

Telecommunications System of Innovation in Brazil: Development and Recent Challenges

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1 - Introduction

The objective of this paper is to examine the development of the Brazilian telecommunications innovation system since the 1970s and the main impacts of structural reforms implemented during the 1990s in Brazil (commercial liberalisation, deregulation and privatisation). The paper reviews how these changes affected the process of capacity building in the system of innovation. It therefore shows the current organisation of the telecommunications innovation system, presents how it is evolving after the structural reforms of the 1990s, and discusses the main challenges it is facing at present.

This paper builds from previous work (Szapiro, 2003a) and it is also part of a PhD thesis due to be presented by the end of 2004 (Szapiro, 2003b).

The paper is divided into three sections besides this introduction. Next section gives a brief description of the development process of the national innovation system of telecommunications in Brazil during the 1970s and 1980s. It presents the old structure of the system and also its main achievements. The third section discusses the recent evolution of the system, particularly how it was affected by structural reforms. It is divided into two sub-sections, the first describing the main changes related to trade liberalisation process and the second discussing the mains changes related to deregulation and privatisation processes. This sub-section presents the impacts of changes: on the telecommunications services supply, on the national telecommunications industry and on the national innovation system. Finally, section four presents the main conclusions of the paper.

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2 – Development, characteristics and main achievements of the innovation system

The Brazilian telecommunications innovation system was originated in the early 1970's and was very concentrated in Campinas, a medium-sized city in the state of São Paulo. The system was the result of a set of federal government policies aiming at deploying in Brazil a technological and industrial structure for high technology areas³.

As a result of these policies, throughout the 1980s industrial structure producing telecom goods was developed. This was remarkable since the 1980s was a period when the overall performance of the Brazilian economy was very poor.

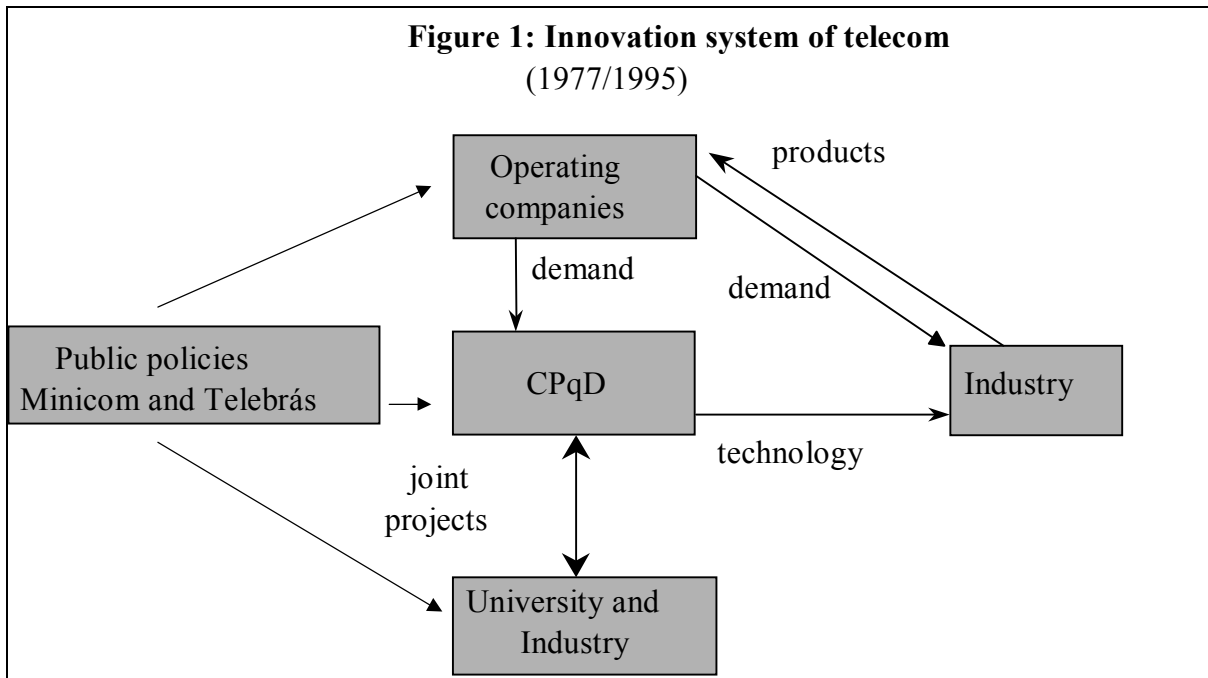
Government policies stimulated the increase in locally added value. Assemblage activities with imported inputs gave way gradually to local production. At the end of the 1980s, 90% of added value was produced locally (Pessini, 1993). In some cases, this was achieved by technologies developed locally in co-operation with other Brazilian institutions, like CPqD and university centres.

