, the secondary dimension of software activities and related services (SW2) and the secondary dimension of services indirectly related to the software industry (SW3) also generated significant NOR (R$ 4.1 billion and R$ 10.1 billion respectively). Complementing the discussion presented in Section 2, these findings once again underscore the transversality and pervasiveness of ICT activities.

Table 9.20
Value of secondary-dimension software and related services industry by subgroup – Brazil & São Paulo State, 2005

Subgroups	Value of secondary-dimension software industry (R$ billion)	
	Brazil	São Paulo State
Software industry workers (SW1)	35.3	16.4
Software & related services workers (SW2)	11.5	4.1
Workers indirectly linked to the software industry (SW3)	16.6	10.1

Source: MTE, RAIS 2005; IBGE, PAS 2005.

5. Indicators of ICT diffusion for Brazil and São Paulo State based on National Household Sample Survey (PNAD)[25]

The diffusion of ICT in any given society is often interpreted as a key element of competitiveness. Although this is somewhat reductionist, the strategic importance of ICT to the new technical and economic paradigm means that the adoption of ICT-intensive processes correlates positively with productivity gains in various sectors of the economy, although it is not the only such factor (see OECD, 2008, p. 284).

Complementarily, alongside the direct impact of the adoption of ICT-intensive processes, ICT diffusion to home users is another driver of higher productivity. The use of ICT in the home contributes, albeit indirectly, to the development of a minimum skill set that makes users familiar with the tools and techniques increasingly used in the sphere of production. In other words, home use of ICT can help develop the skills essential to higher productivity in the workplace.

In addition to the importance of ICT as an instrument for enhancing skills and productive workplace integration, ICT diffusion is also socially important. ICT enhances employability by facilitating networking[26] and access to essential public and private services. More significantly, ICT is often a necessary condition for the integration of citizens into society.

Bearing in mind the importance of access to ICT in its various aspects, this section analyzes indicators of ICT diffusion in São Paulo State, focusing on users because there are no official statistics with which to evaluate diffusion in economic activities.

According to PNAD, São Paulo State had 33.4 million inhabitants over the age of 10 in 2005, or about 22% of the Brazilian same-age population (149.5 million). Roughly 29% had used the internet at least once in the three-month reference period (IBGE, 2006).

Brazil had 31 million internet users in 2005, 31.7% of whom (9.8 million) were residents of São Paulo State. The proportion of the population with internet access in São Paulo was 29%, above the national average (21%), mainly as a reflection of higher per capita income (the data indicate that socioeconomic status strongly influences internet access). In Brazil the number of inhabitants aged more than 10 and earning up to the minimum wage corresponded to 57.6% of the total population and only 22.7% of internet users (IBGE, 2006; see Table 9.21).

Table 9.21
Population aged 10 or more who used internet in three-month reference period by per capita household income – Brazil & São Paulo State, 2005

Per capita household income	Population aged 10 or more who used internet in three-month reference period		
	Brazil (x 1,000)	São Paulo State (x 1,000)	SP/BR (%)
Total	**31,020**	**9,831**	**31.7**
No income to 1/4 of minimum wage	532	124	23.3
More than 1/4 to 1/2 of minimum wage	1,683	356	21.2
More than 1/2 to 1 minimum wage	4,836	1,194	24.7
More than 1 to 2 minimum wages	8,629	2,777	32.2
More than 2 to 3 minimum wages	5,021	1,747	34.8
More than 3 to 5 minimum wages	4,978	1,777	35.7
More than 5 minimum wages	5,341	1,856	34.8

Source: IBGE, PNAD 2005.

25. The main data source for this section is the Supplement "Internet Access and Ownership of Mobile Phones for Personal Use" to IBGE's National Household Sample Survey (PNAD) for 2005. This is justified despite recent changes in ICT diffusion, especially since the introduction of the Computers For All Program (see Box 9.1), by the fact that it is the only official source of data on ICT diffusion in Brazil. It is also worth noting that because the ICT diffusion data concerned come from a special supplement to PNAD, there is no guarantee that the data will be updated by further surveys.

26. Networking involves far more than merely participating in online social networks and Web 2.0.

Digital exclusion is one of the dimensions of social exclusion and is also found in São Paulo State (Tiriçá, 2003; Vaz, 2005) (Figure 9.11). The difficulty of accessing the internet and information technology generally for low-income households is a major obstacle to social mobility for a significant proportion of the population, since basic computer skills are increasingly essential to employability.

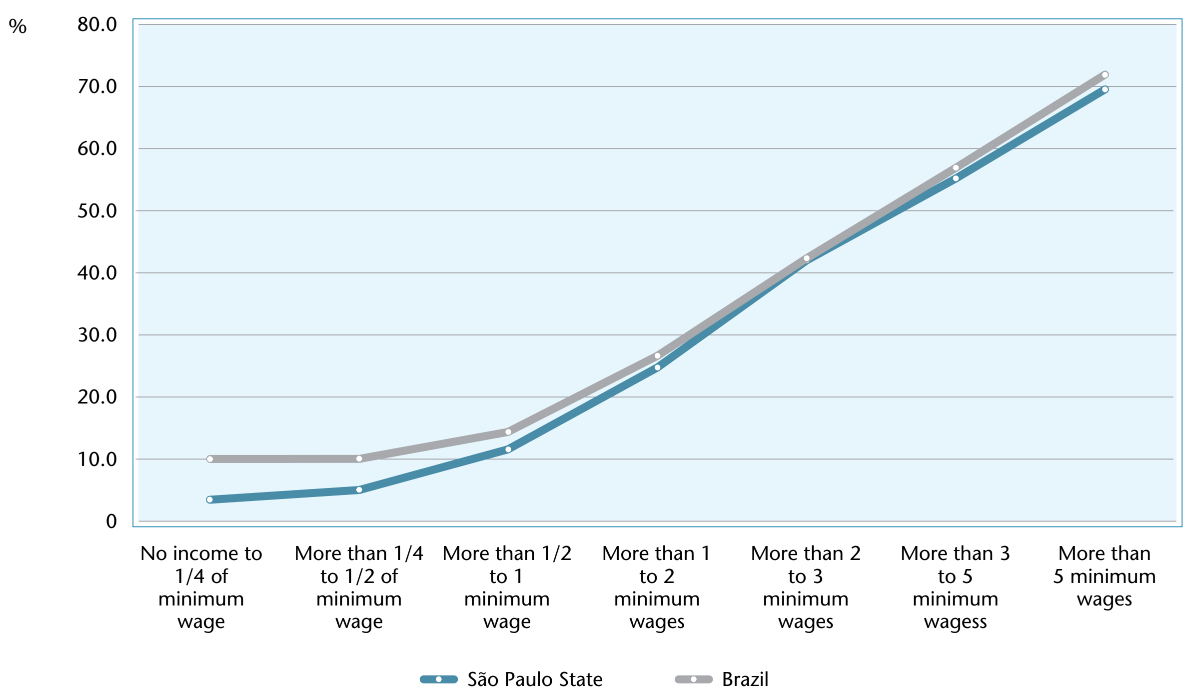
A digital inclusion policy is therefore a necessary, albeit not sufficient, condition for employability and to enable low-income citizens to have regular access to IT, so as to familiarize themselves with the operating systems used, with the internet, and the most widespread productivity tools, especially word processors and spreadsheets.

