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High-tech industries and knowledge-intensive services: why are these activities the core businesses for Sao Paulo's competitiveness?[1]

[STUDENT WORK]

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1) Introduction

Industrial restructuring during the last 30 years demands a new way of looking at how goods and services are produced. The aim of this paper is to analyze the industrial structure of Sao Paulo's economy, focusing on knowledge and technology and arguing that specific sectors are especially important for the future of this city in a knowledge age.

Knowledge creation and diffusion, technological change and innovation processes are essential factors in the competitiveness of firms, regions, and countries if they are to achieve long-term growth. Knowledge-based or higher-tech sectors are the core businesses for industrial restructuring in developed countries; they provide the inputs for modernizing production chains, are carriers and diffusers of knowledge, and also function as central nodes in innovation systems.

Debates on the change in Brazil's industrial structure from the 80's and 90's onwards have shown the need to consider knowledge, technology and innovation in the analysis of local development processes, as well as highlight which sectors can lead to a more competitive city in the knowledge era.

To understand the changes in Sao Paulo's production system, we need to consider them as part of a broader process in the global economy that involves: (i) the new international division of labour; and (ii) the prominence of knowledge, learning and innovation in successful long-term economic growth. In the first case, manufacturing firms outsource less intensive activities and concentrate their efforts on their core businesses, especially in the richest cities of the developed world, opening up opportunities for other regions and countries. On the second point, knowledge flows and the co-production of new ideas through networks (connecting firms, universities and public agencies) and learning processes feed innovation and are central to competitiveness (Boden & Miles 2000, Lundvall 1996, Torres-Freire 2006a).

In this new context, new activities are created and others become more important. Regardless of being manufacturing or service activities, the literature suggests the need for companies to focus on producing value-added goods, employ more skilled workforces and pay better salaries. Examples

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are the so-called knowledge-intensive business services (KIBS) – such as software, computing systems, telecommunications, engineering, marketing, research, financial activities, media, education and health – or microelectronics, industrial automation, optic and medical equipment and biotechnology (Miles et al. 1995, Mueller & Zenker 2001, Torres-Freire 2006b).

The industrial structure in Sao Paulo city is highly diversified and, responding to the new needs for more high-technology and knowledge-intensive production, new sectors have been developed in recent years – the Information Technology sector, for example. In this paper we analyze the characteristics of these high-tech and knowledge-intensive activities in order to show their importance for Sao Paulo's economic future.

Rather than simply arguing that Sao Paulo has undergone a process of deindustrialization – or the opposite, implying that manufacturing is still the engine of the city's economy –, we argue that it is more important to analyze the manufacturing industry that still remains in the city after the industrial restructuring process. Likewise, instead of advancing a weak analytic claim that Sao Paulo has become a 'services metropolis', it is more important to understand which service activities have been created or strengthened over recent decades. In this context, we also need to explore how the universities, research centres and R&D labs in Sao Paulo – which included some of the most important in Brazil – are connected to this new industrial structure.

There are no clear analyses about the sharing of knowledge and technology activities in Sao Paulo or about the concentration of these activities in the city. This paper tackles these problems by highlighting both the characteristics of these activities (firms, employment, income, workforce skills and salaries) and their spatial distribution in the city. To achieve this goal, we use a classification of economic activities that considers different levels of technology and knowledge, based on categories previously used by the Organization for Economic Co-operation and Development (level of technology in manufacturing sectors) and Eurostat (knowledge intensity in services).

Analyzing the industrial structure through a taxonomy based on the level of technology and knowledge is useful when examining the question of competitiveness as it highlights the opposition between more high-tech and knowledge-intensive activities versus lower-tech and less intensive ones. Hence, we go beyond the simplistic opposition between manufacturing and services, focusing instead on the relevance of knowledge and technology for social and economic development, especially in the cities of developing countries in a knowledge era.

Questions guiding this paper:

- What is the importance of high-tech and knowledge-intensive activities in Sao Paulo?
- What is the share of these activities in terms of employment generation, income, and salaries?
- How skilled is the workforce in these sectors?
- What does the spatial distribution of these activities look like in São Paulo and how concentrated are they?

In addition to this introductory section, the paper is structured as follows:

- Section 2: explains the classification based on the level of technology and knowledge;
- Section 3: presents the research findings on the importance of these sectors for the city;
- Section 4: summarizes the research findings;
- Section 5: concludes the article by presenting the challenges faced by São Paulo in becoming a knowledge-based city.

2) Classification according to intensity of technology and knowledge

Constructing a typology of activities based on the description of high-tech and knowledge-intensive sectors is a challenge for any analysis of manufacturing and service activities.

The specialized literature has made considerable progress in terms of understanding the recent transformations in the structure of production, including the integration of the technological and organizational frameworks involved in producing goods and services, and a growing tendency towards homogenizing demands for specialized services, infrastructure and human resources (Boden & Miles 2000, Bernardes, Bessa & Kalup 2005). However analyzing industry and services using the same conceptual base for comparative purposes continues to be a difficult task in terms of constructing methodologies.

The taxonomies developed by the Organization for Economic Co-operation and Development (OECD) for industry – considering technological input – and for services – ranking industrial sectors according to knowledge intensity – represent one of the most successful attempts and serve as a methodological base for the present text. Given the absence of any international norms, we suggest a number of alterations to the taxonomy, especially in the case of services.