By the end of the 1980s, a telecommunications innovation system was established in Brazil. R&D Centre of Telebrás⁴ (CPqD) represented the cornerstone of the system. Local universities played an important part. Almost all big telecom multinational subsidiaries had facilities within the country. More than 40 locally-owned firms were established in less than a decade. These firms were deeply engaged in technology development. Figure 1 is an attempt to provide a synthesis of this system.

At the central stage of the system was CPqD. It was set up in 1976 in Campinas, as part of a larger movement, which intended to transform that region in a high technology centre. CPqD's main objective was to develop strategic expertise and capabilities for the Brazilian telecommunications system, in conjunction with local universities, telecommunications equipment producers and carriers.

³ Cassiolato et alli, 2001 and Doria et alli, 2000 provide more detailed analysis and information on the origins of this system.

⁴ Telebrás was the state owned holding enterprise for telecommunications.



Source: Szapiro, 1999.

Perhaps one of the most interesting achievements of the Brazilian innovation system in telecommunications is the gradual involvement, of subsidiaries of MNCs, which started to interact with CPqD, the university system and local firms (Hobday, 1984 and 1990)

Equitel (now Siemens), for instance, participated in a consortium with four other Brazilian firms to jointly develop switching system technologies for rural areas, generating products that were eventually exported to other Latin America countries. There was also a project, where Equitel and Elebra (the largest locally owned firm) and CPqD jointly developed a medium-sized public switching system. The strategy employed by Equitel targeted the growth of its share of the Brazilian market of telecommunications equipment and was clearly a result of the mechanisms to stimulate local development of technology implemented by the Communications Ministry as well as of the purchasing power of Telebrás.

One of the most important results of these processes was the establishment of a large network of local suppliers. In 1982 there were approximately 120 local firms, responsible for approximately 17% of the market (Hobday, 1984). Although the most important technology effort of the sector was at CPqD, local firms engaged in joint collaborative technological development with CPqD, universities and other firms.

The development of the innovation system brought many benefits for the telecom sector. The share of locally developed products in the total market for electronic equipment steadily increased, from an average of 4% during the 1980s to 14% in 1996. As pointed out by Hobday (1990) 'CPqD has developed virtually from scratch a range of digital exchange systems designed not only to suit Brazil's tropical

climate, but also the particular types of telephone traffic conditions found in the various regions. CPqD's close relationship with industry has enabled technology transfer and joint development with local firms in exchange, transmission and peripheral telecom technology' (p. 19) and 'there can be little doubt that in the areas of industrial and technological progress in digital telecom Brazil was, in the 1980s, leading the Third World, mostly as a result of the policies adopted after 1974' (p. 19-20).

The results were also significant in terms of price reduction of key products. Prices of installed terminals which averaged US\$ 800 in 1987 fell to approximately US\$ 200 in 1993 (Szapiro, 1999). It resulted in a significant reduction in the investment costs of building a telecommunications network in a large country (Mytelka, 1999). In the early 1980s, before CPqD was developing local technologies, the costs of setting up such a network in Brazil would have been exorbitant since the smallest exchanges being built internationally could accommodate many more lines than the needs of small towns and rural areas; they would certainly be under-utilised. As Mytelka (1999) pointed out, 'given the debt crisis and the decline in import capacity that this engendered from the mid-1980s on, there was little likelihood that Brazil could have significantly increased the speed with which its network was expanded and digitalized in the absence of the TDX programme that provided cheaper, more appropriate and technology intensive, digital products' (p. 145). In this sense, CPqD was seen as one exception in terms of successful laboratories in developing countries (Hobday, 1990).

3 - Recent evolution of Brazilian telecommunications institutional and regulatory model and main impacts

In the early 90s, several changes in telecommunications policies, especially the liberalisation and privatisation of Telebrás, caused several changes in the dynamics of the telecommunications innovation system. With the changes came profound impacts on the nature and intensity of the activities concerning technological capability development.

The pressures to change in the telecom industry began in the mid 1980s when the state monopoly of the telecom services were privatized in US, UK and Japan. By the late 1990s, with the agreement to fully liberalize its telecom market of the European Union and the similar agreement of the World Trade Organization (WTO), the essentiality of liberalization of the telecom industry became a consensus (Fransman, 2002). At the beginning of 2002, more than half the countries in the world had fully or partly privatized their incumbent telecom operator. Countries with a privately-owned incumbent operator account for 85% of the world market by revenue (ITU, 2002).

According to Fransman (2002), the new set of influences based on internet technologies, brought about fundamental changes that further transformed the telecommunications industry. Of course, the new telecom industry which has resulted from these technological and regulatory transformations have some fundamental differences from the previous one, that will be discussed later.