These elements are in themselves sufficient to justify the existence of large-scale public initiatives to facilitate internet access, such as the implementation and expansion of municipal and state telecenters (exemplified by the Acessa São Paulo program).

One very important initiative in São Paulo involves municipal telecenters in the state capital. Currently there are 150 telecenters located in different parts of the city according to socioeconomic criteria (average household income, age profile, and the São Paulo Social Vulnerability Index).[27] Serving some 390,000 people per month, this far-reaching structure, which is already operational, is a solid foundation for more effective initiatives designed to extend digital inclusion to vocational education, job creation and income generation.[28]

The importance of public facilities for low-income citizens to access the internet is evidenced by Figure 9.12. The figure shows that home access combined with workplace access is predominant for individuals belonging to households with per capita income equivalent to

Figure 9.11
Inhabitants aged 10 or more who used internet in three-month reference period by per capita household income – Brazil & São Paulo State, 2005

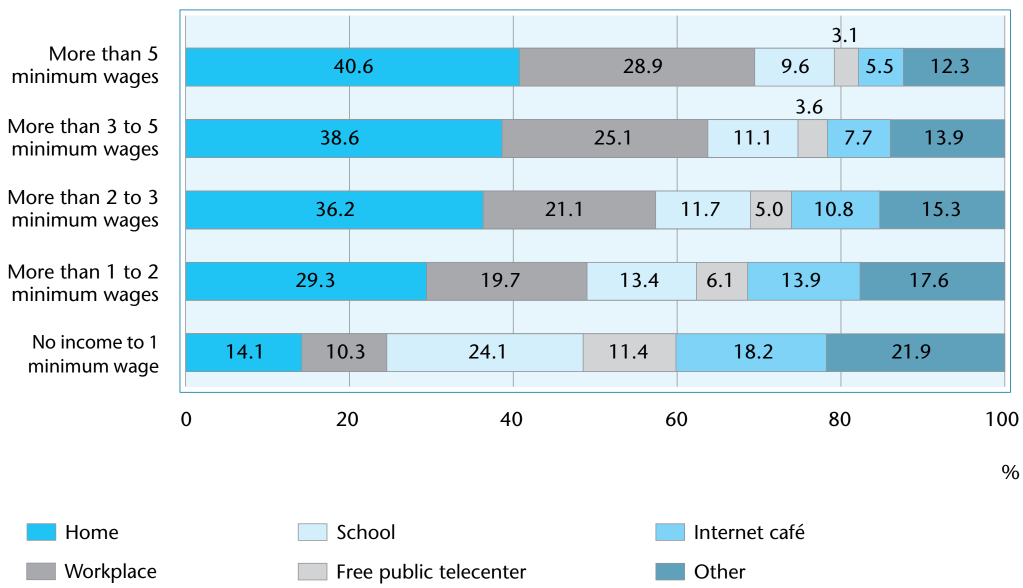


Source: IBGE, PNAD 2005.

27. This index, known locally by the acronym IPVS, was constructed with the aim of measuring the various factors that affect socioeconomic conditions in great breadth, considerable detail and with a high level of geographical disaggregation (the census sector, which corresponds to some 300 contiguous households). The IPVS is used to identify and locate spatially the areas in which the most vulnerable and poorest segments of the population live. To do so it takes multiple dimensions of poverty into account, including educational attainment, family life cycle and spatial segregation of families as well as income.

28. Vaz (2005) argues that this type of policy is important to foster digital inclusion but insufficient to promote employment and income generation.

Figure 9.12
Inhabitants aged 10 or more who used internet in three-month reference period by per capita household income and place of access – São Paulo State, 2005



Source: IBGE, PNAD 2005.

Note: See Detailed Table 9.13.

more than three times the minimum wage. For those in the lowest income bracket (less than the minimum wage), school and public telecenters (free of charge) or internet cafés (paid) are predominant and act as promoters of digital inclusion.

The importance of the internet as a means of communication and social contact for the population of São Paulo State is evidenced by Figure 9.13. These are the reasons for accessing the internet for 21.8%, who mainly use email, instant messaging services and social networks.

It is also worth noting the large proportions who say the use the internet for education and learning (21.3%), to read newspapers and magazines (13.4%), and for leisure (16.2%). The internet is an important alternative to the traditional mass media, such as TV, and a large proportion (40.9%) use the internet on a daily basis for this purpose (Figure 9.14).

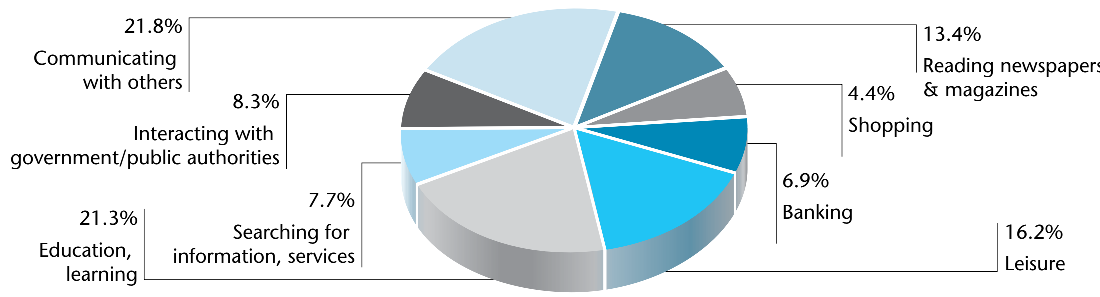
The data show that most internet users in São Paulo State (87.5%) do so at least once a week.

Although broadband (more than 56 kbps) has become more widely used in the recent past, the data for 2005 evidence the predominance of slow connections among home users of the internet (Figure 9.15).

