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**Coping with Globalisation
An Analysis of innovation capability in Brazilian
telecommunications equipment industry**

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COPING WITH GLOBALISATION AN ANALYSIS OF INNOVATION CAPABILITY IN BRAZILIAN TELECOMMUNICATIONS EQUIPMENT INDUSTRY[#]

Sunil Mani

Abstract

Brazil is one of the only three and the first one from the developing world to initiate and maintain innovation capability especially in the switching equipment component of the telecommunications equipment industry. The maintenance of this capability has come under some strain with the increasing external integration of the Brazilian telecommunications economy. Employing a sectoral system of innovation perspective the paper undertakes a comprehensive evaluation of the efforts made by various components of the innovation system, and especially the research and policy-making parts, to maintain this capability. The ensuing analysis shows that the innovation system is learning to cope with changes in its external environment in a bid to maintain existing capability and has even managed to enhance capability in areas such as manufacturing and marketing. In order to cope with globalisation the Brazilian State has put in place a selected number of legal and fiscal instruments of state support. However the very process of globalisation threatens to vitiate or nullify the positive effects of these instruments.

Key words: Innovation capability, Brazil, telecommunications, CPqD, public technology procurement

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1.0. INTRODUCTION

Brazil has one of the largest telecommunications sectors in Latin America. It has both a distribution of telecommunications services and a manufacturing of telecommunications equipment sector as well. In terms of its share in total telecoms revenues the distribution sector accounts for about 74 per cent while the manufacturing of telecommunications equipment and software accounts for the remaining 26 per cent (*Anuario Telecom*, various issues). Brazil is also one of the few developing countries that have established a stand-alone public laboratory for the generation of telecommunications technologies consistent with the usage pattern and other specificities obtaining in the country. The telecommunications sector has undergone a major change in the 1990s. The main dimensions of this change are the opening up of the manufacturing sector to further foreign investments;¹ opening of the mobile sector to competition in 1997;² the creation of a regulatory agency known as Agência Nacional de Telecomunicações (ANATEL) in 1997; privatisation of fixed line services in 1998³ and the transformation of the public research laboratory to a private foundation, also in 1998. These changes are radically altering the landscape of the telecommunications sector in the country.

The performance of the telecommunications sector in Brazil has attracted considerable scrutiny from a number of commentators. Much of the recent analysis has naturally focused on the privatisation of telecom distribution segment.⁴ Brazil's telecom privatisation is considered to be the largest in the developing world and third largest in the world (See Table 1).

¹ Right through the 1950s, there were affiliates of MNCs operating in the telecommunications equipment manufacturing industry.

² During the year companies were licensed to provide B- band cellular services in 10 regions, in competition with the Telebras A band cellular operators.

³ Prior to its privatisation in July 1998, the state-owned Telebras acted as a holding company for 28 operating companies: one long distance operator (Embratel), which also provided telex and data communications services, and 27 companies which provided local, inter-state long distance, and mobile communications services at the state level. Four independent telephone companies provided services outside the Telebras system, in specific geographic areas, accounting for 9 per cent of all lines in service.

⁴ Much of the analysis on this theme is by Brazilian scholars writing in Portuguese. For an important work in English, see Wholers and de Fontenay (2000).

Table 1: Top ten telecom privatisation proceeds, world-wide

| Operating company (Country) | Privatisation proceeds(millions of US \$) |
|------------------------------------|--|
| 1. NTT(Japan) | 70469 |
| 2. BT (UK) | 22931 |
| 3. Telebras (Brazil) | 18966 |
| 4. France Telecom (France) | 15902 |
| 5. Deutsche Telecom (Germany) | 13360 |
| 6. Telecom Italia(Italy) | 12000 |
| 7. Telstra (Australia) | 10882 |
| 8. TelMex (Mexico) | 7769 |
| 9. TeleDanmark (Denmark) | 7693 |
| 10. Swiscom (Switzerland) | 5580 |

Source: Kelly (1999)

Three factors distinguish Brazil's telecom privatisation process from that of other developing countries: first, privatisation took place much later; second, the government sought and facilitated competition rather than a straight exchange of public to private monopoly (Wohlers and de Fontenay, 2000) and; third, the privatisation proceeds of US \$19 billion far exceeded the government's target of US \$14 billion. Against this background, the present study focuses on the movements in innovation capability of the telecommunications equipment industry in the country especially during the post liberalisation/privatisation phase after 1998 - a period that has seen the growing globalisation of the country's economy.

Countries across the world and especially those in developed countries have used public technology procurement as an instrument of state support for building up innovation capability in telecommunications equipment industry (Edquist, Hommen and Tsipouri, 1999). Brazil too has used this instrument to build up its capability. Brazil was also the first among a group of three developing countries to establish a dedicated public research laboratory⁵ devoted to telecommunications R&D. However the importance of this instrument stands considerably diminished consequent to the privatisation of operating companies, which under the umbrella of the main holding company Telebras used to account for almost the entire spectrum of telecommunications equipment manufactured in the country. Hence the objectives of the paper are two fold: (i) to map out the movements in the innovation capability of the domestic telecommunications equipment industry⁶; and (ii) to identify the main instruments of state

⁵ The other two are India and Korea. India established its telecom R&D lab, C-DOT in 1984 and Korea established its lab, ETRI in 1985. For a detailed assessment of the progress of India's innovation capability in telecommunications equipment industry in general and C-DOT in particular, see Mani (1992, 2003) and Ray (2001). The author is currently carrying out field research in the last of this group of countries, Korea.

support and its effect on the build up of this capability. The paper is structured into six sections. The first section surveys the important past studies on the theme and charts out the framework for analysis. Although most of the studies done on the issue are in Portuguese, I restrict myself to available work in English. The second section identifies the main features of the telecom sector in Brazil. A summary of the reforms and a brief assessment of their effects is presented in the third section. The fourth section maps out the structural changes in innovation system for telecommunications equipment sector, while the fifth section identifies the main instruments of state support in building up this capability. The sixth and final section summarises the main findings of the paper and compares the Brazilian experience with that of India.⁷ India provides a good case for comparison because she too has followed a similar strategy of; promoting a sector system of innovation with the government research institute, generating the technology and then transferring it to private and public sector firms. Furthermore, the external environment obtaining to the innovation system in both the countries is comparable, while the instruments and strategies employed by both the systems are different. In short the Brazilian system appears to be better prepared to cope with the ill effects of globalisation than the Indian one.

At the outset it is also important to tackle some specific conceptual issues. Almost all technologies are location specific. Therefore all borrowed technologies will have to be adapted to local conditions. However the location specificity of some of these technologies is such that adaptation can be very time consuming and costly and may not even be acceptable from the opportunity cost point of view. It is generally argued that telecommunications and especially switching technologies within it fall into this category of technologies that are difficult to adapt to local conditions. In fact it is this rationale that prompted a number of developing countries such as Brazil, India and Korea to initiate large government sponsored R&D projects to generate technologies consistent with the peculiarities of usage pattern prevailing in those economies. But such an initiative can run the risk of conflicting with the efforts that are being mounted by the governments of these developing countries for the rapid development of telecommunications infrastructure. My argument however, is that the inability to develop a

⁶ The paper employs a sectoral system of innovation perspective to analyse innovation capability. Central to the perspective are research institutes (which generate this technology) and firms (which employ the technology to manufacture and sell equipment to actual users). In the present paper I focus, by and large, on the research system and not on the firms. This is because other studies have shown that the Brazilian telecommunications equipment firms are the weakest links in the system. This point will become more evident as I continue with the analysis. In fact the public policy focus in the country has been more on the research system and not on the firms.

⁷ At a later stage I intend comparing the Brazilian one with the Korean and Chinese cases. Both the latter cases have been characterised by highly capable (technologically speaking) firms and therefore the innovation system, on the basis of our preliminary understanding, is better prepared to take advantage of the new opportunities provided by globalisation.

telecommunications infrastructure is primarily a function of the lack of investments in this sector and not the type of technologies that are invested in. This point will be further amplified when I present the data on growth of investments in the sector (Figure 1).

2.0. PAST LITERATURE AND FRAMEWORK FOR ANALYSIS

Previous studies on the telecommunications sector in Brazil have focused disproportionately on the manufacturing segment of the industry. There are two possible explanations for this anomaly in research interest. The first is related to the initiation of domestic technology generating efforts, which as explained earlier, was the first of its kind from anywhere in the developing world. It was generally felt, given the complexity of the technology and the well entrenched position of MNCs in the world telecommunications equipment industry, that an indigenous effort by a local public laboratory was indeed a remarkable achievement that was worth writing home about. The second reason is that it is only with the privatisation of the Telebras system in 1998 that the distribution segment has shot into prominence.