Like in many other developed and developing countries, in Brazil those changes reflected in trade liberalisation, deregulation and privatisation of the state monopoly. The technological, regulatory and institutional changes in Brazil can be divided into two groups: one that is mostly related to trade liberalisation, which begun in 1990, and the other that is related to privatisation and deregulation of the state monopoly (Telebrás), which started in 1995.

As argued elsewhere (Szapiro 1999, Cassiolato *et al.* 2002) trade liberalisation of the early 1990s did not significantly affect the organisation of the system of innovation. Technical barriers to entry remained important during the first half of the 1990s since Telebrás maintained the mandate to evaluate and license all equipment used. As a consequence, even if tariffs fell, the telecom equipment market structure did not change significantly during this period and neither did the innovation system. Firms (both locally and foreign owned) kept producing and interacting with the other agents of the system. CPqD was still the main technological agent and began to focus on software development. The major consequence of trade liberalisation was the increase in the share of foreign capital in the telecommunications industry.

However, institutional and regulatory changes in the Brazilian Telecommunications model which took place after Telebrás privatisation deeply altered the local industrial organisation and, as a consequence, the relationships between firms and institutions in Brazil. Many of the cooperative and interactive relationships previously in place were either extinguished or deeply altered in their nature, with important consequences on the dynamics of the national system. These changes brought about many new challenges to the future of the innovation system, which will be discussed in section four.

3.1 - The trade liberalisation of the early 1990s

The main consequence of trade liberalisation at the early 1990s was the significant growth of the market share of new subsidiaries of multinational firms in the Brazilian telecommunications equipment market (Pessini, 1993). A few examples of this are the entrance of Alcatel (which entered through the acquisition of national firms)⁵, of AT&T and of Northern Telecom – Nortel (they installed commercial offices and representations in Brazil). Furthermore, trade liberalisation led to a great increase in partnerships between national and international firms, such as the partnership between Nortel and Promon on cellular and data communications systems.

Firms faced trade liberalisation in different ways, mainly according to their source of capital (Szapiro, 1999). On the whole, trade liberalisation (basically tariff

⁵ In the early 1990s the entry strategy of Alcatel was the one that affected most the internal industrial structure: it acquired the two largest national firms (Elebra Multitel and SESA) which had, in 1991, combined sales of US\$ 174.3 million.

reductions), combined with the economic recession that marked the beginning of the 1990s, provoked a process of restructuring in the telecommunications industry, implemented in different ways by the firms.

In their majority, the nationally owned firms were forced to promote a process of productive restructuring. This type of strategy targeted production cost reduction, change of product lines, and sometimes abandonment of products that did not endure the rapid intensification of external competition. In the case of optical components, for instance, the trade liberalisation caused a significant growth of imports, forcing some nationally owned firms to abandon entire production lines (Szapiro, 1999).

Trade liberalisation and the resulting productive restructuring forced some firms to seek association with international firms allowing their entry into new, more profitable and less competitive segments of market⁶.

Generally, small technology-intensive firms (specially those of national capital) found many difficulties to maintain the leading edge, since trade liberalisation was accompanied by the abandonment of industrial policies. These difficulties, very often, led these firms to a technological downgrading process.

In the case of the multinational subsidiaries that were in Brazil before the beginning of the 90s, most of them went through internal restructuring when faced by trade liberalisation. Even though the information is somewhat scattered, it was possible to observe that because they were all large sized firms (with one exception), operating on various product lines and having financial support from their head office, trade liberalisation produced a less significant impact (Szapiro, 1999).

The most frequent reaction to trade liberalisation was the search for internal capability development (inside the scope of the group) and product and organisational innovations. In the latter case, the industrial and technological capabilities of the headquarters and other subsidiaries of the group were used. The firms introduced several organisational innovations such as just-in-time, Kan-ban, Total Quality Control, ISO 9000 etc. to increase their competitiveness with regard to the imported products (Szapiro, 1999).

However, even if trade liberalisation increased the competition in the telecommunications equipment industry and led the firms to drastically reduce their

⁶ The Promon case well illustrates this situation. In 1990, Promon, targeting penetration into new markets, established a relationship with a multinational subsidiary, Nortel (Canadian). The strategic partnership defined that Promon would commercialise cellular and data communication systems manufactured by Nortel. On the other hand, on supply contracts independent of Nortel, Promon would provide engineering services (Gazeta Mercantil, 1999). It is important to stress that this association did not provide for technological cooperation between both firms, as it was just for commercialisation of goods and provision of services.

costs⁷, it is possible to say that the firms, especially the nationally owned ones, reduced their investments on R&D.

