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Results and Implications of Technological Development in The Telecommunication Industry in Brazil

Débora Segato Martins
University of Sao Paulo - FEA-RP/RAD
debseg06@yahoo.com.br

Simone Vasconcelos R Galina
University of Sao Paulo - FEA-RP/RAD
svgalina@usp.br

ABSTRACT: Significant Science and Technology (S&T) results are expected from the telecommunications industry, as well as good social and economic indicators, once this industry is among those with the highest rates of innovation. This paper shows an analysis of investments and indicators of technological development and its relationship with economic and social changes in the sector in the last few years. An analysis of data leads us to conclude that investments in technological development are vulnerable to the economic environment for the industry.

KEY WORDS: Telecommunications equipment; technological development; indicators of technological innovation.

INTRODUCTION

The importance of the telecommunications industry goes beyond the mere supply of a human necessity of communication, once it is considered strategic for the whole economy. This industry penetrates and integrates all fields of social and economic activity such as financial activity, foreign commerce, government systems, production chains, commercial activities, and leisure (SBRAGIA ET AL., 2004).

The globalization of productive and financial activities and the intense technological development of the sector have allowed it to be of great importance worldwide (PRADO and PORTO, 2002). According to Galina (2001), technological development is currently one of the major supporters of this industry, since many recent changes, such as the increase in competition and the evidence that industrial organization will follow the model of vertical specialization, influence companies to focus on and be stronger in the segments they are competent in. In addition, investments in innovation made by the telecom industry, although declining in the last few years, have been comparable to those of the traditional pharmaceutical industry (FRANSMAN, 2001).

The increase of competition in the telecom sector has been caused mainly by the end of the old institutional model of direct state participation through public monopolies in telecom services (BRUFATO and MACULAN, 2000). With the end of the monopolies and the resulting presence of new national and international players, companies have become more competitive, generating intensification in R&D for technological innovation.

These changes, which took place in the mid 1990s to the beginning of the 2000s, have strongly impacted the sector, influencing many organizational, market and structural changes, both within the companies and in the productive chain of the industry and correlated industries such as computers and electronics. In the past, service companies were in charge of innovation, whereas nowadays, equipment producers are the main technological developers for the sector. In the last few years, we have also observed (starting in 2004) traditional companies from the telecom field – such as Siemens, Ericsson, Alcatel, among others – disaggregating some of their segments and/or joining other companies from the same sector or from the sector of information technology (IT) to take part in the development, production and sales

of telecom products.

Summing up all these changes in the institutional model, we have observed a stronger increase in the association between IT and Communication technologies in the last few years (creating the ICT segment - Information Communication Technology, a term which has been increasingly used by academics, industry and institutions which usually gather data from both industries - IT and Telecom – for joint analysis and studies). It is currently essential to obtain knowledge from both areas in order to develop innovation-oriented technology in this industry.

Technological innovation is therefore fundamental towards becoming competitive in the communications industry, and, for Brazil, which has elected this specific sector as one of the priority sectors to benefit from government policies[1], good results should be found in terms of S&T indicators, and consequently social and economic indicators from this local innovation. The discussion about the results of investments in innovation in Brazil by companies of the sector is recurrent, in social, economic and technological terms (GARCIA and ROSELINO, 2004; DIEGUES and ROSELINO, 2006).

Thus, the purpose of this paper is to show an analysis of investments in technological development by telecommunication equipment companies and to observe the implications and results of these investments by the economic and social changes in the sector, especially after the year 2001, the worst in the sector. In order to reach that goal, we analyzed and compared social, economic and S&T secondary data for the year of the world crisis, in the Brazilian industry of telecommunications equipment.

The evaluation presented in this article is important as it enables the characterization and analysis of one of the sectors that most invest in innovation in Brazil (PINTEC/IBGE) and whose participating companies, in general, benefit from fiscal incentives to develop technology via the "Lei de Informática" (IT Law - law that benefits local investments in computer and communications equipment). This allows us to evaluate whether the results derived from investments in innovation of a sector are continuous and representative. This evaluation is relevant for both government and companies. The paper also contributes in academic terms, once it presents a crossing of indicators of secondary sources conducted in a simplified manner that shows important results, besides contributing to the advancement of research in evaluating technological innovation.

The results are presented as follows: initially, a brief scenario of the sector in the last few years and a referential theory on S&T indicators are shown. The social and economic data, which indicate the evolution of this sector in Brazil, are then presented. The paper follows with an analysis of S&T indicators that conceptualize the development of technology in the sector. In the same section these data are crossed with social and economic indicators presented in the previous section. Then the final considerations are shown.

REFERENTIAL THEORY

Technological Innovation in the telecommunications sector

Innovation, in its varied approaches[2], contributes to the development of a competitive advantage for companies. By focusing on the technological approach of innovation, we should consider the transformations occurred in the last few years, which modified products and processes, introducing, as expected, changes in organizations from different industries, especially in ICT-related sectors. The technological evolution in this industry impacted several other sectors in an important and decisive manner, often promoting their own technological development.

In addition to the great technological advances, political and economic changes of the XIX Century up to the present have contributed to the reformatting of the organizational structure in the sector of ICT. Specially the communications sector, according to Brufato and Maculan (2000, p.2), "has been experiencing a series of ruptures caused by accelerated technological evolution and by changes in the institutional and economical scope in telecommunications services. The technical progress in this sector focused on the technological convergence between the industries of communications, computers, software and entertainment, associated to an environment of financial, commercial and productive globalization of transnational companies that have been changing the demands of world commerce in telecommunications services, and consequently, in the telephone equipment industry".

The model of national monopolies was shaken by the rise of new technologies which pressured the structure to become more flexible (WOHLERS apud PAULA, 2000), and its rupture influenced new tech-

nological development because of the increase in competitiveness with the presence of new players. For Fransman (2001), in the 80s everyone considered the telecommunications sector a natural monopoly, since they thought that the growing scale of telecommunications services could only be supplied by a monopoly. In most industrialized countries, there was a national monopoly in telecommunications services, although the industry of telecommunications equipment was structured differently in each of these countries.

On the one hand we have the USA, where vertical integration was complete; the telephone companies made their own equipment for infrastructure and for the telephone network. On the other hand were the small underdeveloped countries, where the telephone companies bought their equipment from suppliers which were global players. In industrialized countries like Japan, Germany, France and the UK the national industries were strengthened by the cooperation of the national monopolies with the local suppliers. In Brazil, national companies manufactured the equipment for the public carrier (Telebras System). However, corporations like Ericsson, Siemens and NEC were also present in the Brazilian market (GALINA, 2001).

According to Gaffard and Krafft (2000), the carriers had their own research facilities, where initial research, development and prototypes tests were carried out to later be transferred to the manufacturers. This structure used to inhibit the process of learning and development, as knowledge was fragmented and the access to telecommunication networks was restricted to the carriers and their partners (FRANSMAN, 2001).

Eventually, that structure began to change, especially with the end of the monopolies in the main developed countries, like Japan, the USA and the UK, in the 90s (GAFFARD AND KRAFFT, 2000) and with the access of equipment suppliers to third world markets, which created a need for technological development and stimulated the creation of their own research centers (FRANSMAN, 2001). At that time, the telephone service companies began not only to negotiate with different suppliers but they also transferred the responsibility of R&D to these (GALINA, 2001).