The OECD uses expenditure on Research and Development (R&D) to determine the technological input of manufacturing industry. Both direct and indirect expenditure on R&D are considered, including purchase of machinery, equipment and intermediary inputs (Hatzichronoglou 1997).[4] By analyzing overall expenditure according to sector of activity, we can classify manufacturing industries as follows:[5]

(i) *High-technology*: electrical machinery, devices and materials, transport equipment including automobiles, medical-hospital and dentistry equipment (MHDE), measuring instruments, industrial automation equipment, electronic material, communications devices, and machinery and equipment.

(ii) *Medium-high technology*: basic electronic material, chemical and pharmaceutical products, auto parts and accessories, cellulose and other pulps used in paper production.

(iii) *Medium-low technology*: steel working, rubber and plastic items, metal products, non-ferrous metallurgy and smelting, paper, paper packaging and items, non-metallic products, leather, leather items and footwear.

(iv) *Low-technology*: textile products and clothing, food items, furniture, wooden articles, coke production, alcohol production, and recording production and reproduction.

Despite the convergence of technological and organizational standards between the service and industrial sectors, the sheer proliferations of different technical and sectoral configurations among the former prevents any direct use of industry's parameters. Marklund (2000) emphasizes that few innovative service companies make regular investments of resources in R&D, meaning that any internal innovation usually originates in other company departments. Other factors differentiating industry and services are the problems in distinguishing between product and process innovations, the intangible nature of services and the greater impact of human and organizational resources in increasing the sector's productivity (Gallouj & Weinstein 1997, Miles 2005).

[4] For a critique of the taxonomy developed by the OECD, emphasizing the fact that values for internal expenditure on R&D fail to include diffuse and informal forms of learning and innovation in the production chains, see Smith (2000). On the specificities of using the OECD's taxonomy in emerging countries, see Furtado & Quadros (2005).

[5] For Brazil, the OECD taxonomy was adapted by the Brazilian Institute of Geography and Statistics (IBGE) based on observation of the direct and indirect expenditure on R&D of the Brazilian manufacturing industry. The information from the Technological Innovation Industrial Survey (PINTEC) was used as the source material for this task (IBGE 2003).

In this work, the choice for classifying the service industry is based on the OECD's proposal for *knowledge-intensive services* (KIS) (Eurostat 2007a and Eurostat 2007b). Adopting this classification, services can be ordered by groups of activities with relatively uniform characteristics, with the most knowledge-intensive services generally showing higher investment in R&D, use of Information Technology (IT) and a tendency to hire highly qualified personnel.

Here we propose to improve the OECD classification by including other subgroups and redistributing activities between them. These alterations are introduced for analytical and methodological reasons (such as the need for adjustments in order to obtain regional information for Sao Paulo). Consequently, we arrive at the following schema:

(i) *Technological Knowledge-Intensive Services (T-KIS)*: information technology, telecommunications, R&D in physical sciences, architectural services and materials testing.

(ii) *Professional KIS (P-KIS)*: R&D in social and human sciences, legal activities, accountancy and business consultancy, advertisement, and recruitment and employment agencies.

(iii) *Financial KIS (F-KIS)*: financial intermediation, insurance and private pension schemes.

(iv) *Social KIS (S-KIS)*: activities linked to higher education, hospital care, and diagnostic and therapeutic services.

(v) *Media KIS (M-KIS):* cinema, video, radio and television activities and news agencies.

(vi) *Other Services*: housing and catering activities, transportation in general, mail, hire of machinery and equipment, personal and domestic items, urban cleaning, associations, show venues, personal and domestic services.

3) Sao Paulo's structure of production according to technology and knowledge intensity

Setting out from the classification of economic activities according to technology and knowledge intensity, the aim of this section is to provide an analysis of Sao Paulo's structure of production and to identify the relevant activities in terms of knowledge and technology in the municipality.

The main database used in this exercise was the Annual Social Information Report (RAIS).[6] Although utilizing an employment database to analyze the productive configuration of an economic aggregate is not ideal, since sectoral divergences between the intensity of workforce use and production, value and income generation are commonly encountered, its use is justified by: (i) the availability of ample historical data; (ii) representativeness at municipal level; and (iii) fairly high level of sectoral disaggregation.

The period of analysis chosen – from 1997 to 2005 – looks to cover the transformations undergone by Sao Paulo's structure of production over recent years, including, the restructuring of production – stronger in the 1990s – and the later revival in manufacturing dynamism at the start of the 2000s.

The restructuring of production is the first phenomenon to be observed. Seen from the standpoint of companies and the labour force, Sao Paulo's structure of production is experiencing a general decline in manufacturing industry and an increase in services and commerce. The predominance of services in Sao Paulo's formal occupational structure is clearly evident: in 2005 they accounted for around 56% of jobs, while in 1997 the share was 51%. Manufacturing industries meanwhile accounts for 16.3% of jobs, a drop of six percentage points compared to 1997.[7]

[6] The RAIS (Relação Anual de Informações Sociais) is an administrative record produced by the Labour and Employment Ministry, originally used to control, monitor and inspect the movement of the workforce. It collects yearly information on formal hiring of labour by companies and the characteristics of this labour force. It can be considered a census of formal employment in Brazil.

[7] The public administration sector has been removed from the analysis.

Table 1: Establishments, jobs and wages according to economic sectors. São Paulo City, 1997 and 2005*

Sector of activity	1997					2005				
	Establishments		Jobs		Wages	Establishments		Jobs		Wages
	Abs	%	Abs	%	%	Abs	%	Abs	%	%
Manufacturing industry	74.286	14,0	549.050	22,4	23,7	80.314	11,8	459.761	16,3	18,4
Services	219.241	41,2	1.250.324	51,0	57,8	277.766	40,7	1.578.478	55,9	61,1
Trade	216.020	40,6	470.691	19,2	13,4	302.147	44,3	641.834	22,7	16,7
Construction	22.463	4,2	179.471	7,3	5,2	21.689	3,2	143.174	5,1	3,8
Total	532.010	100,0	2.449.536	100,0	100,0	681.916	100,0	2.823.247	100,0	100,0

Source: Rais/MTE. Elaboration: Cebrap. *In Reais as of 12/2006. Adjustment: INPC/IBGE.