At least seven major studies have been undertaken on the broad issue of the telecommunications equipment industry in Brazil. A synoptic view of these studies is presented in Table 2. By contrast, the distribution segment of the industry during the five years of privatisation⁸ is, with the exception of surveys undertaken within the government machinery, still relatively uncharted territory.

⁸ The most important, in my view, in this category is the one by Wholers and de Fontenay (2000).

Table 2: Past literature* on the Brazilian Telecommunications Equipment Industry

| Author | Main findings |
|--|--|
| 1. Hobday (1986 and 1990)** | The study examines Brazil's attempt to absorb and diffuse digital telecommunications technology. With the aid of the theoretical concepts developed in the study the mechanisms by which Brazil acquired and diffused the technology during the learning process are analysed. By these means the study attempts to isolate the ways in which digital technology was accumulated at the levels of R&D, firm, sector, government and macroeconomy. Lessons from the Brazilian case are drawn for other developing countries |
| 2. Dias, Hugueneu and Vianna (1989) | The paper presents the genesis and summary of the R&D activities carried out at the Telebras R&D Centre (CPqD) showing its main projects and highlights the TROPICO system which is an integrated family of digital switching equipment fully conceived and developed at the CPqD facilities. |
| 3. Graciosa (1989) | Maps out the early system of innovation with respect to telecommunications research in the country. traces the evolution of organised attempts towards development of telecommunications R&D in the country and traces its history in detail from 1973 through 1989. |
| 4. Frischtak (1990) | Maps out the structure of the telecommunications equipment manufacturing sector during the 1980s, describes the attempts by CPqD to develop the <i>Tropico</i> family of digital switches. |
| 4. Goransson (1993) | Comparative study of Brazil, India and Korea with respect to the creation of local capability in designing and manufacturing electronic switching systems. Presents the situation in each of the three countries during the 1980s. |
| 4. Fiorentino (1996) | Analyses the structure of the Brazilian telecommunications equipment manufacturing industry during the early part of the 1990s. Also surveys the R&D programme of CPqD during this period. |
| 5. Mytelka (1999) | Presents a comparative analysis of the design and maintenance of domestic technological capability in the Brazilian and Korean telecommunications equipment industry. The Brazilian case is discussed up to the early 1990s. |
| 6. Schjolden (1999) | Analyses the movements in technological capability of the Brazilian telecommunications equipment industry during the 1990s a period when the Brazilian economy experienced considerable liberalisation. It focuses on both the innovation sector and the telecom equipment manufacturing firms. Technology capability is measured in terms of the amount of R&D, its content, sources of technology to domestic manufacturing enterprises, the interaction of local enterprises with CPqD and so on. |
| 7. Szapiro (2000), Szapiro and Cassiolato (2003) | Assess the impact of liberalisation of equipment manufacturing and the deregulation of telecom services on the innovation system for telecommunications in the country during the period upto the late 1990s. |

Note: *. Studies available only in English are included here; ** This work was published later on in 1990.

Source: Own compilation

I do not undertake a critical review of all the studies presented above. It is clear (from Table 2) that most of the studies, although done independently of each other, are repetitive in terms of their scope and main findings. However from the list of seven, four stand out namely the ones by Hobday (1986 and 1990), Goransson (1993), Mytelka (1999) and Schjolden (1999).

Hobday reviews the initiation of indigenous R&D in the country, while Goransson's work traces its progress upto the early 1990s and compares it with similar experiences from India and Korea. Mytelka analyses the maintenance of capability and telecommunications market aspects during this period. Finally, Schjolden's work attempts to critically assess the state of the innovation system and domestic equipment manufacturing industry during the 1990s- a period of liberalisation and privatisation. Specifically, the latter study has attempted to measure, employing a series of well known indicators, the present state of technological capability of the equipment sector.

Hobday examines in detail the Brazilian government's attempt to set up, from scratch, a wholly Brazilian R&D facility in digital telecommunications, namely the Centro de Pesquisa e Desenvolvimento da Telebras or CPqD, as it is more popularly known. He notes that the establishment of CPqD enabled the Brazilian state to achieve two objectives: first, it became an important centre for the generation of local capability in digital switching systems and thereby, secondly, to improve the state's bargaining power with the MNCs for transferring state-of-the-art digital switching technologies at much better terms and conditions than would otherwise have been the case. In fact Goransson's study actually provides us with important evidence to prove this improvement in the relative bargaining power of the Brazilian state.⁹ It was this relatively strong position that enabled the country to import electronic switching technologies from an MNC for a quarter of the price paid by India for a similar technology.¹⁰ He assesses various technological programmes using what he terms, partial indicators of technological performance, such as financial and human resource inputs, and outputs, including products, patents and technology transfers to industry.¹¹ Schjolden's study employs similar indicators to measure the state of technological capability of the Brazilian industry during the 1990s.

An interesting and unique aspect of Hobday's work is his identification of a number of learning mechanisms that were employed by CPqD to assimilate the new technologies. He shows that CPqD itself had a number of technology collaboration agreements with a variety of institutions

⁹ However, Goransson (1993) does not make this point.

¹⁰ See Goransson (1993).

¹¹ During the period 1976 through 1984, CPqD registered 183 patents in Brazil for six broad types of products or processes and transferred 28 different types of technologies to 17 telecom equipment manufacturing enterprises in Brazil. It is interesting to note that 4 of the 17 firms were affiliates of foreign companies. See Hobday (1986), p. 257.

and firms, both domestic and foreign, although an overwhelming majority of these were domestic. The laboratory employed five different types of learning mechanisms, namely; (i) learning by searching; (ii) learning by setting up electronic capital goods; (iii) learning by training and hiring; (iv) learning by designing and adapting of product designs; and (v) learning by installing information feedback systems. In fact Hobday's study provides us with a comprehensive overview of the initial build up of innovation capability in the Brazilian telecommunications equipment industry.

Goransson makes an important contribution to the understanding of Brazilian efforts at local technology generation and his study is also the first attempt¹² at analysing the relative quest for technological self-reliance in telecommunications technologies by three developing countries, Brazil, India and Korea. The study clearly maps out the changes in the Brazilian telecom sector in the 1950s and then in the 1980s. The main structural change in the 1980s was the establishment of an elaborate administrative structure to implement the import substituting industrialisation strategy. While some of the institutions established, such as the, the Industrial Development Council (CDI), National Institute for Industrial Property (INPI), the Foreign Commerce Board (CACEX), are common across a number of industries, two new institutions - the Secretariat of Informatics (SEI)¹³ and the GEICOM (the Executive Group for Devices and Materials Industries)¹⁴ - have basically been responsible for the telecommunications equipment industry. The most important of these institutions for innovations in the telecommunications industry is GEICOM. It was founded in 1975 with the objective of reducing the import content of telecommunications and was responsible for determining a nationalisation index. Following detailed consultations with each of the firms and a study of the availability of local components GEICOM determined the amounts of final product that should be imported. Goransson critically examines the specific ways in which GEICOM controlled the import dependence of the industry and shows that lower import dependence actually increased the final price of domestically manufactured switches. However, summarising the evaluation of the Brazilian strategy in telecom, he is of the opinion that major progress has been made in reaching the stated objective of achieving self reliance in technology generation, the telecom sector has been successfully restructured, foreign dependence in terms of imports has decreased, and a functioning R&D environment has been created. Nonetheless, this analysis is not proved right in later years.

¹² Later on there was a second attempt at comparing the Brazilian and Korean cases by Mytelka (1999).

¹³ The secretariat was responsible for drawing up a list of, primarily, electronic products that were to be protected through a policy of market reservation until October 1992.

¹⁴ See also Botelho, Ferro, Mcknight and Oliveira (1993).

Basing her analysis on domestic production and imports, Mytelka (1999) showed a deceleration in domestic output and an increase in imports from the late 1980s.¹⁵ She identified two factors as being responsible for this trade-off between imports and domestic production.¹⁶ The first was the slower than expected progress in developing Brazilian telecommunications technology and the second was the impact of the changing global competitive environment on the pricing, production and innovation strategies of large multinational firms operating in the market.

Another interesting aspect brought out by some of the studies and especially the one by Mytelka is the relationship between market structure and price levels for digital switches in the country. Although the level of concentration in the digital switching industry increased during the early 1990s compared to the late 1980s¹⁷ there were significant reductions in the price of these systems within the country - prices decreased from an average of US \$ 1100 per line in 1989 to about US \$ 200 per line in 1993. The reasons for this were (i) the introduction of the larger CPqD switches, i.e., Tropicó R and Tropicó RA; and (ii) the competition from the new entrant to the industry.