In 1998, Brazil experienced a turning point in the telecom sector with the privatization of the Telebras System. The CPqD (Center of Research and Development in Telecommunications, which belonged to Telebras prior to privatization) became a private foundation and provider of technological solutions for the market as a whole (NEVES, 2002).

The privatization, according to Brufato and Maculan (2000, p.2), created "a competitive environment based on supplying the growing demand of private carriers". The market became more competitive, with the introduction of several foreign players since service companies were mostly "controlled by foreign groups that took advantage of global sourcing practices". Thus, local Brazilian suppliers did not benefit from the competition present in the country and the sector is now characterized by high concentration of international equipment factories (BRUFATO and MACULAN, 2000).

Indicators of Science and Technology

As mentioned before, technological development is of extreme importance for the sustainability of companies in the present competitive environment, especially in the telecommunications sector; thus S&T indicators should be used to follow up the implementation of policies to stimulate innovation. According to Brisolla (1998), the use of S&T indicators grew after the 1970s due to the crisis of capitalism, when the institutional evaluation spread in all public organs in developed countries and also reached the scientific and technological sector. These S&T indicators were set up to increase productivity and the impact on the economic sector, to enable the evaluation of institutions, and to allow studies on scientific and technological activities. Kondo (1998) identifies several reasons for the use of S&T indicators as a way of understanding the contribution of technical progress to economic growth; answering questions on policies (what is the level of cooperation between public research institutions / universities and private companies? what is the potential of innovation of these sectors? what is the level of quality of research in universities? how can we compare countries in terms of their scientific and technological capacities?); monitoring the performance of the S&T System; evaluating this system, modifying, when necessary, the allocation of resources to improve their efficiency; and supporting activities such as the establishment of S&T policies, assistance to ministers and high government officials, accountability to taxpayers who finance S&T activities.

For Saénz and Paula (2002), no single indicator was

able to reflect the complexity and magnitude of the System of innovation; the indicators reflect the complexity of certain activities and their results in different contexts, therefore, when the indicators are created, the specificities of the environment where they will be used should be taken into account.

The analysis of scientific and technological indicators in developing countries, according Sáenz and Paula (2002, p. 434), "should allow the view of what is lacking and what should be done for social and economic development".

We can verify the complexity in the creation of indicators which, concurrently, allow international comparison, are consistent with the peculiarities of different regions, and truly reflect the reality that they represent. Andreassi et al. (2000) argue that, because of the complexity of the innovation process, which involves multiple flows of information, the measurement of technological innovation becomes a demanding activity. According to Andreassi (2000), based on studies by Archibugi (1988), Patel and Pavitt (1995) and Sbragia (1986), the most used indicators of innovation are sorted into six groups: R&D statistics, patents, economic indicators, direct monitoring of innovation, bibliometric indicators and semi-quantitative techniques.

METHODOLOGICAL ASPECTS

This study is focused on the analysis of technological development in the telecommunications equipment industry in Brazil over the last few years. It is based on quantitative data from secondary sources. Data were analyzed from 1997 to 2005, which covers both transition periods for the sector: in Brazil, with the privatization of Telebras System in 1998, and the global crisis of the sector that started in 2001. The indicators used to characterize the environment of the sector in Brazil, particularly in regard to social and economic aspects, were obtained from three governmental databases: the Annual Study of the Industry (PIA), RAIS, and from Secex[3].

PIA, by the Brazilian Institute of Geography and Statistics (IBGE), supplies the necessary data for the characterization of the Brazilian industrial structure and its transformations over time. The data from PIA are provided annually, for the years 1996 to 2005. RAIS is a database by the Brazilian Ministry of Labor and Employment with social information on a yearly basis. Currently, data are available from 1985 to 2005. The database from Secex, by the Brazilian Ministry of Development, Industry and Foreign Commerce, provides data on imports and exports from 1989 to 2007.

In both PIA and RAIS databases, data can be gathered by sector according to the nomenclature of the CNAE (National Classification for Economic Activities), even for groups in sectors (3 digits). Thus, suppliers of the telecom equipment companies are grouped in division 32, group 32.2 ("manufacturing of devices, telephone and radiotelephone equipment, and radio and television transmitters"). The Secex database allows a search of data by sector according to the Common Nomenclature of Mercosul (NCM).

This paper also analyzes technological development indicators for the sector, which were obtained from the Industrial Research of Technological Innovation (PINTEC) by IBGE. The study covers three periods: 1998-2000, 2001-2003 and 2003-2005. It is also worth to mention that values of data on revenue, average salaries and spending on innovative activities from 1997 to 2004 of PIA and Pintec were corrected for 2005 by IPA–OG for electronic products (advanced price index – global offer).

In order to better analyze the results obtained, we used indicators of patents and *bibliometrics* obtained from the database of the INPI (Brazilian National Institute of Intellectual Property), and the database of the USPTO (United States Patent and Trademark Office). The *Bibliometric* data comes from the SCI (Science Citation Index).

RESULTS OBTAINED

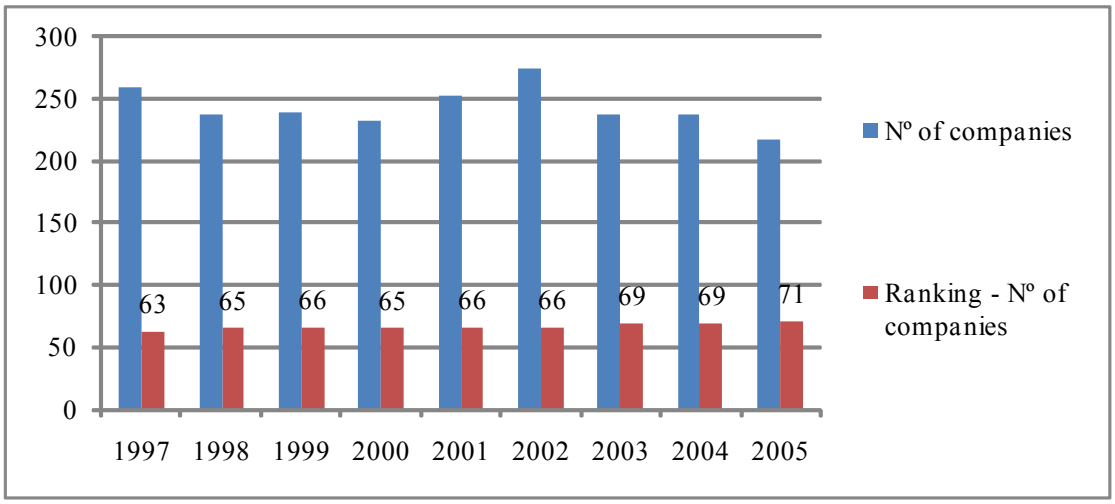
Scenario of telecommunications equipment

In this section, the evolution of the scenario of the sector of telecommunications equipment is presented, considering the number of companies, number of workers, average labor wages, net revenue and amount of exports and imports of the sector. Data from 1997 to 2005 are presented in order to identify possible changes in the scenario of this sector in Brazil during two significant moments in its recent history: the privatization of the Telebras System in 1998 and the world crisis in the sector in 2001.