Income levels are clearly a key determinant of connection speed for home users of the internet (Figure 9.16).

These data suggest that the cost of broadband is an important obstacle to the diffusion of high-speed internet access. Broadband access from the home predominated only among the relatively well-off (earning more than five times the minimum wage) in 2005. The proportion will have increased since then, thanks to falling prices and intensifying competition among broadband access providers (fixed-line telephone companies, cable companies and mobile carriers).

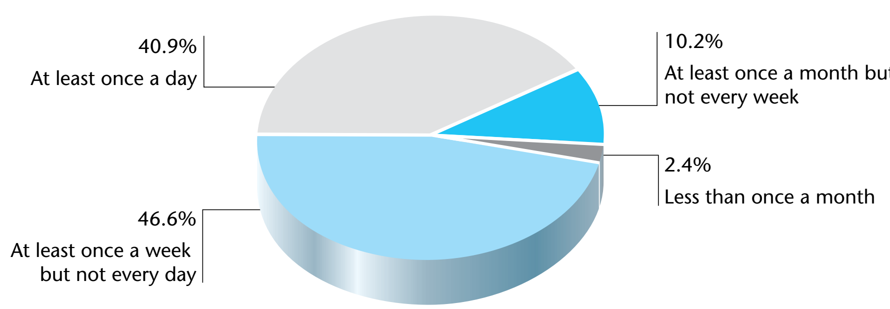
Figure 9.13
Inhabitants aged 10 or more who used internet in three-month reference period by reason for use – São Paulo State, 2005



Source: IBGE, PNAD 2005.

Note: See Detailed Table 9.14.

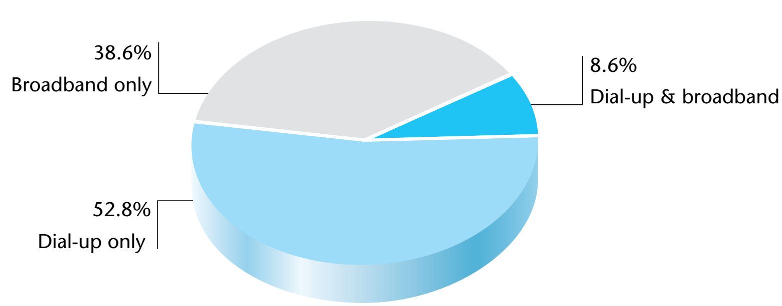
Figure 9.14
Inhabitants aged 10 or more who used internet in three-month reference period by frequency of use – São Paulo State, 2005



Source: IBGE, PNAD 2005.

Note: See Detailed Table 9.15.

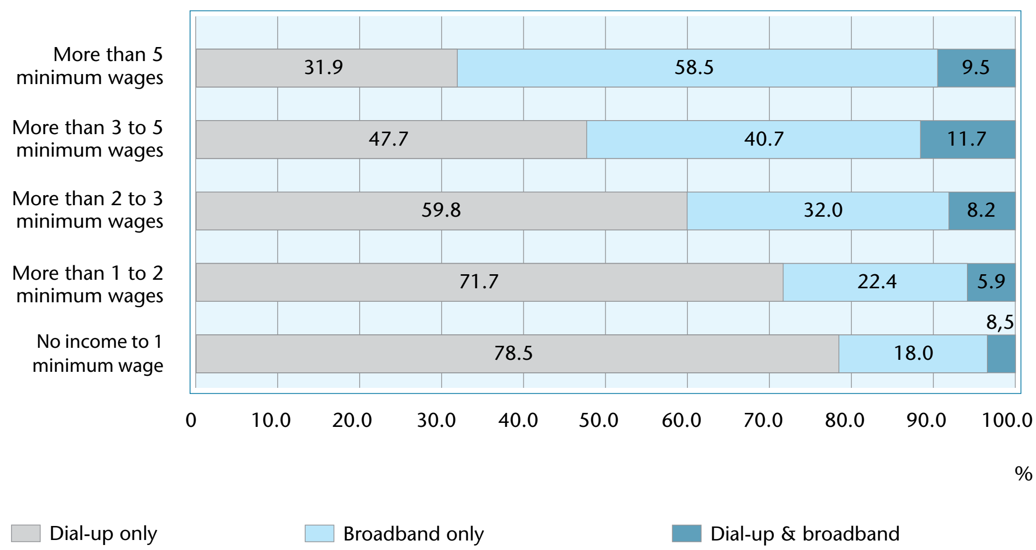
Figure 9.15
Inhabitants aged 10 or more who used internet at home in three-month reference period by type of connection – São Paulo State, 2005



Source: IBGE, PNAD 2005.

Note: See Detailed Table 9.16.

Figure 9.16
Inhabitants aged 10 or more who used internet at home in three-month reference period by monthly income and type of connection – São Paulo State, 2005



Source: IBGE, PNAD 2005.

Note: See Detailed Table 9.17.

6. Innovation by São Paulo's ICT firms: an analysis based on PINTEC data

ICT activities are knowledge-intensive (especially with regard to tacit knowledge) and highly dynamic in terms of technology. Thus an analysis of the innovation process in the ICT sector is essential to an understanding of how competition works and the elements that influence competitiveness,[29] how the value chain is organized, and how the sector participates in international trade.

This section sets out to furnish elements for an understanding of the various dimensions of innovation activities by ICT firms in São Paulo State, using the findings of IBGE's Survey of Technological Innovation in Industry (PINTEC) for the period 2003-05.[30]

The first point raised by an examination of innovation by São Paulo's ICT firms is the important finding that their innovation rate[31] was significantly higher than the national average for the activities covered by the PINTEC survey. While the general innovation rate for all activities in 2003-05 was 33.4% (a relatively low rate compared with the countries with the best performances in innovation), the average for the ICT industry was 56% in São Paulo State and 57.7% in Brazil.

Besides having similar innovation rates, the ICT industries of São Paulo State and Brazil (Table 9.22), also perform similarly in terms of product innovation, with 46.9% and 44.9% respectively, and in processes new to the home market, with 5.3% and 4.9% respectively (Table 9.22). In terms of innovation rates for products considered new to the home market, ICT firms in São Paulo (14.8%) outperform the average for Brazil (10.9%), while the opposite is the case for process innovation in general (37.8% and 41.6% respectively). The evidence therefore suggests that the innovation performance of ICT firms in São Paulo does not differ significantly from that Brazilian ICT firms in general. However, 43.8% of the ICT firms covered by

29. The concept of competitiveness used here is the capacity to increase the value of capital in a setting of confrontation between capital blocs (Possas, 1989).
30. For information on the methodology and procedures used in PINTEC, see IBGE (2007).
31. The innovation rate is defined as the percentage of firms that reported product and/or process innovations during the reference period for the PINTEC survey (2003-05).