Finally I consider the study by Schjolden (1999). This study actually takes the Hobday study forward to the 1990s. The study seeks to answer three pertinent questions: ((i) how has technological capability in the Brazilian telecommunications industry changed since 1990? (ii) what are the reasons behind these changes in technological capability?; and (iii) what are the implications of these changes in technological capability for a country's economic development? The term technological capability is defined as 'the ability to use, produce, adapt and develop a new technology'. Further the term is defined both at the sector and the firm level.

Schjolden measures technological capability through four indicators: (i) import dependence of the sector (ii) quantum and nature of R&D investments; (iii) quantum of products and patents released from CPqD; and (iv) number of technology agreements between CPqD and the private firms. She then confronts each of these four items with empirical data. On the first indicator, she finds significant increases in imports of telecom equipment during the period. However she does not measure the share of imports relative to total availability nor does she provide clear data on the share of CPqD-developed Tropicó switches in the Telebras network, especially over

¹⁵ She considers the period 1975 through 1993.

¹⁶ Mytelka (1999), *op.cit.*, p. 125

¹⁷ Based on the data provided in Mytelka (1999, Table 4.5), it is possible to compute four-firm concentration ratio in the digital switching equipment and these have increased from 74 in 1987 to 90 per cent in 1992. The increase in concentration was due to the take over of five wholly Brazilian manufacturers by a MNC.

this period and she does not present disaggregated data on telecommunications equipment imports. The scanty evidence available from the various studies shows that Tropic switches accounted for only about 30 per cent or so of the network during the 1980s.¹⁸ This share actually increased, albeit at a very slow pace, to about 32 per cent of the network by 1997 (Melo and Gutierrez, 2002). Despite growing imports, Tropic was able to maintain its share essentially due to the public technology procurement policy of the Brazilian state. This point will be analysed in detail in the fifth and sixth sections of the study.

On her second indicator of technological capability, namely the relative investments in R&D (read as investments in CPqD), Schjolden notes¹⁹ that although the absolute investments in CPqD have increased from about US \$50 million in 1991 to about US\$ 100 million in 1998, they have decreased in relative terms as a percentage of overall investment in Telebras from about 2 per cent in 1991 to about 1 per cent in 1998. But as Schjolden herself notes this fall in the relative share in CPqD could easily be explained by the relatively larger investments in network expansion, which took place during the second half of the 1990s. This investment was necessary to improve the image of Telebras before it was privatised in 1998.²⁰ This point will further be elaborated in the next two sub sections.

In short, the reduction in the relative share of CPqD in the total investment of Telebras cannot be construed as contributing to the worsening of technological capability especially because the absolute level of investments in CPqD, as explained before, has actually increased during the period. Further CPqD too was turned into a private foundation in 1998 as part of the overall privatisation of the telecommunications sector. Another dimension of R&D investments considered in the study is the content of R&D and the changes that took place during the time. According to Schjolden, CPqD has, since 1991, become more engaged in developing basic technologies with only a few selected applied technologies developed during the period.

¹⁸ In fact the combined installed capacity of the wholly owned private sector companies manufacturing Tropic digital switches accounted for only about 27 per cent of the total domestic capacity in these switching equipment. Given the fact that capacity utilisation of these firms was only about 50 per cent, the share of Tropic Switches could not have been higher. Another reason for the lower share of Tropic switches is the fact that only two kinds of smaller Tropic switching technologies were actually developed by CPqD during the period, namely the Tropic (capacity to handle 192 subscribers) and R (capacity to handle 4000 subscribers). The largest of the three, Tropic RA (80, 000 to 100, 000 subscribers) was introduced to the market only during the early 1990s.

¹⁹ See, Figures 5.3 and 5.4. of Schjolden (1999), op.cit.

²⁰ The Brazilian Ministry of Communications drew up in November 1995, the *Recovery and Expansion Program for Telecommunications and Postal Systems (PASTE)*. Under this programme various investment plans, including a plan to increase the number of fixed phone lines, was implemented.

However it is clear that by the early 1990s, CPqD had actually completed its development of the Tropico family of digital switching systems and as Fiorentino (1996) commenting on the scope of R&D activities being conducted at CPqD states, the institution was at that time (namely during the early part of the 1990s) focusing its efforts on the evolution of Tropico technology, aiming to improve its competitiveness in the international market and developing features²¹ to meet the demands of the domestic market in Brazil. Thus while continuing to develop the Tropico switches, CPqD was also concentrating on network and service management, and working on projects related to the development of an optical fibre network in the country. Given the nature of R&D programmes and the impending privatisation of both its parent Telebras and CPqD itself, it is not surprising that there might have been a scaling down of its R&D activities during this period. But this scaling down is not tantamount to a decline in the technological capability of the laboratory. The very fact that the Tropico switches continued to maintain one-third of the share of the market shows that this domestic technological capability is very much intact.

Thus based on this short survey of the past literature, the following points emerge:

- (i) CPqD has built up considerable innovation capability in conceptualising and designing digital switching systems, especially during the period 1976-1991. The developed technology was effectively transferred to domestic private sector manufacturers who began to manufacture and sell these switches to the state owned operating company, Telebras;
- (ii) However, the opening up of the Brazilian manufacturing sector to foreign investments led to the takeover of some of these domestic manufacturing firms by multinational companies. This means that the number of wholly owned Brazilian companies has been significantly reduced, to just one;
- (iii) Despite this increased competition from MNC manufacturers within the country and from imports, the market share for Tropico switches has been maintained;
- (iv) There is a general feeling in the literature that the technological capability of the domestic innovation system has decreased consequent to liberalisation of the equipment manufacturing sector, privatisation of the telecom services distribution segment and the privatisation of the main laboratory itself. However, the quantitative evidence that is used to demonstrate this is not very robust and is open to questioning.

21 During my field research it became evident that towards the latter half of the 1990s, CPqD started working toward the development of switching technologies that leads to the migration of conventional telephony network into a NGN (new-generation network), in which voice and data converge on a single platform.

It is against this background that the present study on innovation capability of the sector during the period 1998-2003 is placed. An important aspect of this period has been privatisation and breaking up of the ultimate final consumer, namely Telebras and the main laboratory. Another important development during this period has been the phenomenal growth of mobile communications and the near saturation of fixed line communication. In order to facilitate my analysis, I start with the main features of the Brazilian telecommunications network, especially during the post privatisation phase. This is followed by a discussion of the privatisation efforts itself.

3.0. MAIN FEATURES OF THE TELECOMMUNICATIONS SECTOR

The section is organised as follows: First of all, I outline the current privatised structure of the Brazilian telecommunications sector. This is followed by an analysis of four important dimensions of the sector: (i) growth of investment and capacity; (ii) technological improvements in the network; (iii) phenomenal growth of mobile telephony and the near saturation of fixed telephony; and (iv) structural changes in the telecom industry with the distribution of services accounting for a dominant share of the industry.

Brazil is the fifth largest country in terms of area and, with a population of approximately 170 million people; it ranks as the sixth most populous nation in the world. In 2002, Brazil had the largest economy in Latin America, with a GDP of \$407.7 billion and an annual growth rate of 2.1 percent. As mentioned earlier Brazil has the largest telecommunications sector in the region. In 2002, Brazil's net revenue for telecommunications equipment and services was approximately \$25.28 billion. (*AnuarioTelecom,2003*). Services accounted for \$23.0 billion while telecommunications equipment and software suppliers generated the remaining \$2.28 billion.

The country's telecommunications industry has undergone a complete transformation since early 1998 when state owned Telebrás (Telecomunicações Brasileiras S.A.) acted as a holding company for 28 operating companies: one long distance operator (Embratel), and 27 companies providing local, inter-state long-distance, and mobile communication services at the state level. Four independent telephone companies provided services outside the Telebrás system, in specific geographical areas, accounting for 9 per cent of all lines in service. The mobile lines were opened to competition in 1997, when companies were licensed to provide B band cellular services in 10 regions in competition with the Telebrás A-band cellular operators. The Telebrás companies were amalgamated into three regional, one long-distance (Embratel), and eight cellular operating companies in early 1998, prior to being privatised in July 1998. This process, as seen earlier in Table 1, was one of the single largest privatisations in the world and the Brazilian government netted a premium of about 64 per cent over the combined minimum bid price. Immediately after the privatisation was concluded the Brazilian regulator, ANATEL, initiated plans to offer 'mirror' concessions to operate in competition with the four former fixed operators. The structure of the fixed telecommunications distribution segment in Brazil before complete liberalisation in 2002 is outlined in Table 3.