In general, trade liberalisation forced some nationally owned small and medium enterprises (that had not been acquired) to concentrate in certain market niches, losing the core competence previously developed inside the company. Although trade liberalisation did not provoke significant changes in the structure of telecommunications equipment industry, it has caused significant effects on the strategies and capability development of the nationally owned firms. Nevertheless, it reduced the space for internal technological development.

Concerning CPqD, trade liberalisation resulted in changes of orientation, but the Centre did not have to abandon R&D activities. CPqD started to act more selectively on product development and there was an intensification of activities dealing with development of operating systems for large clients, *i.e.* carriers of the Telebrás system.

3.2 – The deregulation and privatisation of Telebrás at the second half of the 1990s

The deregulation and Telebrás' privatisation processes generated three different types of impacts: one is related to the changes in the supply of telecommunications services, another is related to the changes in the telecommunications equipment industry and the other focus on the transformations of the national innovation system dynamics.

3.2.1 – Impacts on the supply of services

Throughout the privatisation process, the Brazilian government struggled between two totally different approaches. The first option was to move towards privatisation under a scheme that would retain some kind of strategic control by the government and local capital. In this strategy, capital control and technology were to be important variables to be considered in the bidding process. Also important was the fact that even if the private partner(s) could be foreign they should belong to countries that were prepared to accept to negotiate policies fostering local production of equipment. This is a strategy that has been followed by several countries, in their privatisation process.

The second alternative was to look for a good financial bid and, consequently, for a maximisation of financial revenues. Although there were some discussions in government circles about these two diverging alternatives, the second was eventually implemented. In 1998, pressed by the imminent financial crisis, the Brazilian government privatised their operating companies and collected

⁷ For instance, Pessini (1993) emphasised that 24 out of a total of 50 firms in the sector showed losses in their 1991 balances.

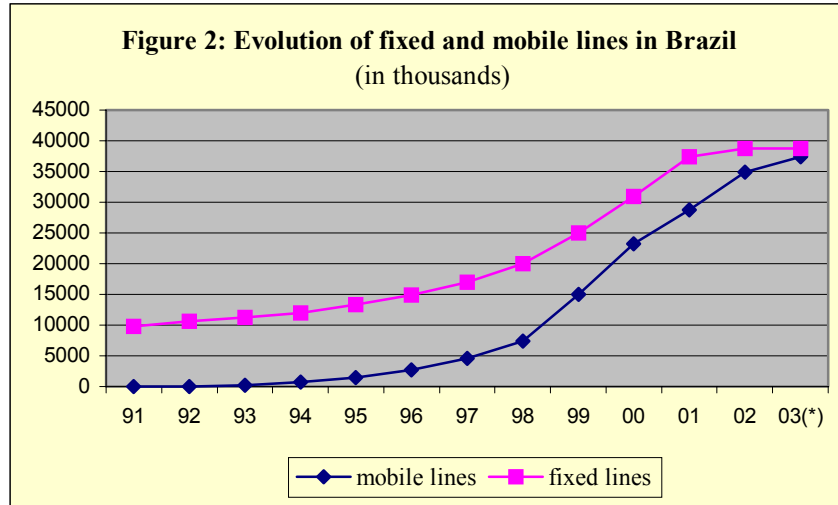
approximately US\$ 20 billion. This reorganisation process obeyed the logic of financial capital, as big international financial institutions were behind main bidders. The same may be said in respect to the mobile market, where both the new providers, chosen in the process that begun with the Minimum Law and the independent companies originated from Telebrás consisted of financial groups.

The original idea behind the chosen model of privatisation was to promote a duopoly in each region⁸ during a transition period up to 2001. This was to be achieved via stimulating the entrance of a new operator – the mirror companies –to compete in each area (3 in local telephony and one in long distance. In 1998, Telebrás was privatised for a total US\$ 22 billion and only in 1999 concession for the mirror companies to operate were given. However a real duopoly never occurred. In fact, after four years of operation, these mirror companies got only less than 5% of market share in the local telephony market. In the state of São Paulo, Telefonica, the incumbent operator, has a de facto monopoly: in 2003 it has 98,7% of the local telephony market.

In the mobile services market the situation is very different from the one in the fixed services. The changes began in 1996 with a law that divided the country in ten regions and sold licences to new operators. In 1998, during the privatisation process, the mobile operators of Telebrás were sold to new groups. Differently from the above case, a real duopoly was set up. In the last few years other new operators were allowed to supply mobile services all over the country. In most parts of the country three to four suppliers compete. The technological characteristics of the mobile telephony allowed the implementation of competition and stimulated the great increase in the number of installed lines in Brazil.