Table 9.22
Results of innovation process in ICT industry: number of firms and innovation rates by activity and origin of capital – Brazil & São Paulo State, 2003-2005

Activities & origin of capital	Results of innovation process in ICT firms					
	Firms (Abs. nos.)	Innovation rate (%)				
		All innovations	Product		Process	
			Total	New to home market	Total	New to home market
ICT firms – Brazil	**5,598**	**57.7**	**44.9**	**10.9**	**41.6**	**4.9**
ICT firms – São Paulo State	**(1) 2,451**	**56.0**	**46.9**	**14.8**	**37.8**	**5.3**
Manufacturing of office machinery & IT equipment	**120**	**74.5**	**71.6**	**10.0**	**56.9**	**1.7**
Domestic	112	72.8	69.7	5.9	57.0	0.0
Foreign	8	100.0	100.0	71.5	56.3	27.8
Manufacturing of communications equipment	**182**	**56.4**	**43.9**	**18.3**	**28.7**	**5.8**
Domestic	149	60.4	46.5	20.2	30.0	4.2
Foreign	33	39.0	32.4	10.1	22.6	12.5
Telecommunications	**73**	**45.2**	**39.8**	**14.4**	**36.9**	**15.7**
Domestic	54	30.8	23.4	6.6	23.3	5.6
Foreign	19	85.9	85.9	36.4	75.4	44.2
IT activities & related services (1)	**1,529**	**54.6**	**47.7**	**15.8**	**35.8**	**5.0**
Domestic	1,405	54.3	47.4	15.3	36.9	4.9
Foreign	124	58.5	51.4	21.5	23.2	6.0
Software consulting	473	85.9	84.2	33.4	49.1	3.6
Domestic	418	87.0	86.7	33.4	50.7	3.1
Foreign	55	77.5	65.3	33.3	37.2	7.5
Other IT activities & related services	1,056	40.6	31.3	8.0	29.8	5.6
Domestic	987	40.4	30.7	7.7	31.0	5.6
Foreign	69	43.5	40.6	12.2	12.2	4.8
Manufacturing of insulated wires, cables & electrical conductors (2)	**160**	**37.2**	**34.4**	**6.2**	**34.5**	**5.4**
Manufacturing of basic electronics material (2)	**168**	**63.8**	**49.0**	**17.6**	**57.1**	**1.5**
Manufacturing of apparatus and instruments for measuring, testing and control (2)	**138**	**53.9**	**44.1**	**14.7**	**23.5**	**6.0**
Manufacturing of machinery, apparatus and equipment for electronic systems dedicated to industrial automation and process control (2)	**81**	**87.4**	**34.3**	**7.0**	**61.6**	**14.0**

Source: IBGE, PINTEC 2005.

Note: The data refer to firms that introduced technological new or substantially improved products and/or processes, and firms with projects that had been abandoned or were incomplete at end-2005.

(1) Because software consulting and other IT activities & related services are subsegments of IT activities & related services, firms in these subsegments are already included under the heading of IT activities & related services.
(2) IBGE does not identify the origin of respondent firms in cases where the proportion between the number of domestic and foreign firms exceeds the limit established and thus does not publish a breakdown of firms by origin of capital for this segment.

PINTEC 2005 were located in São Paulo (as calculated on the basis of Table 9.22), so this similarity may have been due at least in part to the weight of the state's ICT industry in the national average.

It is also important to note the relatively high dispersion of innovation rates across segments of the ICT industry (Table 9.22), varying from 37% for insulated wires, cables and electrical conductors to 87% for machinery, apparatus and equipment for electronic systems dedicated to industrial automation.

Two segments of the software industry provide a good example of this disparity. The innovation rate in software consulting was 85.9%, while the segment classified in PINTEC as "other IT activities" had an innovation rate of 40.6%. The gap no doubt reflects the fact that the latter segment mainly involves routine maintenance and repair, while the former involves software design, analysis and engineering, activities that are highly intensive in tacit knowledge and thus require much more innovation than routine activities, which are relatively standardized and further from the technological frontier.

Despite São Paulo's strong innovation performance, it should be noted that only a relatively small proportion of ICT innovations (especially process innovations) in the state are new to the home market (as is also the case for almost all economic sectors in Brazil). Thus in most cases innovation more closely resembles imitation[32] by firms that are seeking to transcend competitive deficiencies.

Judging from the relationship between total product innovation rates and new-to-market product innovation rates, imitation appears to be most pronounced in IT equipment manufacturing (which mainly assembles standardized imported components) and least pronounced in communications equipment (characterized by rapidly changing product portfolios, especially mobile phones, and led by multinationals, some located in São Paulo State) and software consulting (where a significant proportion of innovation activities requires the mastery of specific tacit knowledge derived from interaction with customers).

An analysis of overall innovation performance from the standpoint of capital origin, i.e. domestic versus foreign firms, does not show a consistent pattern of superiority for one or the other group. Domestic firms are more innovative in some segments, such as communications equipment and software consulting, while foreign firms are more innovative in others, such as IT equipment and telecom. Domestic and foreign firms perform very similarly in IT activities and other IT activities.

Despite this lack of an overall pattern showing significant differences in innovation by domestic and foreign ICT firms in São Paulo, foreign firms outperform in terms of the intensity of product and process innovations for the home market. More in-depth research would be required to explain this difference, but it may be due to adaptations and substantial improvements to products and/or processes existing in the firm's global portfolio but new to the Brazilian market.

Generally speaking there is a certain relationship between firm size and innovation rates (Detailed Table 9.18), but the correlation is not uniform across all segments and is most intense in the top two firm size strata (i.e. firms with upwards of 250 employees). As for segments, the relationship is less intense in software consulting, practically non-existent in IT activities, and very intense in telecom. The stratum comprising firms with upwards of 500 employees is the sole exception, since its innovation rates are above average for all ICT segments except software consulting (Table 9.23).

The above leads to the conclusion that a descriptive examination of innovation results based on PINTEC is not sufficient for the creation of a sound typology that segments firms by size and origin of capital. While segmentation often makes an important contribution to the analysis of the factors determining competitiveness in the São Paulo ICT industry (and indeed in most other economic sectors), the vast (sub)segmentation of the ICT industry suggests that typology construction should be based on competition dynamics, technological learning mechanisms and the technological competencies characteristic of each segment and subsegment, rather than solely on elements that permit a high degree of aggregation, such as firm size and origin of capital.