The evolution of the number of companies in the

sector of telecommunications equipment (group 32.2 of CNAE) gathered by PIA/IGBE[1] is shown in figure 1 from 1996 and 2005. We can observe that the number of companies has decreased as well as the position of telecom group in the CNAE ranking of 111 groups classified by number of companies (also presented in figure 1). In 1996 this group was in 61st place in number of establishments, in 1998 it occupied the position 63, and in 2005 it went to 71st place.

Figure 1 - Number of Companies and Classification of Communications Equipment Group



Source: PIA/ IBGE

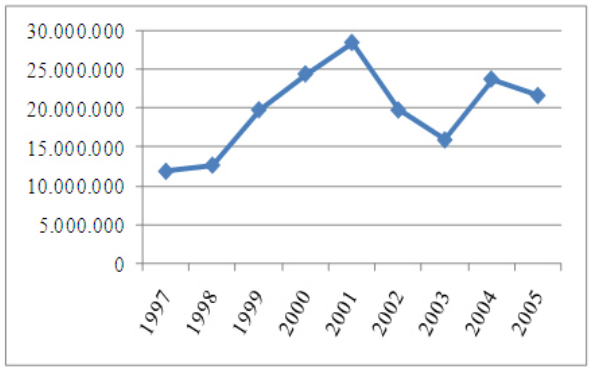
Observing the net sales income of the group, we can notice that it appears to be growing by the year 2001 (Figure 2) and in 2002 and 2003 there was a decrease of respectively 30.3% and 19.7%. The year 2004 was slightly better, with a decline in 2005. Furthering our observations about the characteristics of the financial sector, it was worth analyzing the representativeness of the group of communications equipment on the number of companies and the total net revenue of future sales compared to all industry groups covered by PIA (Figure 3). The percentage of revenue of the group in all companies showed an increase until 2001 and a decrease in the last few years, except for 2004. Moreover, the percentage of companies of the group 32.2% in respect to the total decreased, except for 2002, when an increase of 9.13% was registered. In spite of this increase observed in 2002, the total net revenue went down 30.33% compared to the previous year and kept falling until the following year. In 2004, even with a decrease of 5.88% in the number of companies in the group, there was a 48% increase in net sales revenue, although this was not repeated in 2005, when there was a decrease of 8.83% in net sales revenue.

Therefore, in the two years succeeding the sector crisis (in 2001), the communications equipment group lost not only net sales revenue, but also representativeness. While in 2001, it represented 2.8% of the total net revenue from the sectors covered by the study, in 2003 the net sales revenue of this group went down to just 1.36%. In 2004, the sector started to recover, with a share of 1.92% of the net revenue; however, this growth was not extended to the year 2005, when the net sales revenue of the sector and its percentage in relation to the total of all sectors dropped once again.

1 PIA worked with census research for companies with more than 30 workers and random probability for companies with 5 to 29 workers

Figure 2

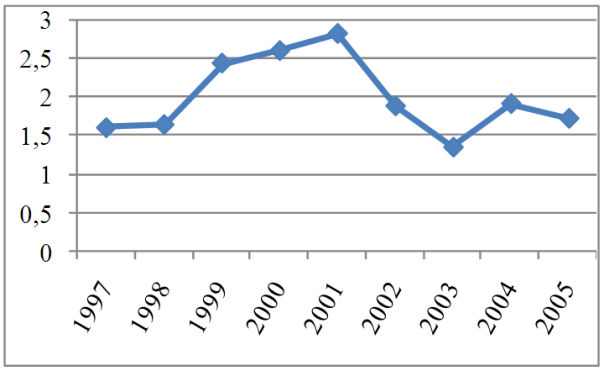
Total of Net Sales Revenue (Millions of Reales)[iv]



Source: PIA/IBGE

Figure 3

Total Net Sales Revenue (Percentage)



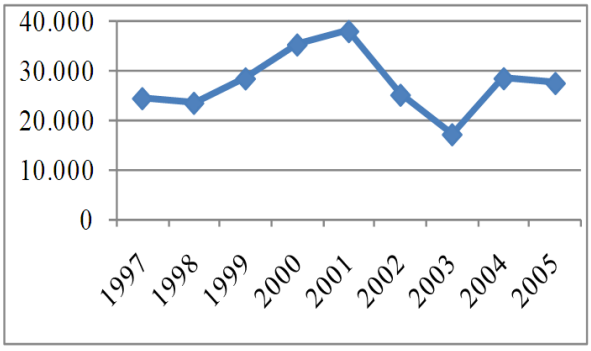
Source: PIA/IBGE

Similarly to what happened with the total net sales revenue, the number of workers in the communications equipment group experienced an increase until 2001, followed by a decrease in the two following years and a recovery in 2004. We observed a high correlation between the percentage of net sales revenue of the group and the percentage of the number of workers - close to 0.81 in the period. Thus, the net revenue and the number of workers followed a similar evolution, that is, with the recovery of telecommunications equipment market, there was an increase in the number of workers in the sector (figure 4). It may also be observed that in 1998 (after the privatization), there was a growth in the number of workers in the group, which dropped considerably after 2001, reaching, in 2003, a lower level than the one prior to privatization; in 2004 and 2005, the employment level of the sector almost equaled the one experienced in 1999.

The evolution of the percentage of workers in telephone manufacturing and communications equipment in relation to the total number of workers in Brazil is shown in figure 5. Data were obtained from the Rais database. Between 1998 and 2000 the workers of this sector represented between 0.09% and 0.1% of the total number of workers in Brazil, in the following three years there was a decrease in the amount of these workers from the total number, in 2003 it went down to 0.057%. In spite of the fact that in 2004 the percentage of communications equipment workers had increased in relation to the total amount of workers in Brazil, it reached mere 0.067%, still distant from the levels before the world crisis in the sector.

Figure 4

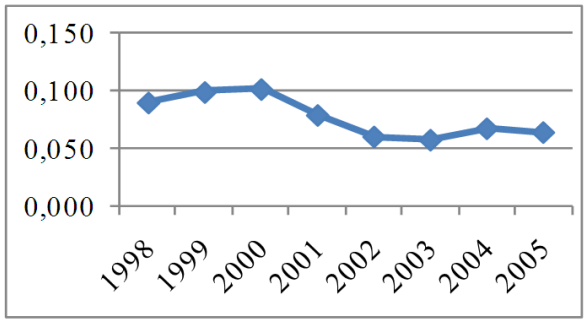
Occupation of the Group of Communications Equipment



Source: PIA - COMPANIES/IBGE

Figure 5

Percentage of Workers in the Group of Communications Equipment Manufacturers

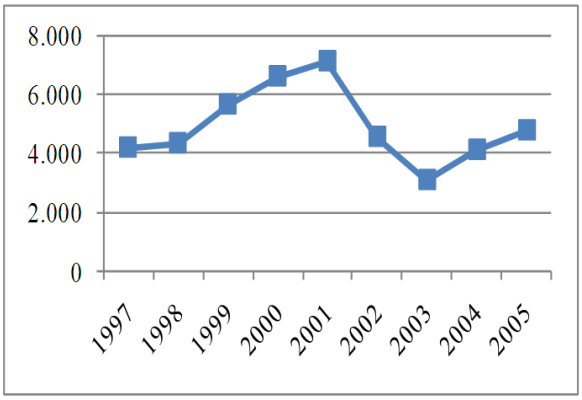


Source: RAIS

The average wage of workers in the sector and the percentage of the sum of salaries, earnings, and other remunerations in the sector in relation to the total from other sectors also increased by 2001, falling for the following two years and recovering for the years of 2004 and 2005, but not reaching the levels before the global crisis in the sector. The total salary and earnings of the sector workers that had represented 1.93% of total wages of all sectors in 2001 came to represent 0.75% in 2003. During the years of 2004 and 2005 it was approximately 0.98%. See evolution in figures 6 and 7.