From the point of view of the services supply, there has been a significant increase in the number of fixed lines and in the mobile phones. In the case of the fixed lines, the investment made by Telebrás prior to privatisation and by the new incumbent operators led to a considerable increase in the number of installed lines. In the case of mobile telephony, this also occurred. In this case however, rapid technological change and competition between the three to four operators in each region caused the increase. According to Oliva (2002), it is estimated that from 1995 until 2001, all the services suppliers invested around R\$ 70 billion (approximately US\$ 24 billion). The result of this investment is the boost in the number of installed lines, as may be seen in the figure 2, what is the most positive result of the liberalisation and privatisation processes.

⁸ The country was divided into three regions for local services; long distance services were to be provided nationally by one carrier. Telebrás was split into four different operators that were sold separately.



(*) until may 2003

Source: Anatel (The National Regulatory Telecommunications Agency – www.anatel.gov.br)

3.2.2 – Impacts on the national telecommunications industry

As for the national telecom equipment industry the entry of new foreign-owned carriers, changed completely their competitive position. The multinational subsidiaries that entered in Brazil with the privatisation and deregulation processes – Telefonica de España, Telecom Italia, MCI, Qualcomm, France Telecom, etc,- all started to prefer their traditional equipment suppliers when placing new orders. As a result, local equipment suppliers were forced to be acquired by foreign equipment suppliers or concentrated on market niches in order to survive.

Although there was a specific clause⁹ in the concession contracts stating specifically that operators would not discriminate against unrelated parts, in practice it did not have any effect in the operators strategy towards equipment acquisition since the clause did not provide any mandatory stipulation.

As an outcome of these processes a significant deterioration of the trade balance in the sector has been observed. Table 1 suggests that imports significantly increased during the 1996-2001 period. The decrease observed in imports in 2002 is due to the crisis in the sector that could also be felt all over the world. As for exports, the increase is related to few products – mobile phones –, which are only assembled in Brazil, relying heavily in imports of parts, pieces and components.

⁹ Clause 15.8 disposes that the carrier is obliged to consider offers of independent suppliers, including national ones, and to base its decision on the various offers presented, taking into account objective criterions of price, conditions of delivery and technical requirements.

Table 1: Trade balance of the telecommunications equipment industry and total electronic complex deficit (1996-2002)

(US\$ million)

Description/Year	1996	1997	1998	1999	2000	2001	2002
Imports	1 925.2	2 664.2	2 578.7	2 540.3	3 160.0	3458.3	1432.9
Exports	154.1	288.1	329.1	484.2	1 310.3	1547,8	1546
Telecom Trade Balance	-1 771.1	-2 376.1	-2 249.6	-2 056.1	-1 849.7	-1910.5	113.1
Electronic Complex Trade Balance	-5 474.3	-6 378.8	-5 680.0	-5 157.9	-6 299.1	-5805.1	-3 115.1

Source: BNDES (Social and Economic Development National Bank - www.bndes.gov.br)

Among other reasons¹⁰, this problem is clearly connected to the consequences of the entry of new producers of telecommunications equipment.

The entry of new producers of telecommunications equipment has been occurring through mergers and acquisitions and through foreign direct investment in new productive plants, strengthening the tendency of trade liberalisation and thus contributing to the de-nationalisation and to a greater internationalisation level of the patrimonial structure of the local industry, which evolution can be seen in table 2. Nowadays, the market share of nationally owned firms is only 8,7%.

Table 2: Market Share of the main suppliers of telecom equipment in the Brazilian market, by origin of capital (*)

Year	1988	1997	2000
Market share of the nationally owned firms	77%	41,5%	8,7%
Market share of the foreign firms	23%	58,5%	91,3%

Source: Oliva, 2002.

(*)The concept of nationally owned and foreign firms are based on the control of voting capital criterion.

As an illustration, Lucent Technologies acquired two Brazilian equipment manufacturers, Batik and Zetax (founded respectively in 1979 and 1987). Both firms had developed small and medium size digital switching systems technology in internal R&D laboratories. At the time of privatisation, Batik and Zetax possessed together approximately 6% of the installed digital plant for fixed telephony. The two firms declared that their acquisition was a result of financial troubles due to the new procurement policies implemented by the new carriers. The acquisition process implemented by foreign firms reached many others

¹⁰ In general, and as a result of the structural changes, it was observed the increase on import of components, parts, pieces and even final products by national industry of telecommunications equipment. It should not be overlooked that the over-valued exchange rate, in force from mid 94 to January 99, greatly contributed to the increase in imports.

nationally owned firms, leading to the reduction of the market share of the nationally owned suppliers of telecommunications equipment.

It is important to highlight that the strategies of the new firms that have been entering in Brazilian market are much more based on import intensive and assemblage strategies with low added value, what intensifies the problem of the commercial deficit in the telecommunications equipment industry shown in table 1. Also, they usually import technology from their parent company and have low R&D and innovation related investment.