As for investment in innovation, once again ICT firms both in São Paulo and Brazil perform far better than the average for all the industries surveyed by PINTEC. Thus ICT firms in São Paulo invest 6% of net sales in innovation on average, with in-house R&D accounting for 1.6% of this investment (Table 9.23),[33] compared with general averages of 3% and 0.6% respectively (IBGE, 2007). In addition to this foreseeable superiority to the general average for the state, ICT firms in São Paulo also outperform the national ICT

32. Nevertheless, as discussed in Nelson & Winter (1982) and in Kim & Nelson (2005), imitation often requires mastery of complex capabilities and is sometimes an important driver of technological and innovative learning by firms.

33. It should be noted that for several segments of the ICT industry the obligations established by the Informatics Law (Lei de Informática) act as important incentives to investment in innovation, and especially in in-house R&D.

Table 9.23
Innovation process in ICT industry: number of firms, innovation rates and investment in innovation by activity and workforce – Brazil & São Paulo State, 2003-2005

Activities & workforce	Innovation process in ICT firms			
	Firms (Abs. nos.)	Innovation rate (%)	% net sales invested in innovation	
			Total	In-house R&D
ICT firms – Brazil	**5,598**	**57.7**	**4.2**	**1.0**
ICT firms – São Paulo State	**(1) 2,451**	**56.0**	**6.0**	**1.6**
Manufacturing of office machinery & IT equipment	**120**	**74.5**	**3.0**	**1.6**
500 +	2	100.0	-	-
Manufacturing of communications equipment	**182**	**56.4**	**9.4**	**1.6**
500 +	6	100.0	3.5	0.9
Telecommunications	**73**	**45.2**	**5.4**	**1.2**
500 +	11	72.7	5.4	1.2
IT activities & related services (1)	**1,529**	**54.6**	**6.1**	**2.4**
500 +	24	81.2	3.8	1.1
Software consulting	473	85.9	5.9	3.0
500 +	15	83.3	3.5	1.4
Other IT activities & related services	1,056	40.6	6.5	1.2
500 +	9	77.8	4.2	0.6
Manufacturing of insulated wires, cables & electrical conductors (2)	**160**	**37.2**	**2.0**	**0.5**
Manufacturing of basic electronics material (2)	**168**	**63.8**	**10.2**	**3.9**
Manufacturing of apparatus and instruments for measuring, testing and control (2)	**138**	**53.9**	**2.7**	**1.2**
Manufacturing of machinery, apparatus and equipment for electronic systems dedicated to industrial automation and process control (2)	**81**	**87.4**	**10.8**	**7.1**

Source: IBGE, PINTEC 2005.

Note: The data refer to firms that introduced technological new or substantially improved products and/or processes, and firms with projects that had been abandoned or were incomplete at end-2005.

(1) Because software consulting and other IT activities & related services are subsegments of IT activities & related services, firms in these subsegments are already included under the heading of IT activities & related services.
(2) IBGE does not identify the origin of respondent firms in cases where the proportion between the number of domestic and foreign firms exceeds the limit established and thus does not publish a breakdown of firms by origin of capital for this segment.

industry, which invests 4.2% of net sales in innovation and 1% of this in R&D (Table 9.23). In other words, ICT firms in São Paulo invest on average 43% more of net sales in innovation than ICT firms nationwide.

In an industry characterized by a very fast pace of technological change and high innovation intensity, both of which are catalyzed by mastery of a broad and increasingly complex set of capabilities, this difference in innovation spending may point to competitive asymmetries in favour of São Paulo's ICT firms. Thus although a merely quantitative analysis of the results of the innovation process does not point to superiority for São Paulo's ICT firms, this difference in investment in innovation may give these firms a key advantage in terms of their capacity to introduce innovations, provide a broader and more complex array of solutions and add more value, thus enhancing their competitiveness.

As already noted in connection with innovation rates, investment in innovation and the proportion allocated to in-house R&D vary considerably from one segment of ICT to another. Some segments are well above the average, including manufacturers of electronic systems for industrial automation, with 10.8% of net sales, of which 7.1% in R&D (Table 9.23), and basic electronics material, with 10.2% and 3.9% respectively. Others are below the average, including IT equipment, with 3% and 1.6%, and wires and cables, with 2.0% and 0.5%. Software consulting is close to the average, with 5.9% and 2.0% respectively.

These findings correlate closely with the results of the innovation process, i.e. the leaders in innovation investment also have the highest innovation rates, and conversely the segments that invest least have the lowest innovation rates. The only exception is the office machinery & IT equipment segment, which invests little in innovation yet achieves a high innovation rate. This distortion may be due to the fact that the segment assembles imported components, whose technological evolution permits the introduction of new or substantially improved products – one form of innovation according to the *Oslo Manual* (OECD, 1997) – so that innovations can be introduced relatively frequently even without significant investment in local innovation activities.

Another interesting phenomenon worth highlighting with regard to innovation efforts by ICT firms in São Paulo is that in several segments relatively small firms (with 10-29, 30-49 and 50-99 employees) invest more than the average for the segment concerned in innovation activities as a percentage of net sales (Detailed Table 9.18). This relatively high intensity of innovation spending in proportion to revenue may be due, at least in part, to the indivisibility of R&D, which requires a minimum initial investment, and to a lack of sufficient scale for firms of this size to dilute investment in innovation.

No overall correlation can be established between innovation spending in proportion to sales and the origin of firms' capital, as noted above in connection with innovation rates. In communications equipment, IT activities & related services and software consulting, domestic firms invest more of their revenue than foreign firms, while the proportions are similar in IT machinery & equipment, and foreign firms invest more than domestic firms in telecom (Detailed Table 9.19).

Reflecting the importance of in-house R&D to competitiveness, ICT firms in São Paulo allocate 91% of their innovation investment to continuing initiatives (as can be calculated from Detailed Table 9.20). Systematic in-house R&D, especially when done continuously, is evidently a key driver of learning about and for innovation. In an industry characterized by rapid technological change based on complex interdisciplinary knowledge and growing ICT convergence momentum, internalization (and expansion of the repertoire) of competencies is fundamental to competitiveness.

Thus because the frontiers between ICT segments become fluid in response to rapid technological change and are themselves subject to constant change, the development of an integrated set of solutions with a high degree of compatibility (given ICT convergence) and fast time to market presupposes the existence of sound learning processes and the construction of technological competencies. These processes are very positively influenced by systematic and continuing R&D efforts by virtue of the positive returns to scale that characterise the accumulation of tacit knowledge.