However, these trends do not allow us to conclude that the municipality of Sao Paulo is becoming a service metropolis. Firstly because some of the decline in manufacturing jobs during the 1990s can be explained by the effects of the restructuring of production, such as the transfer of activities and occupations to the service sector (Amitrano 2004, Diniz & Diniz 2004). Secondly, and perhaps more importantly, because industry, despite having indeed become leaner, has not vanished entirely from São Paulo. Some manufacturing sectors remain strong in the municipality, which indicates that Sao Paulo's manufacturing activity should remain important, at least in the short and medium terms.[8]

Technology-intensive manufacturing industries and knowledge-intensive services generate value

When we examine Sao Paulo's structure of production based on the classification according to the intensity of technology and knowledge – that is, looking less at the traditional opposition of manufacturing versus services and more at the capacity to generate value, high-quality employment, income, knowledge and innovation – the results are more interesting.

Since they usually involve larger establishments, the high-tech and mid-high-tech industries and the five KIS groups (T-KIS, P-KIS, F-KIS, S-KIS[9] and M-KIS) display a lower share of the structure of production in terms of establishments – just 10.4%. However, these seven sectors were responsible for 40.6% of the total wages of São Paulo in 2005 (Table 2).

[8] From 2003 onwards Sao Paulo's manufacturing industry saw a rise in formal jobs, matching the general upward trend in industrial employment seen in the Sao Paulo Metropolitan Region and the State of Sao Paulo as a whole (Abdal 2009).

[9] The S-KIS, made up of both private and public institutions, may be underestimated in the RAIS since some of the staff working in state public hospitals may be assigned to the public administration sector. In addition, because of problems in classifying the establishments, we opted to remove from the analysis activities such as medical clinics and surgeries, emergency hospitals, independent nursing activities, phonoaudiology, psychology and infant, primary and secondary levels of education.

Table 2: Establishments, jobs and wages according to technological and knowledge intensity. São Paulo City, 1997 and 2005*

Sector of activity	1997					2005				
	Establishments		Jobs		Wages	Establishments		Jobs		Wages
	Abs	%	Abs	%	%	Abs	%	Abs	%	%
High-tech MI	8.242	1,5	93.050	3,8	5,0	10.034	1,5	78.591	2,8	3,6
Mid-high-tech MI	7.352	1,4	94.587	3,9	5,5	8.101	1,2	83.036	2,9	5,1
Mid-low-tech MI	23.971	4,5	152.468	6,2	5,4	26.822	3,9	117.292	4,2	3,8
Low-tech MI	34.721	6,5	208.945	8,5	7,9	35.357	5,2	180.842	6,4	5,9
T-KIS	7.474	1,4	77.558	3,2	5,2	10.521	1,5	91.077	3,2	5,7
P-KIS	19.465	3,7	77.484	3,2	2,9	19.734	2,9	147.805	5,2	4,9
F-KIS	10.835	2,0	142.392	5,8	12,2	12.471	1,8	146.125	5,2	11,8
S-KIS	12.332	2,3	136.431	5,6	6,6	10.361	1,5	184.864	6,5	8,6
M-KIS	2.002	0,4	13.071	0,5	0,9	1.670	0,2	14.141	0,5	0,9
Other services	167.133	31,4	803.388	32,8	29,9	223.009	32,7	994.466	35,2	29,3
Trade	216.020	40,6	470.691	19,2	13,4	302.147	44,3	641.834	22,7	16,7
Construction	22.463	4,2	179.471	7,3	5,2	21.689	3,2	143.174	5,1	3,8
Total	532.010	100,0	2.449.536	100,0	100,0	681.916	100,0	2.823.247	100,0	100,0

Source: Rais/MTE. Elaboration: Cebrap. *In Reais as of 12/2006. Adjustment: INPC/IBGE.

The data on value added can be taken as complimentary to the information on total wages. These same more high-tech and knowledge-intensive sectors, excluding the F-KIS, represented 43% of value added produced by São Paulo in 2001[10] – commerce, other services and the mid-low-tech and low-tech industries having generated the remaining amounts. These two succinct sets of data clearly reveal the capacity of these activities to generate value and income.

Moreover, five of the six industrial sectors with the largest share of fiscal value added in Sao Paulo (all above 7% and, combined, totalling 53.6%) are high-tech and mid-high-tech manufacturing industries: pharmaceutical products (10.2%), machinery and equipment (9.2%), metal products (7.9%), chemical products (7.5%), and transport material (auto parts, 7.3%)[11]. Another important fact is that these five sectors increased their relative share in Sao Paulo between 2002 and 2006. This not only shows the importance of these sectors in forming Sao Paulo's industrial base, but also their capacity, albeit weak, to remain dynamic forces in the city. Though we cannot claim that Sao Paulo is following the path of other global cities, where high-tech manufacturing industry has emerged as the strongest sector after restructuring, the contribution of the more technology-intensive sectors is clearly evident.

Number of employees in high-tech and knowledge-intensive sectors is substantial

The high proportion of jobs created by the more high-tech and knowledge-intensive activities is another area of the data worth foregrounding. In 2005, the high-tech and mid-high-tech manufacturing industries, combined with the KIS sectors, employed 26.4% of Sao Paulo's formal workforce – led by the S-KIS, P-KIS and F-KIS (Table 2).