Figure 6

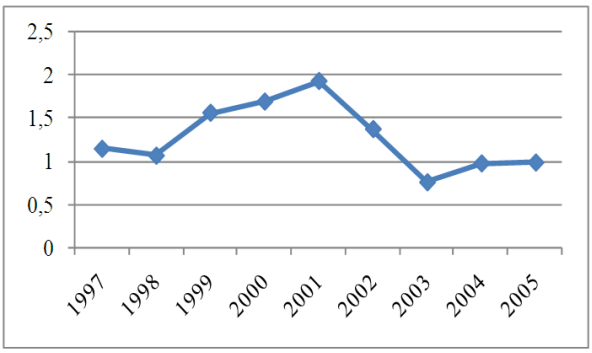
Average Salary (Reals)[v]



Source: PIA/IBGE

Figure 7

Total Salaries, Earning and Other Remunerations (% in Relation to Other Sectors)



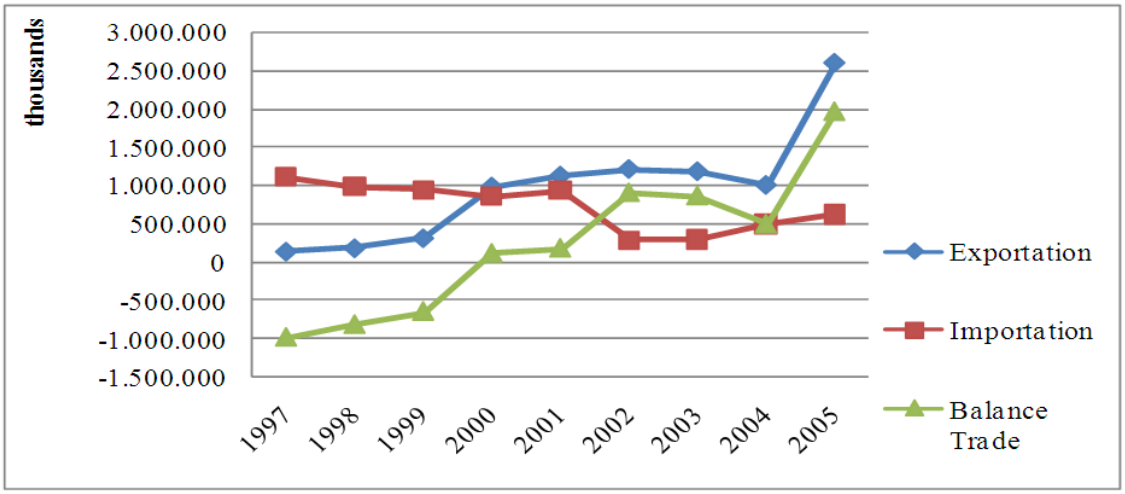
Source: PIA - Companies/IBGE

In order to observe the evolution of the representativeness of the sector in the international sphere, data of import and export of the telecommunications equipment group and the total volumes of Brazil in the years 1997 to 2003 were analyzed. Figure 8 shows that exports grew during all periods, except in 2003 and 2004, whereas, in 2000, the greatest growth was registered (nearly 214% if compared to 1999). In 2001 and 2002 exports also grew, although by approximately 14% and 8% respectively. In 2003 and 2004, exports decreased by 2.45% and 15%. However, in 2005, an amazing growth of 157% was registered, reaching levels never before attained. It was also noticed that the group exports consisted mainly of cell handsets.

On the other hand, imports had a decrease in 1998, 1999, 2000 and 2002 and an increase for 2001, 2003, 2004 and 2005. The year with the most significant decrease was 2002, close to 68%. The years with the biggest increases in imports were 2004 and 2005, with an increase of 61% and 24% respectively.

By the year 1999 the balance of trade for telecommunications products was negative and, for the next six years there was a surplus. In 2005, the year of the highest surplus in the period, the balance of trade was US$1,982,506,919 (FOB). The increase of exports and the decrease of imports in the period may have reflected the variation of the exchange rate at that time. From 1999, the exchange rate of the real in relation to US dollar increased and the Brazilian currency was devalued, which encouraged exports and discouraged imports. Therefore, the drop in imports as well as the increase in exports may have been caused or influenced by the Brazilian exchange rate policy.

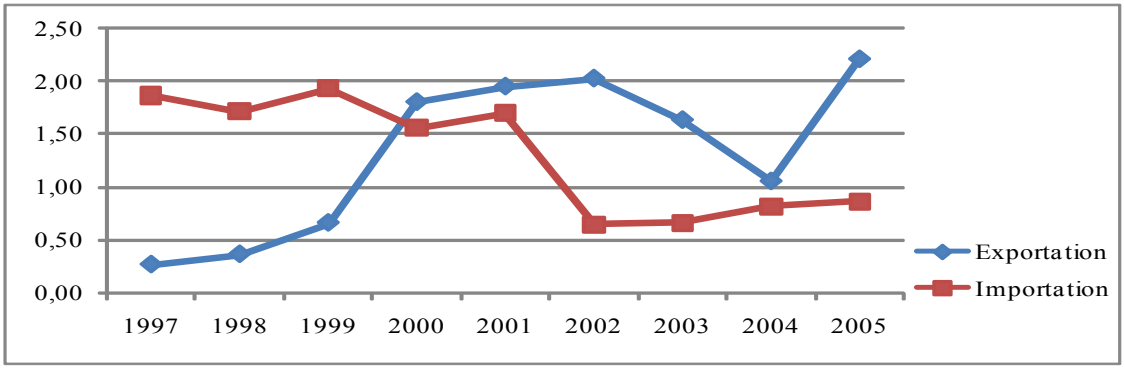
Figure 8 - Imports, Exports and Balance of Trade for Telecom Equipment in Brazil (Amounts in US$ FOB)



Source: SECEX

Figure 9 shows the relation of imports and exports of communications equipment over the total volume of all Brazilian imports and exports. Notice that, in general, exports of telecommunications equipment gained importance over the total of Brazilian exportations, especially after the year 2000. However, the imports of telecommunications products lost importance during this period, especially after the year 2001. Thus, other facts, besides the exchange rate policy, must have influenced the increase in exports and the drop in imports after 1999, since there were an increased share of exports and a declined share of imports of telecommunications equipment over the total volume exported and imported in Brazil; or the exchange policy favored these sectors over others in general. However, for the period from 2002 to 2004 the representativeness of Brazil in the sector was reduced with the fall in exports. In addition, the country became more dependent on imports of such products – in 2005 Brazil's exports of the sector increased again both in monetary values and in percentage of the total Brazilian export volumes.