The setting up of smaller firms, especially in the area of specialised telecommunications software, founded by ex-employees, technicians and engineers of CPqD is also one of the effects of the deregulation and privatisation process on corporate strategies (Doria et alli, 2000).

It is worth noting that most of the local innovative firms have been acquired by multinational subsidiaries, some have disappeared and some still remain. For those that were acquired by multinationals, the result was a decrease in technology activities. For those that survived, they usually are: small and medium enterprises concentrated in the production of parts, pieces and components with low technological specialisation; or either they are concentrated in niches of production and have higher technological specialisation in their products. In this case, the technology has been developed together with CPqD or has been internally developed or either has been acquired from external partners or sources. Some of these firms are: Trópico SA, Daruma, Asga and Parks (Oliva, 2002).

3.2.3 – Impacts on the national innovation system

CPqD, the R&D institution that used to play the most important role in the technology development process, has been transformed into a private foundation (now called CPqD Foundation). Funds for the foundation were assured for the period of three years (transition period of the model) by means of concession contracts with the new carriers¹¹. During the transition period, CPqD had been trying to establish new contracts with clients to carry on after 2001. These contracts comprehended technical cooperation with national and international firms, providing technology services and consultancy to carriers and telecommunications manufacturers.

One consequence has been a change in the mix of activities it conducts, reducing the number of research projects it undertakes and increasing the share of short-

¹¹ The survival of the Centre during the transition period (1999 to 2001) was guaranteed by concession contracts with the new carriers (from the Telebrás system), agreeing to support CPqD in its technological development activities. Total CPqD revenue for the three years is R\$ 124 millions/year. This amount will cover maintenance activities, system development (software), technical consulting services, training and lab services. The resources destined to CPqD by the four utilities allow them to order specific services to the Centre, according to their needs, up to the value invested by each one. CPqD's planned revenue for the three year period is compatible with CPqD's budget in the years prior to the privatisation.

term consultancy and technical assistance activities, which provide them with resources they need.

After 2001, the survival of the Centre in a competitive environment depended on the contracts it has been setting up with private firms and institutions and also on part of the resources of FUNTTEL (Telecommunications Technological Development Fund). The Law established that twenty per cent of the FUNTTEL resources would be given to assure CPqD's survival during 2001 and 2003.

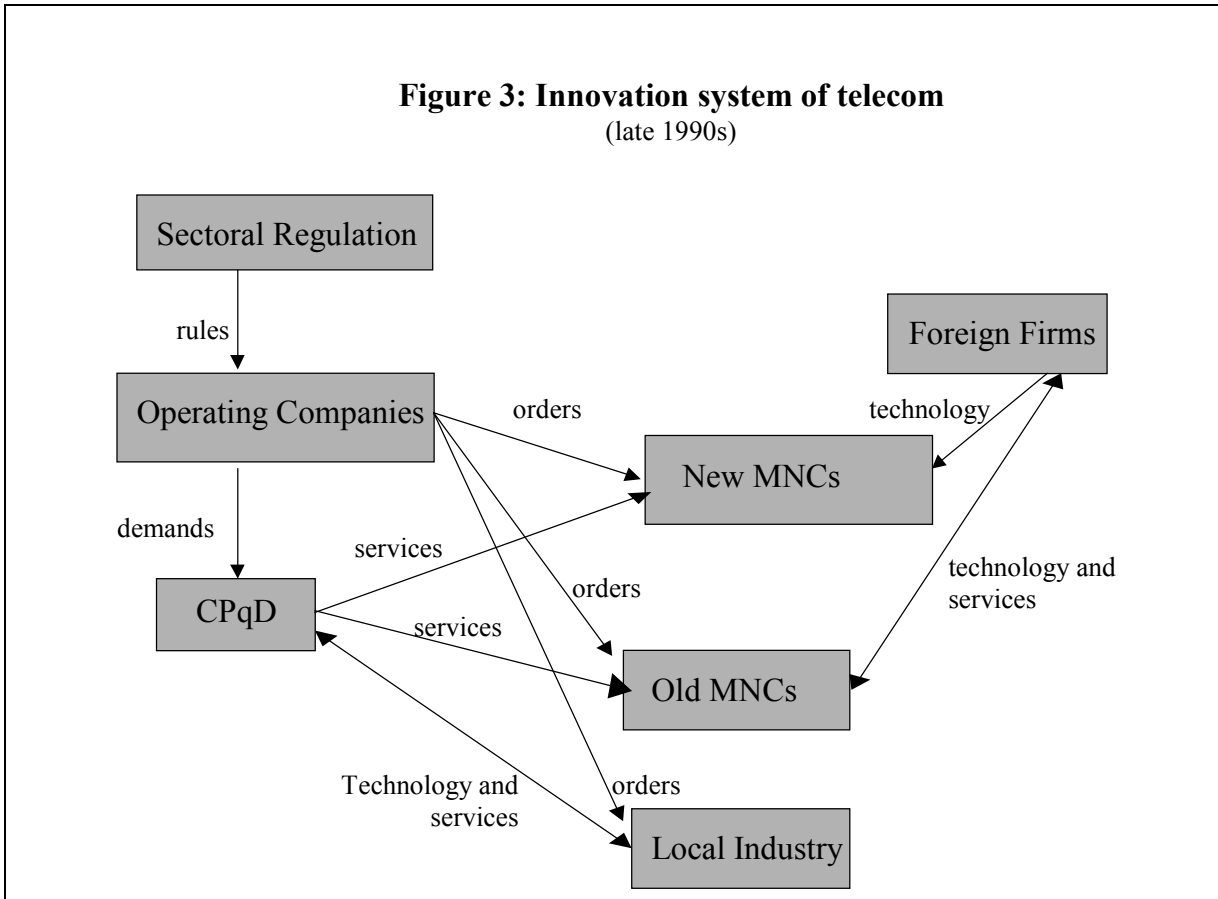
Nevertheless, it seems that the technological research activities of higher risk haven't been continued. Anyway, it is important to point out that many research activities of the centre were already deactivated during the privatisation period and the transition to the new model, as a result of the uncertainties generated by the institutional changes in the sector.