Much of the importance of the S-KIS services in terms of employment is due to the healthcare sector. We can recall that here the focus is on hospitals, laboratories and 'other healthcare

[10] This data has been extrapolated by the authors from the Sao Paulo Economic Activity Survey (PAEP) conducted by the SEADE Foundation for 1996 and 2001.

[11] Fiscal value added data from Sao Paulo State Department of Taxation and Finance. Data organized by Seade Foundation. Accessed from: www.seade.gov.br

activities' as sectors containing the most knowledge-intensive services, whether in terms of research, or the high-level care provided in hospitals and laboratories, especially diagnostic services, blood and organ banks, and so on. Taken as a whole, these activities employ around 170,000 people, or 4.5% of Sao Paulo's total working population – around a quarter of these employees have completed higher education.[12]

The F-KIS activity making the highest contribution to employment is financial intermediation, including banks and brokers, accounting for 3.8% of Sao Paulo's total active workforce, approximately 106,000 people. The biggest employers among the P-KIS are the recruitment and employment agencies, which are more labour-intensive, as well as business management and advertisement firms, which use a more specialized workforce. Finally the T-KIS with the largest contingents of employees are the telecommunications and information technology areas – 28,000 and 43,000 people, respectively.

In relation to manufacturing, the 2005 data reveals the following sectors to be among the largest employers: machinery and equipment (39,000 people employed); appliances and electrical materials (20,000); and chemical products (41,000, almost half in the pharmaceutical sector).

Concentration of high-tech and knowledge-intensive sectors in Sao Paulo is outstanding

The high-tech and knowledge-intensive sectors are not only representative of Sao Paulo's structure of production; they are also fairly heavily concentrated in the city. To begin with, we can note that whatever criteria we use, the scale of Sao Paulo is unmatched by any other Brazilian city. Measured in absolute numbers, the superiority of Sao Paulo is striking.

Comparing with other Brazilian cities (Table 3), while Sao Paulo concentrates around 12% of formal employment in the country and 18% of total wages, the higher-tech and knowledge-intensive sectors combined concentrate 16% of jobs and 22% of wages. This suggests that the level of concentration of these sectors is higher in relative terms than the concentration of economic activities as a whole.

Table 3: Proportion (%) of employment and wages of high-tech and mid-high-tech manufacturing industries and knowledge-intensive services in seven Brazilian capitals; 2005

Cities	High-tech MI		Mid-high-tech MI		T-KIS		P-KIS		F-KIS		S-KIS		M-KIS		Total	
	Jobs	Wages	Jobs	Wages	Jobs	Wages	Jobs	Wages	Jobs	Wages	Jobs	Wages	Jobs	Wages	Jobs	Wages
São Paulo	10,7	12,1	12,2	17,7	18,0	25,6	20,1	32,8	23,5	27,9	13,9	19,9	14,7	23,3	11,7	18,0
Rio de Janeiro	2,1	2,1	3,0	3,6	12,0	16,4	8,4	10,5	9,7	10,0	7,9	8,6	13,4	26,1	6,2	7,8
Belo Horizonte	0,8	0,6	1,0	0,6	6,3	5,2	3,9	2,9	3,4	3,2	4,1	4,2	2,3	2,4	3,1	3,0
Porto Alegre	1,0	1,0	1,1	1,0	2,5	2,7	2,2	2,0	2,8	3,1	3,1	4,6	3,0	3,2	1,7	2,1
Recife	0,3	0,2	0,6	0,4	1,6	1,4	2,1	1,4	1,5	1,3	1,9	1,4	1,4	1,6	1,4	1,2
Salvador	0,1	0,1	0,2	0,2	1,9	1,6	2,5	2,1	1,7	1,7	3,3	3,5	1,6	1,7	1,8	1,6
Curitiba	3,0	3,5	1,9	1,9	3,9	3,5	2,5	2,5	3,1	3,1	2,3	2,1	2,0	1,9	2,0	2,3
Brazil	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

Source: Rais/MTE. Elaboration: Cebrap

Observing these activities separately, we can note that Sao Paulo is the only Brazilian capital among those analyzed whose high-tech and knowledge-intensive sectors all display a concentration of employment equal to or higher than the share of the total jobs of the municipality – led in particular by F-KIS, P-KIS and T-KIS, which concentrate 23.5%, 20.1% and 18%,

[12] However one point needs to be emphasized concerning this employment data, specifically relating to doctors, who usually work in various different locations – ranging from hospitals and outpatient clinics to universities. This makes any precision in calculating their numbers difficult and may lead to an underestimation of the sector's importance in the presented data.