Complementing these processes of learning through continuing R&D efforts, in 2005 ICT firms in São Paulo employed some 9,400 people in in-house R&D, which corresponds to approximately 13 people per firm (Table 9.24). Reflecting the difference between the various ICT segments in terms of the dynamism of technological change, the average number of people employed in R&D was greatest in telecom, with 83 per firm, followed by communications equipment, with 24, and software consulting, with 16, while wires & cables and basic electronics material employed only three and four per firm respectively.

As shown by Table 9.24, in addition to the differences between segments it is also important to note that the average number of people employed in R&D by foreign firms was substantially greater than by domestic firms. One major reason for this discrepancy is the difference in average size, with foreign firms being far larger than domestic firms overall.

Given the crucial importance of R&D intensity to the competitiveness of São Paulo's ICT firms and the indivisibility of R&D, alongside positive returns to scale in these activities, it would appear vitally important to promote an increase in the average size of domestic firms via public policy, or a reorientation of business strategies in pursuit of capital consolidation and concentration, in order to assure their ability to compete with foreign firms in the long run.

In addition to increased scale, several ICT segments have benefited from the internalization of complementary technological competencies. Examples include Microsoft's and Intel's acquisitions of competitors with the aim of converting the technological solutions concerned into new modules for their flagship products.[34]

34. For a discussion of the importance of modularization to the establishment of technological platforms and its effect on the dynamics of competition and innovation in the ICT industry, see Diegues (2007).

Table 9.24
In-house R&D expenditure, average number of R&D employees per firm and total R&D staffing by activity and origin of capital – Brazil & São Paulo State, 2003-2005

Activities & origin of capital	Firms investing in in-house R&D	Average number of people employed in R&D per firm	R&D staffing		
			Total (1)	Full-time	Part-time
ICT firms – Brazil	**1,481**	**13**	**19,747**	**17,399**	**6,924**
ICT firms – São Paulo State	**(2) 717**	**13**	**9,335**	**8,160**	**3,636**
Manufacturing of office machinery & IT equipment	**23**	**14**	**316**	**293**	**60**
Domestic	17	7	128	109	47
Foreign	5	36	187	185	13
Manufacturing of communications equipment	**60**	**24**	**1,457**	**1,406**	**132**
Domestic	50	8	389	358	97
Foreign	10	110	1,068	1,047	35
Telecommunications	**15**	**83**	**1,228**	**747**	**1,585**
Domestic	10	19	186	133	158
Foreign	5	208	1,042	614	1,427
IT activities & related services (2)	**461**	**11**	**5,117**	**4,568**	**1,557**
Domestic	426	8	3,443	2,950	1,382
Foreign	35	48	1,674	1,618	175
Software consulting	257	16	4,021	3,596	1,145
Domestic	236	12	2,743	2,375	971
Foreign	21	62	1,278	1,222	175
Other IT activities & related services	204	5	1,097	972	411
Domestic	190	4	700	575	411
Foreign	14	28	396	396	
Manufacturing of insulated wires, cables & electrical conductors (3)	**44**	**3**	**141**	**114**	**133**
Manufacturing of basic electronics material (3)	**47**	**4**	**191**	**176**	**82**
Manufacturing of apparatus and instruments for measuring, testing and control (3)	**40**	**12**	**502**	**483**	**55**
Manufacturing of machinery, apparatus and equipment for electronic systems dedicated to industrial automation and process control (3)	**28**	**14**	**382**	**372**	**33**

Source: IBGE, PINTEC 2005.

Note: The data refer to firms that introduced technological new or substantially improved products and/or processes, and firms with projects that had been abandoned or were incomplete at end-2005.

(1) Full-time R&D staffing (number of employees dedicated full-time to R&D plus number of employees dedicated part-time to R&D weighted by average dedication in percent).
(2) Because software consulting and other IT activities & related services are subsegments of IT activities & related services, firms in these subsegments are already included under the heading of IT activities & related services.
(3) IBGE does not identify the origin of respondent firms in cases where the proportion between the number of domestic and foreign firms exceeds the limit established and thus does not publish a breakdown of firms by origin of capital for this segment.

The sources of funding for innovation expenditure by firms vary little. With the sole exception of other IT activities, private sources account for 95% or more in all segments (Detailed Table 9.21).

Another key indicator of innovation effort is the proportion of firms rating specific activities highly important to innovation. The highest percentages in PINTEC 2005 were for acquisition of machinery & equipment, with 55%, training, with 52%, and in-house R&D, with 45% (Table 9.25).[35]

Despite the priority given to acquiring machinery and equipment (in ICT and all other industries surveyed by PINTEC on average), the proportion of firms in São Paulo's ICT industry rating this item highly important was substantially smaller than the general average according to PINTEC, which was 64% (IBGE, 2007). A reservation needs to be made regarding the acquisition of machinery and equipment as an innovation activity, however. Although it is classified as such by PINTEC, strictly speaking the acquisition of machinery and equipment is not innovation-related because in itself it is basically passive and self-contained, even though machinery is of course an important innovation input. This passivity is unlikely to bolster the capacity to endogenize technical progress, which must be one of the main goals of any firm's innovation activities.

Such endogenization is due mostly to training, and above all to in-house R&D, prioritized by 45% of ICT firms in São Paulo, far above PINTEC's general average of 18% (IBGE, 2007). R&D is a key driver of innovative learning since the competencies required by the technologically most dynamic ICT segments are grounded basically in tacit knowledge. In other words, given the difficulty of codifying the knowledge needed for innovation, the pursuit of competitive asymmetries in ICT requires routines that make innovation-related learning endogenous, continuous and systematic.

The importance of innovation to competitiveness for São Paulo's ICT firms is evidenced by the fact that in 2005 37% said new or substantially improved products accounted for over 40% of domestic sales and 42% said new products accounted for 10%-40% (Detailed Table 9.22). On one hand, this proportion shows the significant potential for boosting growth via the introduction of new products; on the other, it shows that market positions are constantly being challenged.

Thus successful innovation not only assures a competitive advantage but also often constitutes a strategy for defending and maintaining market position. Indeed, 52% of ICT firms in São Paulo that innovated in the period 2003-05 rated new products highly important to the maintenance of market position, while only 37% saw new products as highly important to expansion of market share (Detailed Table 9.23).