Figure 9 - Relation of Exports and Imports of Telecom Equipment Over the Total Volume of Brazilian Importations and Exportations



Source: SECEX

The indicators presented in this item allow the observation of a growing evolution in the sector until the year 2001. Except for the number of companies, all other indicators show growth until the year 2001. Net sales grew 137% during this period; growth was particularly strong after the year 1998. Following the growth in sales, the number of employees and the average salary of the workers in the sector of communications equipment increased considerably by the year 2001, it was a growth of 31.8% and 68.9% respectively. Furthermore,

the representativeness of total wages in the industry face to all sectors covered by PIA / IBGE was growing in the same period. On the other hand, besides advancing by the year 2002, Brazilian exports of equipment had increased participation in the total volumes exported by Brazil. In 1997, exports of telecom equipment represented 0.26% of Brazil's total export volumes and went up to 2.03% in 2002.

According to these same indicators, the growth of the sector in Brazil was not sustained after the year 2001, which was the period of the industry collapse around the globe. After this year, almost all indicators showed retraction. The net sales decreased, the number of workers in the sector and their average salaries fell by 46.2% and 55.9% respectively from 2001 to 2003. The sector showed an attempted recovery in 2004, with an increase of 48% in net sales, of 24.8% in the number of workers and of 32.8% in average salaries. The following year the sector was unable to reproduce the growth experienced in 2004, with a decrease of 8.83% in revenue and an increase of 0.6% in the number of workers. However, there was an increase of 15.5% in average salaries. As for the balance of trade, the sector recovered from the crisis in 2005, where we can find the best positive surplus balance for the sector.

Indicators of Technological Development

As mentioned before, the S&T data was gathered from PINTEC/IBGE which covers three periods: 1998-2000 (which we will call in this paper as 'period 1'), 2001-2003 ('period 2') and 2001-2005 ('period 3'). These data were analyzed in parallel with the indicators shown in the previous item, in order to identify a possible relationship of investments in innovation due to the changes in the industry scenario. For the group of communications equipment manufacturers (group 32.2 of the CNAE), the number of studied companies went from 298 to 306 and to 318 for the three different periods (table 1).

The rate of innovation of these manufacturers dropped from the first period to the second, from 62.10% to 51.63%, although increasing to 55.35% in period 3. Still, with companies in general (from all sectors included in the study) there was an increase in the rate of innovation, of 31.50% to 33.27% then to 34.31%.

It is worthy to observe that the second period of PINTEC/IBGE, in which the communications equipment group had a decrease in the rate of innovation, covering the years of 2002 and 2003, was the one with the greatest reduction in sales volumes, as mentioned before. Thus, the shrinkage of the sector of communications equipment after the year 2001 may have led companies to restrict the focus on technological innovation, in order to support other activities considered more important for the sustainability of the companies. In the third period, there was an increase in the rate of innovation, a period during which sales experienced a slight recovery.

The decrease in the rate of innovation during the second period was probably due to the reduction of the expenditure rate on innovative activity in relation to the total revenue. However, as seen in table 1, the decline in this indicator was not a fact restricted to companies of the communications equipment group, as the total volumes of all sectors also show that the rate fell from 3.8% to 2.46% of total revenues. For the group of communications equipment, the innovation rate dropped from 5% to 4.12%. The rate of expenditure on internal R&D activities was also reduced from one year to another, both for all sectors and for the group of communications. In the third period of the study, there was an increase in the rate of innovation as well as in the rate of expenditure on internal R&D activities both for the communications equipment group and for companies in general.

The turbulent scenario for the international communications equipment industry after 2001, which also affected operations of companies established in Brazil as seen when observing the economic indicators, was probably the main reason for the reduction of investments in innovative activities and, consequently, resulted in the reduction of the innovation rate for companies in this sector. In the global scenario, Galina and Plonski (2005) show that, in spite of the crisis in 2001, the percentage of global R&D investments in the sector related to revenues (relative investments) was, for that year and for 2002, above the percentage of investments for the year before the collapse (2000).

In order to check whether investments in innovative activities were vulnerable to the economic environment of the industry, expenditures in innovative activities and net income for the years 2000, 2003 and 2005 were correlated, resulting in high positive correlation for the two values, about 0.92. In order to analyze the possible influences of expenditure on innovative activities in the social environment, these indicators were correlated, which resulted in a positive correlation of 0.92 (high correlation) be-

tween expenditures on innovation and the number of employees, and of 0.68 (moderate correlation) between expenditures on innovation and average salaries. It is useful to point out that the analysis of the correlation was limited, since the period of analysis is not continued and covers merely three years, which is the period available in the data bases.

Table 1 - Profile of Companies and Intensity of Innovation - PINTEC[vi]