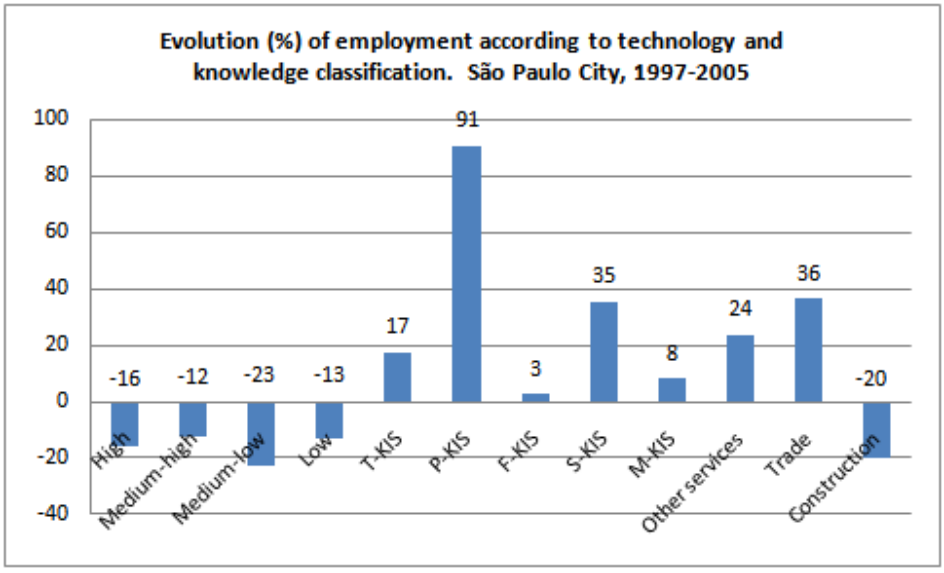
respectively, of their population employed in Brazil. The same applies to total wages: all the high-tech and knowledge-intensive sectors, with the exception of the high-tech manufacturing industry, have total wages equalled to or higher than average – again, these figures are led by P-KIS, F-KIS and T-KIS, which generate 32.8%, 27.9% and 25.6% of the national income in their areas. These statistics indicate the strength of Sao Paulo in the more high-tech and knowledge-intensive sectors compared to the rest of Brazil and other important global cities.

Higher-tech manufacturing industries and KIS display tendency towards growth

The growth in jobs in P-KIS and S-KIS sectors seems to have become consolidated over the last ten years, since these services show the largest upturn in employment figures between 1997 and 2005 in Sao Paulo (91% and 35%, respectively), along with commerce, which saw a 36% increase in its workforce, as show in Graph 1.

In the P-KIS group, the growth in business management consultancies is striking, both in terms of jobs (55%) and in terms of wages (147%). Increases in the number of employed workers and in wages are also seen for legal activities and advertisement. In the S-KIS, both higher education (growth of 43% in employment and 54% in total wages) and hospitals (47% and 46%, respectively) possess a similar dynamic.

Graph1



Source: RAIS. Elaboration: Cebrap.

Among T-KIS we can pick out the information technology sector with a 40% increase in jobs and a 33% rise in wages. In the F-KIS, financial intermediation (banks and brokers) saw a 20% growth in employees compared to 1997. In the M-KIS, despite low absolute numbers, cinema activities experienced a 25% growth in jobs during the period.

As indicated earlier, the biggest downturn was in manufacturing industry, which presented a decline in all four sectors analyzed. Although the high-tech and mid-high-tech industries declined considerably between 1997 and 2005, the data between 2001 and 2005 shows that it was precisely these two groups that pushed up growth figures in absolute terms. In the high-tech manufacturing industry, the sectors that grew between 2001 and 2005, albeit weakly, were machinery and

equipment, electrical materials and medical-hospital and dentistry equipment. In the mid-tech sector, chemicals and auto parts displayed some growth.

Employees with higher levels of education and above average income are characteristic of the higher-tech manufacturing industries and the KIS activities

The information on the proportion of employees with completed higher education in each activity sector, combined with data on average income, can be used as a proxy for the capacity of each sector to generate better paid and higher quality jobs.[13] This in turn allows us to describe the structure of production, as well as observe which activities employ more or less workers.

Both the employment of staff with higher education and the payment of higher wages are characteristic of the high-tech and knowledge-intensive sectors highlighted by the international literature and confirmed in Sao Paulo. In 2005, the high-tech and mid-high-tech industries and the T-KIS, P-KIS, F-KIS, S-KIS and M-KIS as a whole accounted for 52.9% of employees with higher education in Sao Paulo.

Table 4: Proportion (%) of employees with higher education, average income (R$) and proportion (%) of income compared to total average according to intensity of technology and knowledge. São Paulo, 1997 and 2005*

Sector of activity	2005		
	Employees with higher education (%)	Average income (R$)	Average income v. total average (%)
High-tech MI	14,7	2.119	129,2
Mid-high-tech MI	20,9	2.844	173,4
Mid-low-tech MI	6,4	1.484	90,5
Low-tech MI	10,7	1.520	92,7
T-KIS	38,9	2.877	175,3
P-KIS	18,8	1.524	92,9
F-KIS	56,9	3.733	227,5
S-KIS	37,3	2.160	131,6
M-KIS	27,6	2.919	177,9
Other services	13,6	1.364	83,1
Trade	7,7	1.208	73,6
Construction	6,7	1.223	74,5
Total	16,6	1.640	100,0

Source: Rais/MTE. Elaboration: Cebrap.

*In Reais as of 12/2006. Adjustment: INPC/IBGE.

The F-KIS and T-KIS have the highest proportion of formal employees with higher education – 56.9% and 38.9%, respectively – and the highest level of income – approximately 127% and 75% higher than the average income of the economy as a whole. Financial intermediation activities, for

[13] We recognize that higher education is not the ideal proxy for measuring the capacity of these activities to deal with technology and knowledge since it ignores the employment of technical personnel. However we were unable to use this information.

example, represent 10% of the total wages of the municipality and have an average monthly income of R$ 4,109.

The T-KIS group is led by information technology: it employees around 43,000 people, almost half of the T-KIS, with an average monthly income of R$ 2,773 and a proportion of employees with higher education of approximately 40%.[14] Furthermore, if we observe the more specialized activities such as systems consultancy and software development, we can note that the average income is more than double the general income and more than half of employees have completed higher education.