Table 3: Structure of the fixed telecommunications distribution sector in Brazil: 2001

| | Service provider | Company/ (Main Shareholders) | Source of equipment used in the network |
|---|------------------------------------|---|--|
| Region 1 Amazonas (AM), Roraima(RR), Maranhão(MA), Amapá(AP), Piauí (PI), Ceará (CE), Rio Grande do Norte (RN), Paraíba (PB), Pernambuco (PE), Alagoas (AL), Sergipe (SE), Bahia (BA), Minas Gerais (MG), Espírito Santo (ES) and Rio de Janeiro (RJ) | Local | TELEMAR (BNDESPar, Pension Funds, Andrade Gutierrez, Opportunity) | Ericsson, Siemens, Lucent, NEC and Tropicó |
| | Local (Mirror Concessionary) | VESPER (Qualcomm, VeloCom, Bell Canadá) | Lucent |
| | Local (Mirror image Concessionary) | CTBC Telecom | N/A |
| | Total Market Region 1 | | |
| Region 2 Acre (AC), Rondônia (RO), Mato Grosso (MT), Tocantins (TO), Distrito Federal (DF), Goiás (GO, Mato Grosso do Sul (MS), Paraná (PA), Santa Catarina (SC) and Rio Grande do Sul (RS) | Local | BRASIL TELECOM Incumbent (Solpart, Pension Funds, TIM, Timepart) | Ericsson, Siemens, Lucent, NEC and Tropicó |
| | Local (Mirror Concessionary) | GVT (Magnum Group IDB Group, Merrill Lynch Group) | Nortel |
| | Local (Mirror image Concessionary) | Other | N/A |
| | Total Market Region 2 | | |
| Region 3 Sao Paulo (SP) | Local | TELEFONICA (Telefonica de Espanha) | Ericsson, Siemens NEC, and Trópico |
| | Local (Mirror Concessionary) | VESPER (Qualcomm, VeloCom, Bell Canada) | Nortel |
| | Local | Other | Nortel / Lucent |
| | Total Market Region 3 | | |
| Region 4 Long Distance – National Coverage | LDI | EMBRATEL (WorldCom) | Ericsson, NEC, Lucent |
| | LDI (Mirror Concessionary) | INTELIG (NGC, France Telecom, Sprint) | Alcatel, Cisco, HP and Nortel |

Notes: LDN – Long Distance National; LDI – Long Distance International
Source: ANATEL

Three findings are important. First, an interesting aspect of the fixed telecommunications sector is the fact that most of the new entrants have foreign equity holdings. Second, all the major service providers have diversified equipment or infrastructure providers and these providers, with the exception of Tropicó, are of foreign origin. Third, Tropicó switches are used only in the local network. Thus the privatisation of the telecommunications network and the consequent change in the ownership from state to private foreign entities has important implications for telecom equipment based on domestic technologies. In very specific terms, privatisation has the potential to significantly reduce the share of domestic technology, although, as will be seen later in section 5, the government has sought to protect domestic technology through the enunciation of certain specific legal and fiscal instruments.

i) Growth of investment and capacity in fixed telephones

Investments in telecommunications averaged only about 2.6 per cent of gross domestic investments until the mid 1990s (Figure 1). Thereafter they increased significantly to about 6.3 per cent of gross domestic investments. In short privatisation has actually led to an increase in the level of investments in the sector. Other indicators of growth, namely the growth of equipped capacity, actual number of connections available and density of telephones all have shown impressive increases during the post privatisation period (Table 2 and Figure 2). Compared to other Latin American and indeed other developing countries, Brazil has one of the best telecommunications infrastructure. An interesting feature of the network is the growth in both the numbers and density of public telephones throughout the country. This growth has occurred both in absolute terms and in the relative sense, with the number of public telephones increasing from less than one per cent of fixed telephone lines available to about 3 per cent. This shows that access to basic telecommunication services has increased significantly during the post privatisation phase.

ii) Excess capacity

There has however been a mismatch between equipped capacity and the actual number of lines available. It can be seen from Figure 2 that over the last three decades, equipped capacity showed significant increases during the early 1970s and again during the late 1990s. In order to quantitatively estimate this gap between equipped capacity and the actual number of lines used, I define an index of excess capacity which is measured by taking the ratio of actual number of lines available to equipped capacity multiplied by 100 (Figure 3). The index shows, as expected two peaks, the first one during the early 1970s and the second one during the late 1990s. The first peak could be attributed to a lack of purchasing power or related to the relatively higher price of telecommunications services especially in the initial years. Given that the price of telecommunications equipment has fallen considerably, the second peak may be a reflection of

over-investment. However this proposition needs to be researched into before firm conclusions can be drawn.

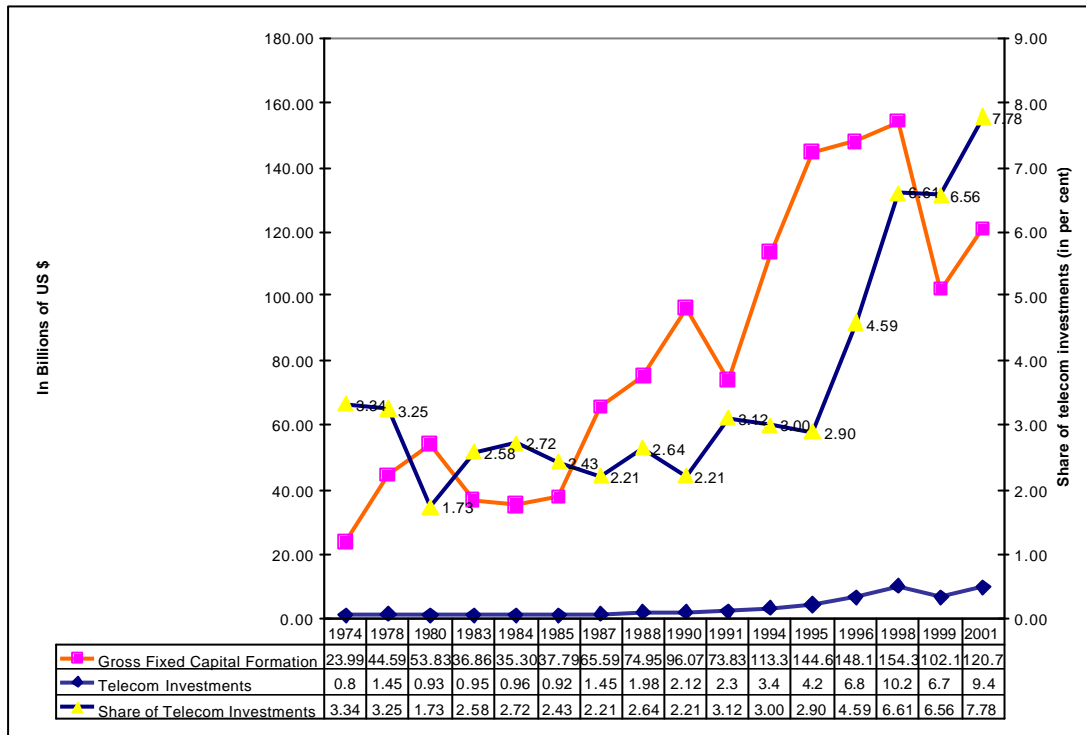


Figure 1 Evolution of investments in the Brazilian telecommunications sector, 1972-2001

Source: Mytelka (1999) and ANATEL (2002) , World Bank (2002)