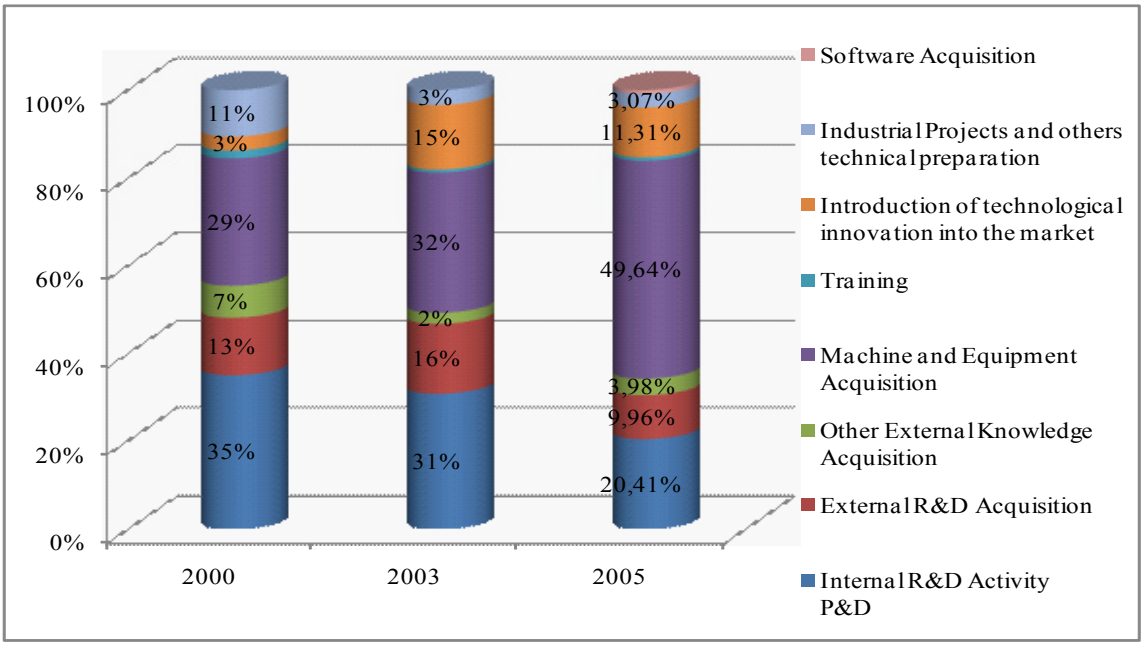
Period	**1998-2000**		**2001-2003**		**2003 – 2005**	
Profile of Companies	**Average Base**	**Average of Group***	**Average Base**	**Average of Group ***	**Average Base**	**Average of Group ***
Total Number of Companies	72,005	298	84 262	306	95 301	318
Number of Companies that implemented innovations	22,698	185	28036	158	32796	176
Rate of Innovation (%) (Number of innovative companies / total companies)	31.50%	62.10%	33.27%	51.63%	34.41%	55.35%
Gross Income – Average per company (R$)**	8,088,412	70,105,469	11,318,334	68,437,761	14,242,557	105,556,423
Number of workers – Average per company**	69	191	64	135	67	179
Productivity per worker (R$) (Revenue / Nº workers)**	117,223	367,044	178,099	505,478	211,756	590,057
Intensity of Innovation (expenditures)	**2000**		**2003**		**2005**	
Expenditures on innovative activities– Average / company (R$)	1,165,862	6,220,970	1,136,911	6,351,257	1,258,971	10,501,002
Expenditures on internal activities of R&D – Average / company (R$)	504,799	3,316,072	1,031,939	3,156,714	1,684,198	3,440,345
Expenditures on training – Average per company (R$)	60,917	303,096	83,921	122,285	136,293	288,647
Expenditures on introduction of innovation in the market – Average per company (R$)	248,254	480,426	268,765	2,007,206	474,504	2,573,855
Expenditures on industrial projects and other technical preparations– Average per company (R$)	404,838	1,140,770	389,324	390,000	621,112	812,696
Expenditures on external Acquisition of R&D – Average per company (R$)	378,140	2,609,230	561,279	4,796,621	904,542	4,627,459
Expenditures on acquisition from other external know how– Average per company (R$)	400,898	1,792,238	391,843	558,105	68,813	6,366,302
Expenditures on acquisition of machines and equipment – Average per company (R$)	750,794	2,905,817	715,680	2,942,564	1,030,002	9,280,614
Rate of Expenditures – incidences of spending on innovative activities over sales	3.80%	5%	2.46%	4.12%	3.04%	5.51%
Rate of Expenditures – incidences of spending on internal activities of R&D over sales	0.64%	1.75%	0.53%	1.27%	0.77%	1.12%
* Section 32, Group 32.2 (manufacturers of phones and communications equipment) according to CNAE classification						
** Data refers to the last year of the period						

Elaborated by authors - Source: IBGE/PINTEC

Figure 10 shows the distribution of investment in innovative activities for the communications equipment group in the years 2000, 2003 and 2005. In 2000, the main investments were in internal R&D activities (35% of investments) and machinery and equipment purchases (29% of investments). In 2003 the focus remains on investments in machinery and equipment (32%), followed by internal R&D activities (31%), but in reverse order of relevance. And in 2005, investments in machinery and equipment accounted for nearly half the investments in innovative activities for companies in the group (49.64%). Such increase was due to the decrease of investments on R&D activities by the companies, both internally and externally.

Besides the decrease in the number of companies which innovated, and the rate of expenditure on innovative activity, companies from the group that innovated reduced the average investment in innovative activities by 23.36% and also changed the focus of the investment. One significant change was the introduction of technological innovation in the market, which is the last step in the overall R&D process. There was an increase in the number of companies that invested in this activity – from 4 companies in 2000 to 63 companies in 2003 – and there were increases of 214% in the average investments per company in this activity. On the other hand, internal R&D activities, which are long term activities with uncertain profits, were reduced by 28.54% from one period to another, and the number of companies was also reduced from 110 to 84. This shows that, during a period of crisis, the studied companies focused their investments in later phases of product life cycle, thus reducing the risks inherent to the process of innovation. Although in the third period of the study (PINTEC), companies that invested in R&D activities had increased the average of their investments, this increase was mainly in acquisition of machinery and equipment. For the same period, investments in R&D activities, both internal and external, decreased in average spending per company, but there was an increase in the number of companies that made these investments.

Figure 10 - Spending for Innovative Activities: Communications Equipment Suppliers



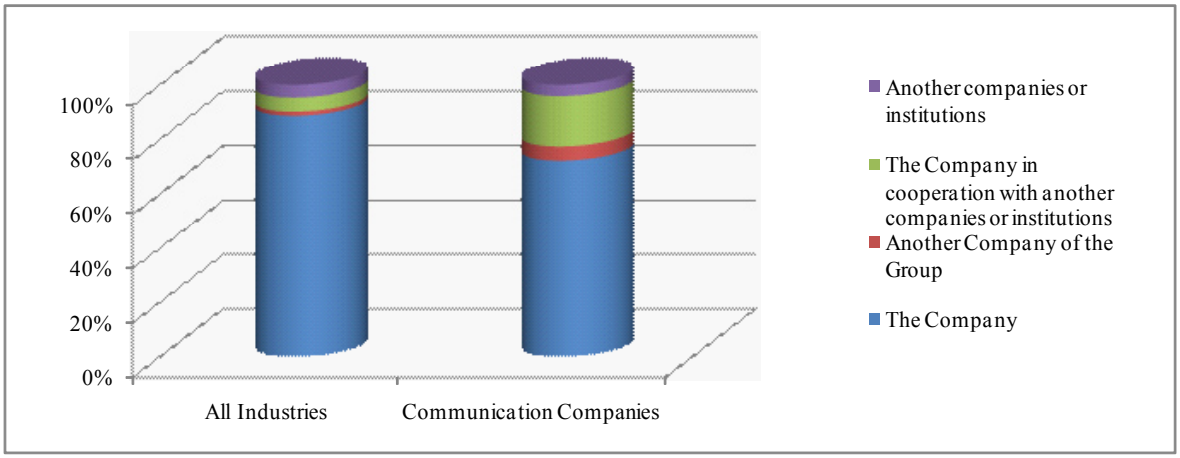
Source: IBGE/PINTEC

It is also important to analyze who are the main players responsible for technological development. In figure 11 we can observe that while for 88.63% of the companies in general, those responsible for the development of innovative products were the companies themselves, for the companies from the group of communications equipment manufacturers this percentage was 72.23% in the period from 2003 to 2005. Thus, it is verified that for almost 28% of the companies in this group the development of products was either made by other companies (5.2%), or in cooperation with other companies or institutions (18.4%), or was entirely developed by other

companies or institutions (4.1%). Despite the increase in product development inside the companies during the periods of the study, the percentage of companies which developed products in cooperation with other companies or institutions also went up (5.52% in period 1, 11% in period 2 and 18% in the third period).

The decentralization of technological development by companies from the communications equipment group may be explained, among other factors, by the "Lei de Informática" ("IT Law", a Brazilian law which establishes rules and incentives for manufacturing computer equipment and automation). This law stimulates cooperation between companies and research institutions offering fiscal incentives to companies which apply a percentage of revenues in R&D activities carried out cooperatively with research centers or universities (SBRAGIA ET AL., 2004).