In the P-KIS both the levels of employees with higher education (18.8%) and average income (R$ 1,524 per month) are low due to the group's internal diversity. In the S-KIS aggregation, on the other hand, the large proportion of employees with higher education (37.3%) is not directly translated into higher income levels – just 31% above the average for the municipality of Sao Paulo.

The M-KIS services, despite their low numbers in absolute terms (formally employing just 14,000 people), employ staff with higher education above the municipal average and high wages. The average monthly income (R$ 3,537) of those employed in television activities and the important chain of services linked to the cinema sector suggest the need for more precise assessments based on other information sources.

Finally the high-tech and mid-high-tech manufacturing industries do not employ as many workers with higher education as the KIS service sectors – 14.7% and 20.9% respectively. However they do generate similar levels of income – 29% and 73% higher than the municipality's average income. Here we can highlight the chemical products sector (including pharmaceuticals) which registers the manufacturing industry's highest average income – R$ 4,122 per month – and the largest proportion of employees with higher education, approximately a third of the sector's work force.

Employees with lower levels of education earn more in the higher-tech manufacturing industries and knowledge-intensive services than in other sectors

The importance of the more high-tech and knowledge-intensive sectors for São Paulo's structure of production is also shown by the income generation levels for less educated groups. Table 5 shows average income and compares this with the total average income of employees in three education bands: completed higher education, secondary education and 'others,' which combines incomplete secondary education, along with complete and incomplete primary education.

Employees with secondary education and those from the 'others' group working in the low-tech and less knowledge-intensive sectors generally have an average income below that of people employed with the same levels of schooling in the high-tech and knowledge-intensive sectors.

The F-KIS and M-KIS and the mid-high-tech manufacturing industry pay average wages between 60% to 70% higher than the overall average income of employees with secondary education. Meanwhile low-tech industry pays practically the average wage and other services pay almost 10% below the average for this group of employees with secondary education.

[14] This number of employees may be under-represented since it refers to formal jobs, while it is known that many IT forms hire workers using other employment connections, such as freelancing or company outsourcing.

Table 5: Average income and proportion (%) of total average income by level of education acccording to intensity of technology and knowledge. São Paulo City, 2005

Sector of activity	Higher		Secondary		Others*	
	Income	% of average income	Income	% of average income	Income	% of average income
High-tech MI	5.814	133,1	1.715	132,5	1.260	138,6
Mid-high-tech MI	7.250	166,0	2.066	159,7	1.257	138,3
Mid-low-tech MI	5.439	124,5	1.470	113,6	1.071	117,8
Low-tech MI	5.091	116,5	1.329	102,7	945	104,0
T-KIS	5.040	115,4	1.615	124,8	1.053	115,8
P-KIS	4.195	96,0	976	75,4	732	80,5
F-KIS	4.894	112,0	2.241	173,2	1.841	202,5
S-KIS	3.644	83,4	1.344	103,8	1.103	121,3
M-KIS	5.204	119,1	2.196	169,7	1.754	192,9
Other services	3.553	81,3	1.201	92,8	875	96,3
Trade	4.408	100,9	1.076	83,1	806	88,7
Construction	4.723	108,1	1.286	99,4	889	97,8
Total	4.368	100,0	1.294	100,0	909	100,0

Source: Rais/MTE. Elaboration: Cebrap. * Corresponds to incomplete and complete primary education and incomplete secondary education

When we turn to the 'others' group, which includes employees without secondary education, the difference is even more striking: F-KIS, M-KIS and S-KIS present an average income far above the norm. High-tech and mid-high-tech manufacturing industries are also above average (around 40%). In this case it is worth recalling that the sectors with low-tech and less knowledge-intensive industries employ many more people with lower schooling than the high intensity sectors.

Even so, this data suggests that working in the higher-tech and knowledge-intensive sectors is better in income terms not only for those with higher education but also for those with lower levels of schooling.

Other exercises conducted on the basis of a logistic regression model corroborate the findings of Table 5. This model allows us to observe the impact of the variables in isolation in order to determine the dependent variable. Here we should stress that the model does not allow us to state when each of the chosen independent variables explains the variation of the dependent variable.

Consequently we have compared the sectors classified as higher-tech and knowledge-intensive with the possibility of an employee earning an income above or below the average for Sao Paulo municipality (R$ 1,700). In other words does the fact that an employee works in a particular sector raise (or reduce) the person's chances of earning a higher than average income?

To construct the model,[15] we selected the variables of educational level, age, company size and length of employment, all commonly recognized as factors likely to increase an individual's income, as well, of course, as the variable of sector technological intensity. In relation to the latter, we decided on two modes of comparison. Firstly for manufacturing only, which compares the differential in terms of the chance of earning a wage above the municipal average for formal employees in the high-tech, mid-high-tech and mid-low-tech manufacturing industries compared to the low-tech sector. Secondly for services only, looking at the same differential for the five KIS groups compared to the "other services" aggregation.

[15] Details of the model are provided in Annex 1 of the article.

Tables 6 and 7 illustrate that all the selected variables have a positive influence on the chance of an individual obtaining a higher than average income. However what we wish to underline here is that by controlling the variables of educational level, age, company size and length of employment, we find that the sectoral component indeed plays an important role in determining income.

In all the higher-tech and knowledge-intensive sectors, except for S-KIS services, the chances of employees earning above average wages are increased by working for firms in these sectors.

Table 6: Relation between income and manufacturing sectors. Total employees. São Paulo City, 2005

Independent variables (control and sectoral)	*Chance (%)*
Education	475,5
Length of employment	35,5
Size of establishment	33,8
Age	6,4
Low-tech MI	-
High-tech MI	105,5
Mid-high-tech MI	95,3
Mid-low-tech MI	34,6

Note: Statistical significance for all variables at the level 0.00. Source: Rais/MTE. Elaboration: Cebrap.