The relationships between CPqD and other agents in the system went through substantial changes. Trade liberalisation, entry of new and foreign telecommunications service carriers, equipment industry denationalisation and the resulting new relationships between carriers and equipment suppliers changed substantially the Centre's focus of activities. The Centre, which was the main actor in the process of national technology capability building, is now seeking contracts for technological services and consulting, besides offering educational courses to form and qualify workers for the sector.

From the point of view of the telecommunications equipment industry, there have been big changes, as it was discussed in the previous session. In general, the technological and innovation strategies pursued by firms have been strongly transformed. Some technology intensive nationally owned firms were acquired and the multinational subsidiaries' strategies were substantially altered.

In short there have been important differences in technological strategies pursued by firms. Three types of strategies associated to different firms could be found. One, that of the newcomers, emphasises technologies imported from their parent companies. The second, that of the 'old' MNCs, partially relies on foreign and local technology. The third, that of the local firms, relies on local technology, but abandons long run development. The empirical evidence suggests that they are facing growth difficulties. R&D expenditures by these firms have been significantly reduced and R&D teams were dismantled. Finally, CPqD changed the mix of activities it conducts, increasing the share of services and decreasing R&D projects. An overall view of the Brazilian telecom innovation system as it is now, after the structural reforms, is presented in figure 3.

Figure 3: Innovation system of telecom
(late 1990s)



4 - Conclusion

During the 1970s and 1980s, a telecom innovation system was built up in Brazil. This was a result of the implementation of explicit federal government policies, targeting the creation of national telecommunications equipment firms and the development of national technologies for the sector. The main objectives behind this strategy were the reduction of dependence on foreign technologies and attaining equilibrium of the trade balance in the telecommunications sector.

The structural reforms of the 1990s (trade liberalisation, deregulation and the privatisation of Telebrás) created significant impacts on the innovation system, as it has been discussed along this paper.

Although the Brazilian government has been implementing many instruments to foster the telecommunications services and equipment industry, these instruments focus exclusively on isolated parts of the innovation system. There is not anymore a systemic view of innovation and productive capability building at the national level. This is a fundamental change what can have negative impacts, especially for

a developing country like Brazil, where the firm innovation related investment is usually low.

This point brings us to an important discussion about the recent changes of the international telecom industry. According to Fransman (2002), the R&D intensive activities have moved from the incumbent telecom operator to the specialist telecommunications suppliers, particularly to the equipment suppliers. This shift implies that the incumbent operators have been diminishing their R&D effort and also that the new carriers (the so called new entrants) do not need to have internal R&D and innovation capabilities to supply services in the telecom industry. They can successfully enter the telecom industry relying their technology demands on the equipment producers, which have reduced the entry barriers in this industry. This change can be clearly illustrated with the data presented in Fransman (2002, pp. 218). However, as also he notes, the decision to completely outsource R&D (strategy taken by some of the new entrants) does raise the question of whether this is an efficient solution in the longer run for many reasons¹².

Apart from the sustainability of those strategies, it is important to stress that the recent changes in the configuration of the international telecommunications industry does not imply that the national character of the related policies have disappeared.