Figure 11 - Main Responsible for Products Development: 2003 to 2005



Source: IBGE/PINTEC

Table 2 shows data on the intensity of technological innovation in human resources for the years 2000, 2003 and 2005. The PINTEC data for human resources confirm what was previously discussed in this paper using data by Rais and PIA/IBGE: reduction of labor force of communications equipment companies in 2003 compared to 2000. The average number of workers per company decreased from 191 to 135 workers for the communications equipment group, i.e. a reduction of 29.3%, facing a decrease of 7,25% in the average number of workers per company for all sectors; in spite of that, the communications equipment group had 2.11 times more workers per company than the companies in general. For the year 2005 the average number of people employed per company increased 35.12% in the communications equipment group, but the average number of workers per company for all sectors increased 5.09%.

The percentage of employees in R&D in relation to the total number of workers rose, for the communications equipment group, from 3.66% to 3.99% in 2003, but decreased to 3.45% in 2005, while for all sectors it decreased from 0.84% in 2000 to 0.72% in 2003 and rose to 1.31% in 2005. In spite of the increased percentage of employees allocated for R&D, there was a decrease in absolute numbers of workers in R&D for the year 2003 compared to 2000. For the year 2005, even with a decreased percentage of workers in R&D, there was an increase in their number.

The qualification of people employed in R & D is also found in Table 2, where it is observed that most workers are graduates, both in the communications equipment group companies, and for companies from all sectors. An increase in the percentage of graduate workers can also be noticed, from 56.9% to 67.3% and to 69.6% for periods 1, 2 and 3 respectively. And, for the same periods, the percentage of employees with post graduation courses increased from 6.9% to 9.9% and to 10.5%, while the percentage of workers with secondary education (high school) decreased from 22% to 18.5% and to 15%. Thus, we conclude that there was an increase in the qualification of workers allocated in R&D for the communications equipment group, because the percentage

of graduates and postgraduates increased and the percentage of workers with secondary level decreased. These changes for the specific group are similar to those of the companies from the general database studied by Pintec.

Table 2 - Intensity of Technological Innovation - PINTEC

Period	2000		2003		2005	
Intensity of Innovation Technological: Human Resources	**Average of Base**	**Average of Group***	**Average of Base**	**Average of Group ***	**Average of Base**	**Average of Group ***
Workers – average number per company	69	191	64	135	67	179
Worker in R&D – average number per company that invested in internal R&D	5.6	19	7.8	19.7	14	19
Worker in R&D – Postgraduates (total % of workers in R&D)	7.10%	6.90%	8.10%	9.93%	13.44%	10.49%
Worker in R&D – Graduates (total % of workers in R&D)	41.40%	56.90%	48.47%	67.25%	45.35%	69.60%
Worker in R&D –Secondary Level (total % of workers in R&D)	35.90%	22%	31.94%	18.52%	28.69%	15.01%
Workers in R&D – Other (total % of workers in R&D)	15.60%	14.20%	11.48%	4.30%	12.52%	4.90%
* Section 32, Group 32.2 (manufacturing of phones and communications equipment) according to CNAE classification						

Elaborated by authors - Source: IBGE/PINTEC

The percentage of companies from the communications equipment group which had no innovations decreased in periods 2 and 3 if compared to period 1. The obstacles to technological innovation pointed out by the companies are found in table 3. In general, in the first period, the obstacles, both economical or non economical, apart from "economic risks", were more relevant to the companies of the communications equipment group than to companies in general; in the second period, the economical obstacles were more relevant to the companies of the specific group and the non-economic obstacles, with the exception of the "centralization of innovative activity in another company of the group", were more relevant to the companies in general than to those of the group; and in the third period the situation was inverted once again - the economical obstacles were more relevant to companies in general and the non-economical were more relevant to the companies of the communications equipment group.

Since the economic barriers to innovation caused more impact to the sector in the second period of the study, especially those "economic risks", we conclude that the decrease in spending on innovative activities was probably caused by the crisis in the sector after the year 2001. The economic problems that derived from the collapse in the industry may have led communications equipment manufacturers to centralize their R&D activities in the headquarters or in a number of subsidiaries, other than the Brazilian ones. After 2001 the telecommunications equipment suppliers were affected by the world crisis in the sector, which led to a decrease both in net sales and in the number of workers. This fact must have contributed to the market conditions and economic barriers gained importance as obstacles to investment in technology by local subsidiaries, highlighting the importance of better public policies to encourage investment in innovative activities (MARTINS; GALINA, 2006).

In the third period of the study, in which there was improvement in net sales of communications equipment companies, the economical obstacles lost importance. Better economical and financial health may have led companies to increase their investments in innovative activities. It is also noticed that in the last period of the study there was a percentage decrease in product development in other companies of the group and, in addition, the obstacles to technological innovation caused by the "centralization of activity in other companies of the group" decreased, which could mean that the improvement in the economic situation of companies in

the industry led Brazilian subsidiaries to play a more important role in the global network for technological development within corporations, as opposed to what had happened in the previous period. However, even with the increase in most indicators for the two last periods (2003 to 2005) when compared to the first two (2001 to 2003), the rate of innovation and spending on R&D activities is still below the rate before the sector crisis and, furthermore, spending on innovative activities was strongly linked to acquisition of machines and equipment.

In order to better understand the centralization of R&D activities in the headquarters of companies or in other subsidiaries, it is worth conducting a comparative analysis of results of patents and bibliometric data from Brazil and from other countries that compete globally with Brazil in R&D resources, presented by Galina and Bertoloti (2004). These are indicators frequently used to analyze S&T results. Data gathered for this study allow us to observe that the number of domestic patents (applied for in Brazil) by the main subsidiaries of transnational companies (TNC) among telecom equipment manufacturers are more favorable to Brazilian subsidiaries, although it has decreased in the period from 1999 to 2003. Thus the decrease in investments and technological development, in the second period of PINTEC, could have damaged the S&T results of these Brazilian subsidiaries.

Besides, the same study also shows that international patents data are even less encouraging when comparing Brazil with other developing countries such as China and India. Brazilian subsidiaries have worse indicators, showing that activities linked to technological development in Brazil do not generate patents or scientific articles (GALINA, BERTOLOTI, 2004). In other words, the Technological Development of the sector in Brazil, extremely dependent on foreign TNC companies as mentioned before, is not generating innovation, as shown by S&T indicators.