Table 2: Growth of Brazil's telecommunications service sector, 1972- 2003(in million lines)

| | Number of fixed telephone lines installed | Number of fixed telephone lines actually used | Number of Public Telephone Lines available | Number of mobile telephone lines available |
|-------------|---|---|--|--|
| 1972 | 1.5 (1.5)* | 1.3 (1.3)* | 0.01 (0.1)** | |
| 1973 | 1.7 (1.7) | 1.5 (1.5) | 0.01 (0.1) | |
| 1974 | 1.9 (1.8) | 1.7 (1.6) | 0.01 (0.1) | |
| 1975 | 2.3 (2.1) | 1.9 (1.8) | 0.02 (0.2) | |
| 1976 | 3.0 (2.7) | 2.4 (2.2) | 0.02 (0.2) | |
| 1977 | 3.7 (3.3) | 2.9 (2.6) | 0.03 (0.3) | |
| 1978 | 4.7 (4.0) | 3.7 (3.2) | 0.04 (0.3) | |
| 1979 | 5.0 (4.2) | 4.2 (3.5) | 0.05 (0.4) | |
| 1980 | 5.5 (4.6) | 4.8 (4.0) | 0.05 (0.5) | |
| 1981 | 5.8 (4.8) | 5.3 (4.4) | 0.06 (0.5) | |
| 1982 | 6.4 (5.2) | 5.7 (4.6) | 0.07 (0.6) | |
| 1983 | 6.8 (5.4) | 6.2 (4.9) | 0.08 (0.6) | |
| 1984 | 7.3 (5.6) | 6.7 (5.2) | 0.09 (0.7) | |
| 1985 | 7.6 (5.8) | 7.2 (5.5) | 0.11 (0.8) | |
| 1986 | 8.1 (6.0) | 7.4 (5.8) | 0.15 (1.1) | |
| 1987 | 8.5 (6.2) | 7.9 (6.0) | 0.18 (1.3) | |
| 1988 | 9.1 (6.5) | 8.4 (6.2) | 0.21 (1.5) | |
| 1989 | 9.7 (6.8) | 8.8 (6.5) | 0.23 (1.6) | |
| 1990 | 10.3 (7.1) | 9.4 (6.9) | 0.24 (1.7) | negligible |
| 1991 | 10.8 (7.3) | 10.1 (7.2) | 0.23 (1.6) | 0.007 |
| 1992 | 11.7 (7.8) | 10.8 (7.6) | 0.26 (1.7) | 0.03 |
| 1993 | 12.4 (8.2) | 11.5 (8.0) | 0.28 (1.8) | 0.19 |
| 1994 | 13.3 (8.6) | 12.3 (8.5) | 0.34 (2.2) | 0.76 (0.5) |
| 1995 | 14.6 (9.3) | 13.3 (9.4) | 0.37 (2.3) | 1.42 (0.9) |
| 1996 | 16.5 (10.4) | 14.8 (9.4) | 0.43 (2.7) | 2.74 (1.7) |
| 1997 | 18.8 (11.7) | 17.0 (10.6) | 0.52 (3.2) | 4.60 (2.8) |
| 1998 | 22.1 (13.6) | 20.0 (12.4) | 0.59 (3.6) | 7.37 (4.5) |
| 1999 | 27.8 (16.8) | 25.0 (15.1) | 0.74 (4.5) | 15.03 (9.1) |
| 2000 | 38.3 (23.1) | 30.9 (18.6) | 0.91 (5.5) | 23.19 (14.0) |
| 2001 | 47.8 (28.2) | 37.4 (22.1) | 1.38 (8.1) | 28.75 (17.0) |
| 2002 | 49.23 | 38.81(28.7) | 1.37 | 34.88 |
| 2003 | 49.6 (28.5) | 39.1 (28.5) | 1.40 (8.2) | 38.8 |

Notes: * Figures in parentheses indicate density of telephone lines per 100 population; ** Figures in parentheses indicate density of public telephones per 1000 population.

Source: ANATEL (2001), pp 84-5; Ministry of Communications, <http://www.mc.gov.br/telecom/metas/> Albernaz (2003)

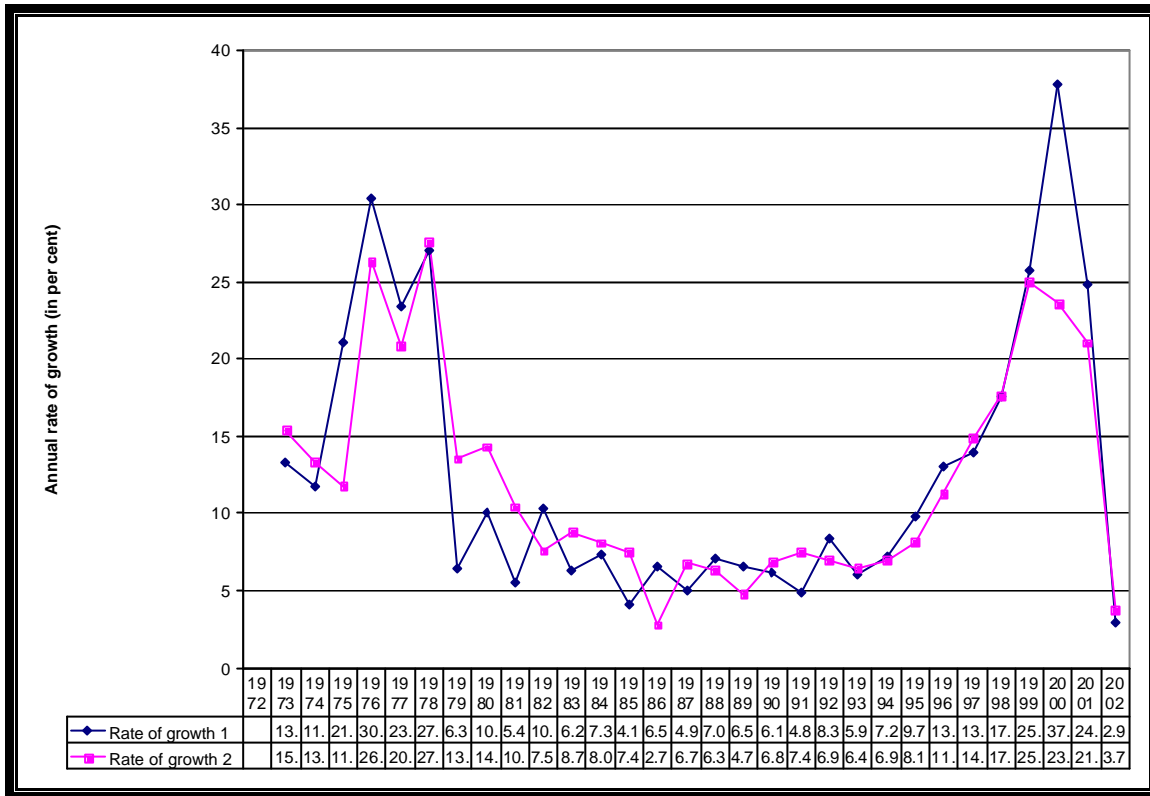


Figure 2: Rate of growth of equipped capacity and actual number of lines available in Brazil, 1972-2002

Notes: Rate of growth 1: annual percentage change in equipped capacity; Rate of growth 2: annual percentage change in actual number of lines used.

Source: Computed from Table 2

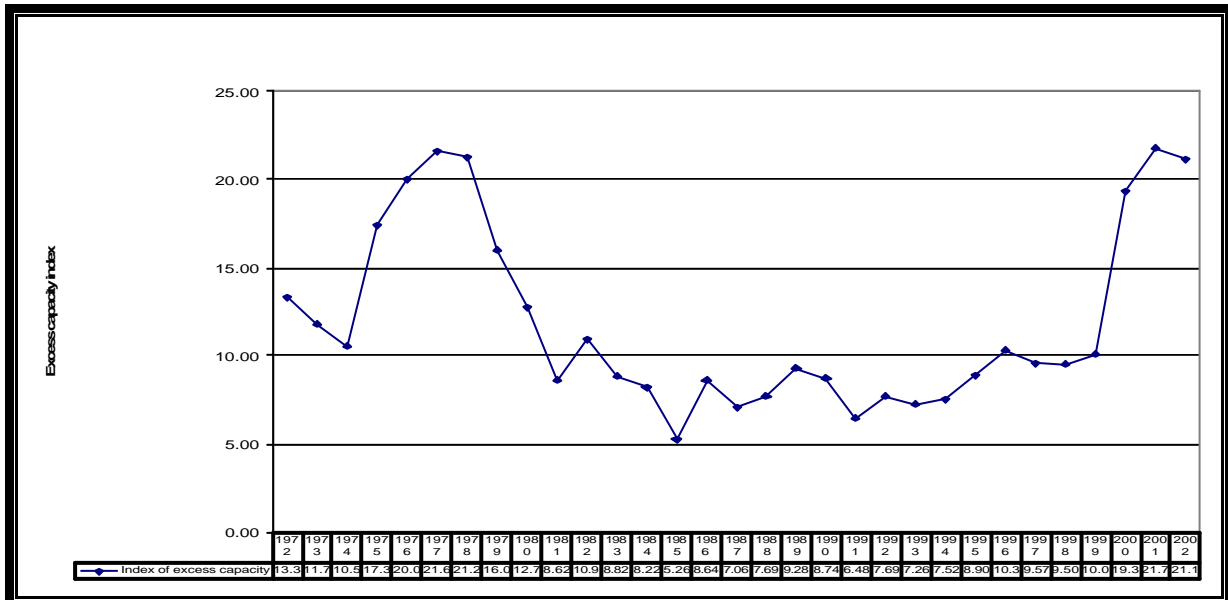


Figure 3: Index of excess capacity in fixed telephone lines in Brazil, 1972- 2001

Source: Computed from Table 2

iii) Technological changes in the network

I consider three separate indicators of technological changes in the telecommunications network in the country. They are: (a) growing digitalisation of the network; (b) phenomenal growth of mobile communications, which even of late has surpassed fixed line telephones; and (c) the increasing use Wireless in Local Loop (WLL) technologies to quickly deploy fixed line telephones to ultimate customers.