Despite the importance of innovation results to maintaining as well as growing market share, 44% of ICT firms in São Paulo reported no innovations in the period 2003-05 (as can be calculated from Table 9.22). The main justifications given by these firms were: the high cost of innovation, cited as highly important by 50.9% of non-innovators; excessive economic risk, cited by 38.6%; and a scarcity of appropriate funding sources, cited by 29.1% (Table 9.26).

The differences between domestic and foreign firms in the importance attributed to the high cost of innovation and the scarcity of appropriate funding sources, both of which relate to a firm's financial capacity, point once again to the phenomenon mentioned earlier in connection with intensity of R&D investment: the larger proportion of domestic firms rating these factors highly important appears ultimately to reflect their smaller size and hence weaker financial capacity. Hence the necessity of initiatives to increase the size of domestic firms via consolidation and capital centralization in order to build up their capabilities for innovation, as suggested above.

An important justification for lack of innovation cited by foreign firms is that other group companies perform innovation activities. This explains the low priority given by these firms to difficulties with funding and the cost of innovation: the units concerned are hierarchically inferior in the global value chain, acting as disseminators rather than creators of technological progress, so that local development of technology is often simply omitted from their strategic guidelines. In other words, local development of technology is frequently excluded from the global mandates under which such units perform.

35. Respondents could evidently attribute high importance to more than one activity.

Table 9.25
Highly important activities for innovation according to innovative firms by origin of capital – Brazil & São Paulo State, 2003-2005

Activities & origin of capital	Highly important activities for innovation according to innovative firms (%)							
	Acquisition of machinery & equipment	Training	In-house R&D	Acquisition of software	Industrial design & other technical preparations	Market introduction of technological innovations	Acquisition of other external knowledge	Acquisition of external R&D
ICT firms – Brazil	**57.5**	**47.4**	**40.9**	**32.4**	**24.4**	**21.0**	**17.1**	**5.4**
ICT firms – São Paulo State	**54.5**	**51.7**	**45.5**	**29.3**	**28.1**	**22.1**	**15.4**	**6.6**
Manufacturing of office machinery & IT equipment	**73.2**	**58.4**	**26.8**	**9.9**	**56.8**	**55.9**	**4.8**	**52.4**
Domestic	75.8	58.6	22.9	9.4	56.9	58.4	2.8	54.4
Foreign	44.9	56.3	69.6	14.4	56.3	28.5	26.6	30.4
Manufacturing of communications equipment	**46.8**	**34.0**	**64.6**	**11.4**	**49.6**	**29.6**	**4.0**	**21.0**
Domestic	48.7	35.3	63.1	9.5	51.1	29.1	0.0	14.4
Foreign	33.5	24.4	75.6	24.2	39.8	33.1	31.9	66.9
Telecommunications	69.4	51.6	22.9	48.5	45.7	52.8	34.7	6.0
Domestic	51.1	36.6	21.6	42.6	49.0	33.1	18.0	0.0
Foreign	87.9	66.6	24.2	54.5	42.4	72.7	51.5	12.1
IT activities & related services (1)	**51.9**	**51.6**	**44.7**	**34.8**	**18.6**	**15.7**	**19.2**	**0.9**
Domestic	53.3	51.9	46.5	34.3	19.5	12.9	18.1	0.7
Foreign	37.4	47.9	26.0	39.2	9.3	45.0	30.6	3.0
Software consulting	34.0	53.9	53.5	21.9	31.8	22.0	20.7	0.6
Domestic	33.0	56.5	54.8	20.8	35.1	21.6	20.9	0.3
Foreign	42.2	31.2	42.2	31.3	2.9	25.3	18.8	2.9
Other IT activities & related services	68.9	49.4	36.4	47.0	6.1	9.7	17.7	1.2
Domestic	71.8	47.8	38.9	46.7	5.2	4.9	15.5	1.0
Foreign	30.8	71.3	3.3	50.4	18.2	72.5	47.1	3.3
Manufacturing of insulated wires, cables & electrical conductors (2)	**69.6**	**70.9**	**63.9**	**10.3**	**29.4**	**50.0**	**3.7**	**8.2**
Manufacturing of basic electronics material (2)	**55.3**	**35.6**	**46.0**	**27.8**	**32.5**	**17.4**	**7.3**	**2.5**
Manufacturing of apparatus and instruments for measuring, testing and control (2)	**35.6**	**62.7**	**59.3**	**25.7**	**24.3**	**15.9**	**14.4**	**6.0**
Manufacturing of machinery, apparatus and equipment for electronic systems dedicated to industrial automation and process control (2)	**72.6**	**66.6**	**30.3**	**27.8**	**60.8**	**20.2**	**15.3**	**1.7**

Source: IBGE, PINTEC 2005.

(1) Because software consulting and other IT activities & related services are subsegments of IT activities & related services, firms in these subsegments are already included under the heading of IT activities & related services.

(2) IBGE does not identify the origin of respondent firms in cases where the proportion between the number of domestic and foreign firms exceeds the limit established and thus does not publish a breakdown of firms by origin of capital for this segment.

Table 9.26
Highly important problems and obstacles for non-innovative firms by activity and origin of capital – Brazil & São Paulo State, 2003-2005

Activities & origin of capital	Highly important problems and obstacles for non-innovative firms (%)											
	Excessive economic risks	High cost of innovation	Scarcity of appropriate funding sources	Organizational rigidity	Lack of qualified personnel	Lack of information about technology	Lack of information about markets	Scarcity of opportunities to cooperate with other firms or institutions	Difficulty of complying with standards, rules & regulations	Weak consumer response to new products	Scarcity of adequate external technical services	Centralization of innovation activities by other group company
ICT firms – Brazil	**38.1**	**41.9**	**40.8**	**3.7**	**10.7**	**4.6**	**5.3**	**10.8**	**9.4**	**7.5**	**4.3**	**4.7**
ICT firms – São Paulo State	**38.6**	**50.9**	**29.1**	**4.2**	**2.3**	**0.0**	**0.0**	**7.6**	**14.5**	**4.8**	**1.9**	**11.2**
Manufacturing of office machinery & IT equipment	-	**51.3**	-	-	-	-	-	-	-	-	-	-
Domestic	-	51.3	-	-	-	-	-	-	-	-	-	-
Foreign	-	-	-	-	-	-	-	-	-	-	-	-
Manufacturing of communications equipment	**44.3**	**44.3**	**71.8**	-	-	-	-	-	-	-	-	**55.7**
Domestic	100.0	100.0	51.5	-	-	-	-	-	-	-	-	-
Foreign	-	-	88.0	-	-	-	-	-	-	-	-	100.0
Telecommunications	**100.0**	**69.6**	**69.6**	-	-	-	-	**69.6**	-	-	-	-
Domestic	100.0	100.0	100.0	-	-	-	-	100.0	-	-	-	-
Foreign	100.0	-	-	-	-	-	-	-	-	-	-	-
IT activities & related services (1)	**34.0**	**49.5**	**22.0**	**2.8**	**0.9**	-	-	**2.4**	**16.0**	**6.0**	**2.4**	**7.9**
Domestic	35.2	51.9	24.8	-	1.0	-	-	2.7	17.2	6.8	2.7	-
Foreign	24.7	31.0	-	24.7	-	-	-	-	6.3	-	-	69.0
Software consulting	27.5	42.8	-	27.5	8.4	-	-	-	7.0	-	-	15.3
Domestic	-	16.6	-	-	16.6	-	-	-	-	-	-	-
Foreign	55.2	69.2	-	55.2	-	-	-	-	14.0	-	-	30.8
Other IT activities & related services	34.7	50.3	24.5	-	-	-	-	2.7	17.0	6.7	2.7	7.0
Domestic	37.4	54.1	26.3	-	-	-	-	2.9	18.3	7.2	2.9	-
Foreign	-	-	-	-	-	-	-	-	-	-	-	100.0