Table 3 - Obstacles for Technological Innovation - PINTEC

Period	**1998-2000**		**2001-2003**		**2003-2005**	
Obstacles for Technological Innovation	**Average of Base**	**Average of Group***	**Average of Base**	**Average of Group ***	**Average of Base**	**Average of Group ***
Reasons for not implementing - Companies that do not innovate						
Previous Innovations	11.60%	1%	11.10%	18.16%	11.39%	15.53%
Market Conditions	55..60%	69.50%	65.39%	56.69%	69.69%	67.11%
Other Factors	32.70%	29.40%	23.51%	25.15%	18.91%	17.36%
Degree of importance of the obstacles faced by companies that innovate (Degree of importance evaluated as High or Average)						
Economic Risks	76.40%	63.30%	74.55%	88.53%	73.14%	61.72%
Innovation Costs	82.80%	90.00%	79.69%	84.13%	76.23%	68.24%
Scarcity of Financing	62.10%	64.70%	56.56%	65.66%	57.72%	49.88%
Organizational Rigidity	21.20%	35.20%	17.87%	3.84%	26.02%	52.59%
Lack of Qualified Personnel	45.60%	56.80%	47.47%	14.48%	46.97%	72.28%
Lack of Information on Technology	36.60%	41.70%	35.84%	3.81%	32.84%	39.91%
Lack of Information on Markets	33.90%	60.40%	30.49%	22.74%	31.08%	33.33%
Cooperation	32.20%	55.40%	29.56%	13.30%	28.26%	28.40%
Adequation to norms	25%	20.10%	32.93%	30.72%	32.19%	66.67%
Consumer Response	25.60%	25.90%	23.96%	19.56%	27.89%	41.98%
Scarcity of technical services	28.20%	28.80%	25.48%	13.21%	33.72%	41.98%
Centralization of innovative activity in another company of the group			0.96%	6.35%	1.30%	3.70%

* Section 32, Group 32.2 (manufacturing of phones and communications equipment) according to CNAE classification

Elaboration by authors - Source: IBGE/PINTEC

FINAL CONSIDERATIONS

In order to maintain the competitive advantage of companies, the capacity of innovation is not only crucial but also a key characteristic in the present globalized economic environment, with high-quality products and fierce competition; in addition, innovation becomes a fundamental issue in guaranteeing development of regions and countries. For Prado and Porto (2002), the telecommunications industry is extremely dependent on innovation since companies need to adapt to the competition imposed by the market. With a view to gaining competitive advantage, these companies should both expand their internal capacity for innovation and for incorporation of knowledge, and look for new sources of technology which are complementary to those internally developed.

However, despite recognizing the importance of investment in technological development to achieve competitive advantage, we find a decrease in the rate of innovation of this industry in the periods from 2001 to 2003 and from 2003 to 2005 if compared to the period from 1998 to 2000 (PINTEC/IBGE). This drop in the rate of technological innovation contrasts with what happened to companies located in Brazil: for companies in general, PINTEC shows that there was an increase in the rate from period 1998-2000 to period 2001-2003 and also for 2003-2005.

The analysis of the scenario of telecommunications equipment companies for the period from 1997 to 2005 and the analysis of the S&T indicators have allowed us to conclude that investments in activities of innovation have been vulnerable to the economic environment of the industry; the vulnerability was confirmed by the high correlation between spending on innovative activities and net revenue of companies. The reduction in net sales between 2001 and 2003 and in exports in 2003 and 2004 of telecommunications equipment, resulting mostly from the world crisis in the sector after 2001, has led companies to reduce investment in innovative activities in Brazil. After the year 2001, there have also been social consequences for the sector, such as the decrease in number of workers and in their average salaries. According to PINTEC/IBGE, for the first two periods of the study, the main obstacles for innovation of the sector were of economic nature, especially economic risk. In the last period, in spite of a decrease in the importance of economical obstacles and an increase in revenues, the increase of innovation rate was not significant and the increase of expenditure on innovative activity was strongly tied to the purchase of machinery and equipment. Thus, although most indicators improved in relation to the second period, most of them are still lower than before the crisis of the sector (first period).

The fact that telecom equipment manufacturers have their investments in innovative activities vulnerable to the national economic environment shows that these companies, even benefiting from fiscal incentives – mainly related to the IT Law (as data from the Ministry of Science and Technology indicate), do not take advantage of these benefits in terms of incorporating competences for technological development as a source of sustainable competitive advantage. This is, among other factors, due to the characteristics of R&D in these companies, which are mostly informal and not relevant. Furthermore, it is worth considering that the Brazilian telecom industry has major participation of foreign companies as players. Potential economical risks and low dependence on local innovation for competitiveness of companies lead these corporations to focus their R & D activities on the headquarters or on other subsidiaries of the group.

The inferiority of Brazilian subsidiaries in global development of products was confirmed by the analysis of indicators of Patents and Bibliometrics data, which show that the Brazilian subsidiaries in this sector have much lower S&T results than the ones from other countries such as China, India and Israel.

The combination and analysis of S&T, social and economic data from different databases show the vulnerability of activities of technological development in the sector of telecommunications in Brazil, providing subsidies for the discussion of the effectiveness of current policies to incentive local innovation. By analyzing this data, we conclude that technological development in telecom in Brazil is not stable, since it is influenced mostly by the economic situation. Besides, after the crisis of the sector in 2001, investments in innovative activities of companies located in Brazil decreased, while world investment percentages in R&D increased in 2001 and in 2002 when compared to 2000.

Consequently, current public policies, such as the "Lei de Informática" (IT Law), should be reconsidered and re-defined in order to consolidate these activities, which are of major importance for the development of the sector in Brazil, especially because

these are mainly undertaken by foreign TNCs. Government initiatives are usually important to improve investments in technological development by local subsidiaries, however, as it was discussed in this paper, current Brazilian public policy has not stimulated formalization and continuity of R&D activities of the telecommunications equipment manufacturers.

LIMITATIONS OF THE STUDY

When developing the study that originated this paper, we found some obstacles which generated limitations in the analysis of data. The existence of different nomenclatures in databases was a limitation, since it may have led us to incorporate distinct companies in the composition of indicators which may in turn have influenced their analysis. Another limitation of the study is the impossibility of desegregation of data for the sector of telecommunications equipment, thus, for almost all databases used, we were obliged to gather data from the sector of communications equipment in general. Finally, another obstacle for the study was the non-existence, in most of the databases, of data for more recent years.

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(Endnotes)

1. Since the 1960s the sector has been the target of incentive policies, either directly or indirectly (SBRAGIA and GALINA, 2004).
2. According to the Oslo Manual (OCDE, 2005), "Innovation" is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations.
3. PIA - Pesquisa Industrial Anual (Annual Industrial Research); RAIS - Relação Anual de Informações Sociais (Social Information Annual Report); SECEX - Secretaria de Comércio Exterior (Secretariat of Foreign Commerce)
4. Total net revenue amounts from 2005 by the IPA – OG - other electronic material.
5. Average salary in figure 7 amounts from 2005 by the IPA – OG - other electronic material.
6. Expenses in innovative activities from 2000 to 2003 amounts from 2005 were corrected using the IPA – OG for other electronic products.

AUTHOR'S BIOGRAPHY

Débora Segato Martins - Bachelor´s Degree in Business Administration from School of Economics, Business Administration and Accountancy of Ribeirão Preto at University of São Paulo (USP/FEA-RP), master student in Administration at the same University. Studies the telecommunication sector, the internationalization of R&D and technological innovation, having written several papers. Also works in habitats of innovation of technology.

Simone Vasconcelos Ribeiro Galina – Professor at Department of Business Administration at School of Economics, Business Administration and Accountancy of Ribeirão Preto / University of São Paulo (USP/FEA-RP) in the areas of Production Management and Technological Innovation. Bachelor's Degree in Computer Science from Federal University of Uberlândia, master in the same area at Federal University of São Carlos and doctorate in Engineering at Polytechnic School at USP. Has been studying the telecommunication area for at least ten years. Researcher and author of works in the areas of management of innovation technology, internationalization of R&D, indicators of S&T and globalization of operations.