(a) Increasing digitalisation of the network: Currently the Brazilian network is almost 100 per cent digitised (Table 3). It is interesting to note that significant increases in digitalisation occurred during the period 1994 through 1998 or in the pre-privatisation period and this was achieved without incurring significant increases in investments (the ratio of telecom investments to gross domestic investments was more or less constant during the period as indicated by Figure 1 above). It is quite plausible that the availability of domestically developed digital switches (for instance the Tropic RA) might have facilitated this process of increasing the digitalisation of the network without incurring additional investment expenditure.

Table 3: Extent of digitalisation of the Brazilian network, Fixed and Mobile Services, 1994- 2002

| | Rate of local network digitalisation- Fixed telephones (%) | Target (%) | Rate of network digitalisation- Mobile telephones (%) |
|------|--|------------|---|
| 1994 | 35.5 | | |
| 1995 | 45.8 | | |
| 1996 | 56.1 | | |
| 1997 | 67.8 | | |
| 1998 | 72.3 | 67.4 | |
| 1999 | 84.6 | | 66 |
| 2000 | 92.5 | | |
| 2001 | 97.2 | 75.9 | 98 |
| 2002 | 98.28 | | |

Source: ANATEL (2001), p. 85; ANATEL (2000), p.78; and Ministry of Communications, http://www.mc.gov.br/telecom/metas/fixos_instalados.htm

(b) Phenomenal growth of mobile communication: In contrast to their late entry in most other developing countries mobile communications in Brazil go as far back as 1990. However, real growth of the network took place only after privatisation in 1998. This is indicated by the sharp increases in the ratio of mobile to fixed lines since the period, with the ratio beginning to be greater than unity from July 31 2003 onwards (Figure 4). The growth in mobile communication was a product not only of an increase in the number of service providers, but a diversification of the types of technologies used (Table 4) and the consequent reduction prices that ensued (this aspect is discussed at length in the next section on reforms in the sector). For instance in June 2000, ANATEL announced the adoption of a 1.8 GHz spectrum band for the national wireless system - bringing Brazil into the global

GSM wireless community.²² Thus Brazilian consumers have three different technologies to choose from thus increasing competition not only between service providers but also across different technologies. Another important feature of mobile communications is the adverse consequences for the demand for fixed line telephony equipment.²³ Given the fact that domestic technology capability has so far focused almost entirely on fixed line telephony this shift has important implications for the future build of innovation capability in fixed line telephony sector. This is exacerbated by the fact that almost all the equipment used in mobile telephony (switching, transmission and terminal) is supplied by MNC manufacturers.²⁴

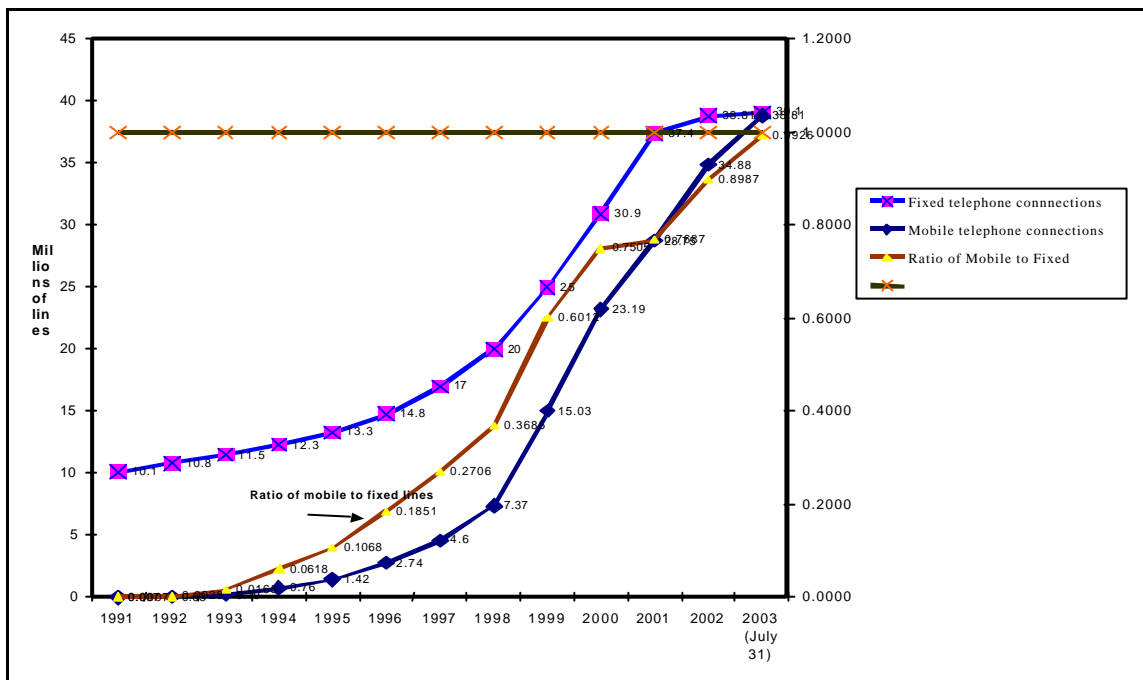


Figure 4: Ratio of mobile to fixed connections in Brazil, 1991-2003

Source: Table 2

²² According to the World GSM association, the choice of 1.8 GHz for the "C" band in Brazil preserves the 1.9 GHz frequency for Third Generation (3GSM) technology, allowing for full scale evolution of the wireless Internet. ANATEL has said that this decision would allow Brazil to adopt 3GSM technology within two to three years via a smooth evolutionary path from GSM today, into wireless multi-media networks of the future. See the Press Releases Archive of the Association at <http://www.gsmworld.com/>.

²³ In this respect the Brazilian scenario is very similar to that of India. For details of the Indian case see Mani (2003).

²⁴ In 1998, the largest share in mobile switching centres is accounted for by NEC (40%), followed by Nortel (25%), Ericsson (24%), Lucent (6.5%), Motorola (4%) and Alcatel (0.5%). See Melo and Gutierrez (2002), p. 7.

Table 4: Distribution of Mobile Communications in Brazil according to technology (As on July 31 2003)

| Type of mobile technology | Number of subscribers | Percentage share | Density of mobile telephones (access/100 population) |
|---------------------------|-----------------------|------------------|--|
| 1. AMPS | 785,405 | 2.02 | 0.44 |
| 2. TDMA | 22,530,516 | 58.04 | 12.74 |
| 3. CDMA | 11,994,546 | 30.90 | 6.78 |
| 4. GSM | 3,510,193 | 9.04 | 1.98 |
| Total | 387,820,660 (73.27) | 100.00 | 21.95 |

Note: Figures in parentheses indicate the percentage share of pre paid subscribers in the total number of subscribers.

Source: Albernaz (2003)

(c) Diffusion of Wireless in Local Loop Systems (WLL): WLL technology allows network operators to connect homes or businesses to central offices using fixed wireless equipment, rather than the traditional copper wire loop. This technology allows network operators to meet quickly and cost-effectively the growing demand for communications services ranging from ordinary telephone service to high-speed data for Internet access. Hence a WLL is sometimes called a 'fixed cellular system' (Garg and Sneed, 1996). There are sharply divergent views about the use of WLL in Brazil. The incumbent companies have the contractual obligation to provide universal access to basic telephone services and are authorised to use WLL in localities with fewer than 50,000 inhabitants. In these cases the technology will be totally subsidised as a rapid alternative to construction of a landline network, especially in economically deprived areas where there is little or no demand for data transport. The question is not so straightforward for the new competitive carriers, however, which are free to choose whatever niche markets they consider worthwhile. Although using WLL saves most of the cost involved in implementing a physical network (pole rental, excavation etc.), the cost per subscriber is still significant. There is a raging debate in the country as to which of the four technologies - DECT, CDMA IS-95 or proprietary technologies (Tropico) - is most suitable for Brazil. The Brazilian telecommunications "mirror companies" have begun to purchase WLL technology to serve cities with less than twenty thousand inhabitants. It is not clear what the share of domestic technology is, although domestic technology, in terms of its better cost considerations, may have an edge over foreign technologies.²⁵ The first WLL systems to operate in Brazil came on

²⁵ A Brazilian company called Tropico offers the domestic WLL technology and it has teamed up with the MNC Airspan.

stream at the end of 1999 with Proximity II, the second release of Nortel's proprietary CDMA platform. According to the latest data (as on June 30 2003), there are 1056536 subscribers on WLL technology working out to just 2.27 per cent of the total number of fixed line connections in the country. At this rate of slow WLL deployment, ANATEL's target of one-third of the fixed line telephony to be offered through WLL does not appear to be an achievable one.