Table 7: Relation between income and service sectors. Total employees. São Paulo City, 2005

Independent variables (control and sectoral)	*Chance (%)*
Education	431,7
Length of employment	38,3
Size of establishment	15,3
Age	4,4
Other services	-
T-KIS	163,5
P-KIS	28,7
F-KIS	236,1
S-KIS	-19,6
M-KIS	323,3

Note: Statistical significance for all variables at the level 0.00. Source: Rais/MTE. Elaboration: Cebrap.

In terms of manufacturing industry, employees working in the high-tech and mid-high-tech sectors have a roughly 100% greater chance of obtaining an above average income compared to those working for low-tech industries. In the service sector, these chances double or triple, as in the cases of KIS-T (163%), KIS-F (236%) and KIS-M (323%) compared to the “other services”.

We conducted the same exercise excluding employees with higher education in order to investigate the effects of the variables in question on those workers with fewer qualifications (employees with complete or incomplete primary education and complete secondary education). The results (Tables 8 and 9) were similar: in other words the sectoral component is also a relevant factor in determining

whether the employee has a greater chance of obtaining an income above the average for the formal workforce.

Table 8: Relation between income and manufacturing sectors. Employees with incomplete or complete primary education and complete secondary education. São Paulo City, 2005

Independent variables (control and sectoral)	*Chance (%)*
Education	243,4
Length of employment	37,3
Size of establishment	33,8
Age	5,9
Low-tech MI	-
High-tech MI	112,2
Mid-high-tech MI	88,2
Mid-low-tech MI	33,0

Note: Statistical significance for all variables at the level 0.00. Source: Rais/MTE. Elaboration: Cebrap.

Table 9: Relation between income and service sectors. Employees with incomplete or complete primary education and complete secondary education. São Paulo City, 2005

Independent variables (control and sectoral)	*Chance (%)*
Education	313,7
Length of employment	14,5
Size of establishment	50,3
Age	4,2
Other services	-
T-KIS	146,6
P-KIS	8,6
F-KIS	354,6
S-KIS	-34,0
M-KIS	366,1

Note: Statistical significance for all variables at the level 0.00 (with the exception of P-KIS, which was at 0.099). Source: Rais/MTE. Elaboration: Cebrap.

In the manufacturing sector we can even identify an interesting 'ladder effect' where the chance of obtaining a higher than average income increases in proportion to the sector's technological intensity. In the case of services, the same T-KIS, F-KIS and M-KIS areas emerge as those activities with the highest chances, especially the latter two (over 350% higher chance than the "other services" group).

These exercises show that by producing a cross-sectional analysis of technology and knowledge, we are not simply privileging employees with higher educational levels. As well as employing relatively more people with higher qualifications and paying better wages, these productive sectors also pay better wages to those with lower levels of schooling.

4) Discussion

Irrespective of whether they belong to the manufacturing or services sectors, higher-tech and knowledge-intensive activities have a cross-sectional effect within the economy. They are simultaneously producers, suppliers and disseminators of inputs and knowledge to processes involving innovation and learning in all sectors. The description of the Sao Paulo structure of production with an emphasis on its more higher-tech and knowledge-intensive sectors allows us to identify the importance of certain activities for the city. The fact is that these activities comprise central assets in the evolution of Sao Paulo's economic competitiveness.

As the analysis has demonstrated, higher-tech manufacturing industries and knowledge-intensive services have a relatively higher level of concentration in the city than other economic activities and show a trend towards growth. Additionally, they generate value, income and higher quality jobs, both for the more educated workforce and the less educated section. This occurs because, contrary to common sense, they do not involve just "super-high-tech" activities. There is a whole series of more routine activities – such as call centres, software coding, basic healthcare, the manufacture of syringes, condoms and less complex pharmaceuticals, assembly of electronic equipment, recruitment and employment agencies – which are directly related to the more complex industries – such as software conception and design, production of scripts for cinema, radio and television, higher education, R&D, business consultancy and management, specialized medical care, production of pharmaceuticals, electrical material and capital goods – which form the high-tech and knowledge-intensive sectors.

This is an important point of the analysis since the identification of these sectors as generators of high-quality jobs, as well as their cross-sectional effect, shows that investments and specifically targeted public policies do not favour just an elite section of the labour market or the economy. In other words, we argue that the development of these sectors is positive for economic development in general.

In the case of Sao Paulo, it should be pointed out that the activities we are discussing did not always exist or take the same form as they do today. The economic transformations of the last two decades have been especially strong with far-reaching implications for Sao Paulo's structure of production. Here we can highlight the restructuring process, the macroeconomic reforms at the start of the 1990s and the beginning of the new cycle of economic growth and workforce expansion from the start of the 2000s. In this setting, a series of economic activities continued in Sao Paulo, while a significant number were created and/or renewed.

On one hand, there are a number of manufacturing activities, such as the machinery and equipment sectors, and the production of electrical material, electronics, chemical products and pharmaceuticals. The viable industry in Sao Paulo today has very different characteristics compared to 20 years ago. Though further research is needed on this "new manufacturing sector", we can hypothesize that it involves: (i) a relatively low intensity of labour, but, even so, they comprise an important factor in generating jobs in the municipality; (ii) the use of increasingly smaller spaces; (iii) an increasing use of outsourcing, whether of low or high complexity activities; and (iv) the potential to use knowledge and generate innovative products and processes.[16]

On the other hand, a set of service activities are revived, acquire new formats or even emerge as new forms. These include telecommunications, information technology, business management and consultancies in general, financial activities, higher education and healthcare (hospitals and laboratories), advertisement and market research and audiovisual media.