As it was observed in section 3.2, the new carriers operating in Brazil exhibit a trend to use specific criteria to purchase equipment in the sense that they rely on their traditional suppliers, almost always from their home countries (Gazeta Mercantil, 1999). This fact brings a serious problem to less developed countries, that do not have neither a nationally owned carrier providing services nor nationally owned equipment producer. If we believe that the telecommunications sector is a strategic one and that the productive and innovative capability in this sector is a key competitive factor, then the need to have a new kind of policy becomes clear.

The absence of a systemic view in the formulation of the industrial and technological policies has led to the destruction of important intangible assets developed along the 1970s and 1980s. In this case, the national system of innovation approach can be very useful to design new policies.

The developed countries maintain their innovation related investment and activities in the telecommunications industry, independently of the new configuration of the innovation system. This means that these activities can be concentrated in the network operator or either in the equipment suppliers. The strategic capabilities still remain in the national borders.

¹² Fransman (2002, pp 233) talks about a dilemma brought by the changes in the R&D organisation within the telecom industry. He says that the pressure being put under the network operators reduces their capacity to fund and undertake longer term R&D that could bring benefits for the Infocommunications industry and for the society as a whole.

In the less developed countries, including Brazil, the structural reforms of the 1990s have resulted in the dismantling of the telecom innovation system. This happened both by the changes in the roles of each agent of this system and by the disappearing of some important (national) firms.

First of all, CPqD used to play a fundamental organisation role in the innovation system during the 1970s and 1980s. It was not only Telebrás' R&D centre, but it was also the key actor in the productive and innovative capability building process for the whole Brazilian telecom sector. With the deregulation and privatisation, the role of the Centre became undefined.

The entry of new multinational subsidiaries suppliers of equipment and the change in the strategies of the old ones that used to operate in Brazil caused the reduction of the local innovative efforts. This occurred through the acquisition of nationally owned firms that used to maintain those activities locally or through the changes in the multinational subsidiaries' strategies. As argued before in this paper, these firms used to establish interactions with other firms and CPqD in the past, contributing to a virtuous process of innovation capability building that is now ended.

Nevertheless, as argued by Galina (2003), who studied the role of the Brazilian multinational subsidiaries of the equipment industry in the process of global development of products, these firms are concentrated in doing products adaptations to local market and in the development of local products. From her analysis it can be implied that these multinational subsidiaries down-graded their R&D efforts in Brazil as a result of the liberalisation process. This harmful insertion of the Brazilian subsidiaries in the globalisation process has obvious negative impacts on the national innovation system.

On the one hand, it is true that the R&D efforts are now concentrated in the telecom equipment suppliers. On the other hand, those efforts and activities are fundamental for the country competitiveness. Therefore, it becomes essential the design and implementation of new policies by the Ministry of Communications or by the Government. This may encompass all the actors operating in the national telecommunications industry aiming at reconstructing and strengthening the national innovation system.

Taking into account the strategic role played by the Brazilian subsidiaries equipment suppliers for the national telecom industry in the past, it is important to think how the new policy could foster a more positive insertion of the Brazilian multinational subsidiaries in the national innovation system.

It is worth noting that the government has some instruments to support isolated actors of the innovation system. Among them, there is the technology fund

(FUNTTEL¹³), which aims at supporting national research and development in telecommunications and the Telecommunications Fund for services universalisation (FUST). There are the supporting instruments from BNDES (the national economic and social development bank) to support investment from the network operators and from the equipment suppliers and there are the incentives provided by the New Informatics Law¹⁴.

Although there is no doubt that all these instruments are extremely important, together they do not have a systemic approach of the innovation system. The creation and implementation of such a policy instrument is the major challenge of the new government.

Important to say is that there are some good opportunities that could bring together efforts of different agents, gathering at the improvement of the telecommunications national innovation system. The digital television and the next generation network (NGN) are two great opportunities that could articulate all the policy instruments available and combine efforts and activities of the various agents of the innovation system (CPqD, nationally owned firms, multinational subsidiaries, research institutes, universities, among others). This would certainly promote the national innovation and productive capability building process.

There have been deep changes in the telecommunications industry, but they did not alter the relevance of the innovative activities and efforts, the national or else the systemic character of this kind of investment.

¹³ In 2002, the FUNTTEL had approximately US\$ 40 millions available to telecommunications projects related to innovation and technology development. Nevertheless, only 30% of the resources were effectively spent in these projects.

¹⁴ Law 8248 (New Informatics Law) is the public incentive to national electronics industries. This Law provides fiscal incentives to internal production of telecommunications equipment. The main incentive is IPI (value added tax on industrialised products) exemption to firms complying with the Basic Productive Process (PPB). It is required, as a counterpart, that firms invest 5% of their revenue in research and development activities, 3% of which inside their plants and 2% in universities and/or Brazilian institutes of research.

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