(iv) Structural changes in the telecommunications industry²⁶

The industry (both the services and the equipment sector) has grown at an average rate of 17 per cent per annum during the 1990s. The fall in growth rate in 1999 was due to the devaluation of the Brazilian Real. On the whole there has been a significant deceleration in growth rate of the sector in the post privatisation phase of 1998-2002. This is largely due to the 'telecom bust' of 2000. Although data on equipment and services are not available for the entire period, they are available for the post-1998 phase. Analysis of this disaggregated data shows (Figure 5) that the deceleration is largely contributed by the equipment sector even though its own relative share in the industry has suffered considerable erosion.

²⁶ A major difficulty in writing about the features of the Brazilian telecommunications industry is the absence of good quality data from official sources. This is especially acute when one discusses the production structure of the telecommunications equipment industry, as there is a variety of good quality data on the services side or aspect of the industry, which is published by ANATEL in its annual reviews of the industry. The central statistical office of the federal government known as Instituto Brasileiro de Geografia e Estatística (IBGE) does indeed conduct an Annual Survey of Mining and Manufacturing (PIA), which includes the category 'manufacture of electronic and communication equipment and apparatus'. Data on employment, number of factories and net sales revenue of this category are available for the 1996-1999 period. Owing to changes in the classification method used, however, data prior to 1996 are not comparable with the post 1996 period. Most Brazilian and international scholars have used the data compiled by either Brazilian Electrical or Electronics Industry Association (ABINEE) or the specialised journal *Anuario Telecom*. Unfortunately the ABINEE data are available only at the aggregate level and that too only for one year at a time. I have used the data provided by the latter source. This source is also referred to by official agencies in Brazil such as the Ministry of Communications and ANATEL. The Ministry of Communications is currently in the process of developing a statistical series on the Brazilian telecommunications industry.

Table 5: Growth performance of the combined telecommunications industry in Brazil, 1992-2002

(Value in billions of US Dollars)

| | Gross income | Percentage change in gross income | Net income | Percentage change in net income |
|------|--------------|-----------------------------------|------------|---------------------------------|
| 1992 | 8.7 | | 6.87* | |
| 1993 | 10 | 15 | 7.89* | 15 |
| 1994 | 15.3 | 53 | 12.08* | 53 |
| 1995 | 17 | 11 | 13.42* | 11 |
| 1996 | 26.1 | 54 | 20.60* | 54 |
| 1997 | 33.1 | 27 | 26.13* | 27 |
| 1998 | 39.8 | 20 | 31.41* | 20 |
| 1999 | 33.2 | -17 | 26.20 | -17 |
| 2000 | 42.2 | 27 | 33.50 | 28 |
| 2001 | 39.7 | -6 | 31.50 | -6 |
| 2002 | 32.4 | -18 | 25.30 | -20 |

Note: * Net income during the period 1992-1998 was derived using the gross/net ratio during the 1999-2002 period. The gross net ratio during the latter period was remarkably stable at around 1.27.

Source: Vainsencher (2003)

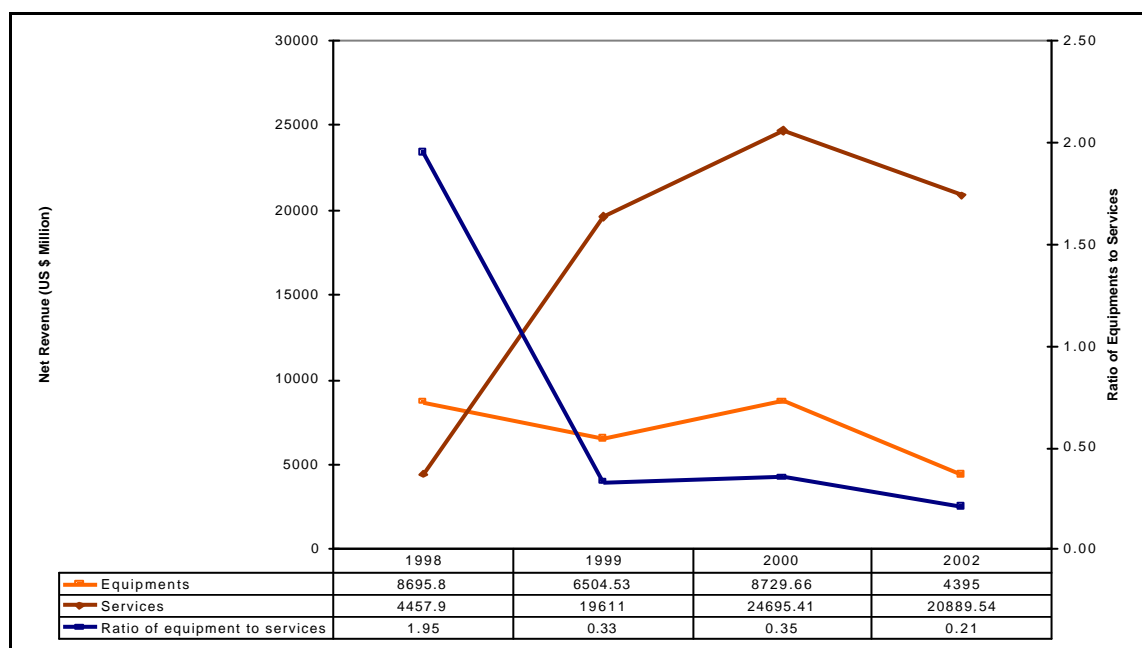


Figure 5: Structural changes in the Brazilian telecommunications industry, 1998-2002

Source: Anuario Telecom (various issues)

Within the equipment sector the share of fixed line switching equipment has shown significant reductions (Figure 6). In 2002 it accounted for only about 6 per cent of total equipment where as a few years earlier it accounted for as much as quarter of total equipment sales. The share vacated by fixed line switching equipment has largely been taken up by the cellular sector (both terminals and other cellular equipment).

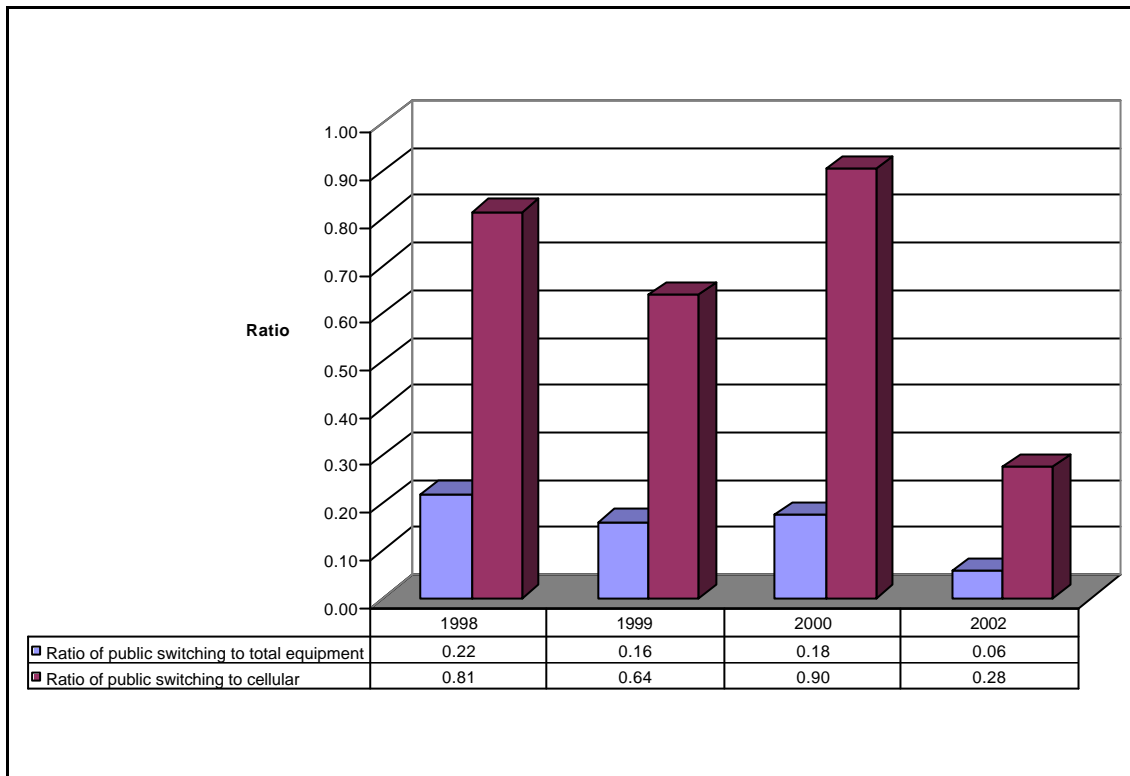


Figure 6: Declining importance of fixed line switching equipment, 1998-2002

Source: Anuario Telecom (various issues)

Thus it can be seen that there has not been a decline in the share of the domestic equipment industry but a number of major structural changes have occurred in the industry that have significant implications for the innovation system of the domestic equipment industry.