Some have acquired considerable dynamism from the restructuring process and the associated outsourcing of activities, such as security services, the food industry, cleaning, some areas of IT

[16] As well as containing this manufacturing industry that emerged from the restructuring of production, it should be emphasized that Sao Paulo still concentrates the central offices, branches, R&D centers and technical assistance services of a series of manufacturing firms that relocated their production plants.

and accountancy. Once exposed to the competitive dynamics of the market, the range of services offered diversifies along with the types of clients.

Other activities that simply did not exist previously have been created, generating a complex web of subcontracting, including certain niches of the telecommunications industry, the IT sector and specialized consultancy. The creation of new demands and activities following the restructuring process, internationalization and the greater importance of knowledge and information for the networks of production, form the core of the process of developing new service activities. The latter are consolidated as activities encouraging the circulation of knowledge and produce new chains of value (Torres-Freire 2006a).

The service sector in general and the KIS groups in particular have acquired their own dynamics over the last two decades. This does not mean that manufacturing has ceased to be part of their list of clients, but that it has become one more sector among other very important clients, such as the financial sector, governments and the services sector itself.

Contrary to more simplistic interpretations of Sao Paulo's structure of production, we believe that it has become more complex in recent years. It is at once immensely diversified and specialized. Diversified because it includes practically all the production chains. Most of its competitiveness derives from this diversity. And specialized in the sense of comprising Brazil's main zone of production in a range of economic activities – including manufacturing industries. This specialization in a wide range of sectors explains the strength and competitive potential of a city like Sao Paulo, which, if linked to well-formed public policies, has every chance of expanding.

5) Conclusion

We emphasize that the present paper focuses on just one of the three dimensions of the triple helix: business companies, based on the structure of production. These dimensions determine the competitiveness of cities in the era of the knowledge economy. The best environment for development is one in which businesses interact with the infrastructure of science, technology and innovation, especially universities and research centres, and with public authorities committed to expanding the productive capacity of regional spaces.

In terms of Sao Paulo's infrastructure of science, technology and innovation, based on the investigation conducted by Consoni (2010), we can highlight the city's considerable potential in: (i) concentrating higher education institutions and training a highly qualified workforce at both graduate and postgraduate levels, especially healthcare-related areas; (ii) scientific production, which can be measured by the number of scientific articles indexed in international journals; and (iii) providing a home for technical institutions supporting the research, development and innovation activities of businesses, such as laboratories and certification bodies.

Despite this potential, Sao Paulo fails precisely at the moment of transforming this considerable capacity for scientific production and knowledge generation in technological production into new products and processes. Data on patents, for example, shows that the number of applications registered by Sao Paulo firms and other institutions with the United States Patent and Trademark Office (USPTO) has failed to match the evolution in the city's capacity for scientific production. Moreover, universities appear as the main patenting institutions, demonstrating the weakness of firms based in Sao Paulo when it comes to producing technological developments (Consoni 2010, CGEE 2009).

The actions of local public authorities vary considerably. Investments in S&T and R&D by both federal and state governments have risen sharply over the last 20 years. As well as supporting science, these initiatives look to foster closer links between universities and businesses, with direct subsidizing of firms for innovative projects and payment of grants to researchers working in companies (Arbix & Martin 2010, CGEE 2009). However the results are still weak and the adoption of consistent policies supporting higher-tech and knowledge-intensive sectors has yet to take place

– a fact shown, for example, by the difficulty in implanting the system of technology parks in Sao Paulo State.

Perhaps one of the biggest challenges for municipal and state public authorities is intensifying the incentives to encourage the Sao Paulo productive sector to make better use of the infrastructure of science, technology and innovation offered by the city. These include hiring postgraduate researchers in the private sector, subsidies for carrying out R&D activities in the private sector, and incentives for creating small technology-based companies. The fact is that the municipality possesses a higher-tech and knowledge-intensive structure of production, a robust S&T infrastructure and various support initiatives from different spheres of government. Building the interaction of these three dimensions is the great challenge.

ANNEX 1: **Logistic Regression Model – RAIS 2005, São Paulo Municipality**

1. Dependent variable: Average income of São Paulo: dummy variable comprising the average income of the municipality for the total employees recorded in the RAIS 2005 survey (R$ 1,700), adjusted by the INPC (National Consumer Price Index: value in Reais as of 12/2006).

2. Independent variables:

A. Control variables (with effects confirmed by the literature):

1. Educational level: by completed levels. Categories: complete or incomplete primary education; complete secondary education; complete higher education.
2. Size of business establishment: using the categories already employed by the RAIS data: up to 4 employees; from 5 to 9; from 10 to 19; from 20 to 49; from 50 to 99; from 100 to 249; from 250 to 499; from 500 to 999; 1000 or over.
3. Length of employment: using the categories already employed by the RAIS data: up to 2.9 months; from 3 to 5.9; from 6 to 11.9; from 12 to 23.9; from 24 to 35.9; from 36 to 59.9; from 60 to 119.9; 120 or over.
4. Age: in full years.

B. Sector variables: we separate the industrial sectors from service sectors for internal comparison of the effects of knowledge and technological intensity on income variation.

1. Industry (ordinal categorical variable): we maintain the 4 categories: high, mid-high, mid-low and low.
2. Services (nominal categorical variable): we keep separate the KIS areas and “other services”.

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