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Table 9.26
Highly important problems and obstacles for non-innovative firms by activity and origin of capital – Brazil & São Paulo State, 2003-2005

Activities & origin of capital	Highly important problems and obstacles for non-innovative firms (%)											
	Excessive economic risks	High cost of innovation	Scarcity of appropriate funding sources	Organizational rigidity	Lack of qualified personnel	Lack of information about technology	Lack of information about markets	Scarcity of opportunities to cooperate with other firms or institutions	Difficulty of complying with standards, rules & regulations	Weak consumer response to new products	Scarcity of adequate external technical services	Centralization of innovation activities by other group company
Manufacturing of insulated wires, cables & electrical conductors (2)	-	100.0	-	100.0	-	-	-	100.0	-	-	-	-
Manufacturing of basic electronics material (2)	100.0	46.9	100.0	-	46.9	-	-	53.1	53.1	-	-	-
Manufacturing of apparatus and instruments for measuring, testing and control (2)	100.0	100.0	-	-	-	-	-	-	-	-	-	-
Manufacturing of machinery, apparatus and equipment for electronic systems dedicated to industrial automation and process control (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: IBGE, PINTEC 2005.

(1) Because software consulting and other IT activities & related services are subsegments of IT activities & related services, firms in these subsegments are already included under the heading of IT activities & related services.

(2) IBGE does not identify the origin of respondent firms in cases where the proportion between the number of domestic and foreign firms exceeds the limit established and thus does not publish a breakdown of firms by origin of capital for this segment.

Conclusions

The ICT industry comprises a heterogeneous set of economic activities, encompassing both manufacturers and service providers. This is why the analysis presented in this chapter covers both dimensions. The choice of this intersectoral analytical approach is supported by international research and was originally made by the OECD in the 1990s.

Despite the significant differences among the sectors that make up the ICT industry in terms of technological density, competitive dynamics and market structures, they all work with the processing and/or transmission of digitally encoded information as a common substrate.

The ICT industry plays a crucial role in the information society, furnishing key technological inputs for innovation and efficiency to practically every other sphere of the economy, including public services. As a result, the ICT industry deserves special attention on the part of the academic community and framers of public policy.

The analysis of selected indicators presented in this chapter shows that ICT firms in São Paulo State account for 40% of the value and jobs created by the ICT industry in Brazil. São Paulo's leadership in national wealth creation, accounting for 33.9% of GDP in 2005, is especially pronounced in the case of the ICT industry. This is probably due to a combination of several factors: on the demand side, the state is home to a significant proportion of the most dynamic business activities in technological terms, which require ICT goods and services, and has the highest per capita income in the country; on the supply side, it has a sophisticated education system, especially at the tertiary level, which is capable of supplying ICT firms with qualified human resources.

The geographical distribution of these activities within São Paulo State also displays a high level of concentration. The regional concentration of significant innovation inputs (universities and research institutions, among others), as well as related manufacturing sectors and specialized service providers, explains the greater presence of ICT firms in the São Paulo metropolitan area and in the Campinas and São José dos Campos microregions.

The penetration of ICT activities in practically every economic sphere is highlighted in this chapter using an exploratory methodological effort that shows the presence of a large contingent of workers dedicated to the development and delivery of IT services in a vast array of sectors. The chapter shows that it is a mistake to restrict analysis of the importance of ICT activities to those economic spaces considered proper to the ICT industry, given the significance of the value created by ICT activities outside the industry's frontiers. This exercise ratifies the penetration and diffusion of these technologies in every walk of life.

The importance of São Paulo's firms to Brazil is evidenced not just by the magnitude of the economic values involved, but also by the reproduction of the structural limitations of Brazilian industry. São Paulo accurately reflects both the best of Brazil's technological activities and the limitations of industrial development on the periphery of capitalism.

These limitations are made all the more evident by an analysis of the indicators relating to the international dimension of the ICT industry. An assessment of ICT imports and exports, and of their origins and destinations, shows that São Paulo's ICT firms were unable to generate a trade surplus even though exports grew vigorously in the period considered. The structural nature of the deficit appears as the quantitative expression of a qualitative obstacle: generally speaking, trade by ICT firms in São Paulo is limited to the lower levels of the global value chain. Growth in production and exports drives up imports because of the industry's dependency on inputs shipped in from other countries.

The indicators of ICT diffusion point to greater penetration and use of ICT by the population of São Paulo compared with the national average. The information presented in Section 5 also evidences the correlation between socioeconomic status and quality of access to ICT, reinforcing the perception of the importance of public policy to democratize access to IT, and especially the internet, for low-income citizens.

Finally, the chapter presents a diagnosis of innovation activities by ICT firms in São Paulo State. Despite the heterogeneity of the indicators for the various activities of which the ICT industry is made up, ICT firms are clearly more innovative than firms in other industries. São Paulo's ICT firms do not diverge significantly from the national average in terms of innovation rates. Where they do differ notably is in their innovation investment, including in-house R&D.

An analysis of the indicators for firms suggests a close correlation between size (measured by the number of employees) and innovation investment capacity. The corollary of this is the importance of public policy designed to strengthen ICT firms in São Paulo by providing incentives for them to build their capacity to undertake efforts in innovation and technology, thus reinforcing and improving their competitive position with regard to multinationals.

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