4.0. PRIVATISATION OF TELECOM SERVICES AND ITS IMPLICATIONS FOR THE EQUIPMENT INDUSTRY

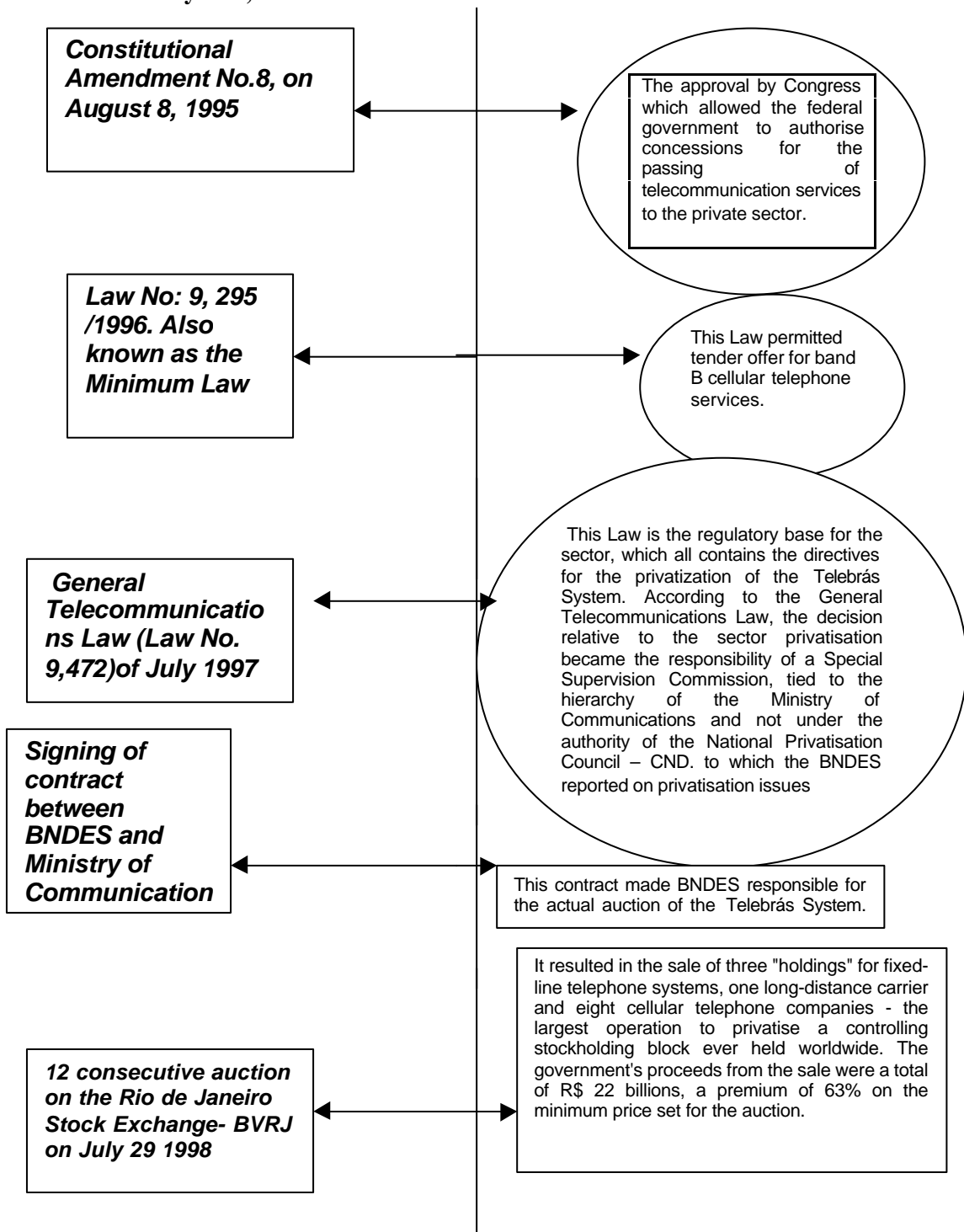
In Brazil you own a phone like you own your car. And while used car prices fall, used phone prices only rise. To buy a phone is a great investment. You can't get a telephone in Rio or São Paulo very quickly. With \$3,000 you can get yourself a cellular in no time at all and, depending on the line location, \$3,000-\$6,000 will buy a conventional telephone line. The alternative is to pay more than \$1,000 in monthly installments in the so-called self-financing plans. But then you will have to wait years for an actual line .All this has changed now²⁷

This section has two objectives. First, it analyses the privatisation of telecommunication services, with a focus on the state of competition and its possible effects on the price of telecommunications services. Second, it traces the extent of foreign participation in the distribution telecom services. Both these issues have important implications for equipment based on domestic technology. Before I proceed on to these two issues, I present, albeit briefly, an overview of the actual process of privatisation.

Brazil's telecom privatisation process was much better structured than that of many other developing countries. The whole process, which started with the constitutional amendment in 1995, had five distinct steps (Figure 7). The most important one was the passage of the General Telecommunications Law of 1997, the regulatory base for the sector. This Law also led to the establishment of the telecom regulator ANATEL.

²⁷ The words of an interviewee during the field work

Figure 7: Key public policy changes leading to privatisation of the Brazilian Telecommunications System, 1995-1998



Source: Own compilation based on ANATEL (2001), pp. 5-6.

ANATEL represents an important step towards telecom liberalisation in Brazil. As an independent regulatory agency,²⁸ ANATEL is responsible for creating and enforcing telecom service regulations, as well as resolving disputes in the administrative arena. It is also ANATEL's responsibility to decide, as a last administrative recourse, on matters under its jurisdiction (There can be no appeal against the Agency's decision to the Ministry of Communications; it must go through the Brazilian judicial system.) ANATEL's tasks are to: define and change rules for telecommunications services; manage and monitor radio frequency spectrum and telecom satellite orbits; grant concessions for public service providers; grant authorisations for private service providers; monitor prices and tariffs; conduct bidding processes; verify the execution of concession contract terms; vote on disputes involving economic entities and users; and ensure competition among operators and service providers.

In order to promote competition in the industry in a structured manner, the following timetable (Table 6) for opening of the Telecommunications market over the period 1999-2004 was agreed.

Table 6: Timetable for opening of the Brazilian Telecommunications Market, 1999-2004

| Segment | 1999 | 2000 | 2001 | 2002 | 2003* | 2004** |
|---------------------------|---|--|------|---|-------|--------|
| Fixed Line | | | | Free entry authorised into any segment or type of service (the entry of the concessionaires and mirror companies will be permitted provided that all the companies operating within their concession regions have met their targets in advance) | | |
| Local | Regional duopoly formed by three local concessionaires | | | | | |
| Intra-regional | Competition between the three local concessionaires and their mirror companies as well as Embratel and its mirror company | | | | | |
| International | Duopoly between Embratel and its mirror company | | | | | |
| Mobile service | Regional Duopoly (A and B-Band operators) | Free entry authorised for provision of PCS services (except in Area 8) | | | | |
| Other Services *** | Competitive | | | | | |

Notes: * From 2003 onwards, authorised operators will be allowed to enter any segment of the service market provided that they meet all the service provisions and expansion objectives established in their contracts; ** From 2004 onwards concessionaires will be permitted to enter

²⁸ For a detailed survey on the regulatory experience of the country see International Telecommunication Union (2001). Increasingly ANATEL is considered to be a model regulator.

any segment of the market or area of services, provided that they meet all the service provision and expansion objectives established in their contracts; and *** Value added services.

Source: Pires (Undated), p. 7

It is seen that competition in the provision of fixed telephone lines has increased although the market share of the mirror companies is not high - it ranges from 21 per cent in Region 1 to about 10 per cent each in Regions 2 and 3 (Table 3). Hence, consumers in all the regions can increasingly choose between two or more service providers (See Table 7).

Table 7: Ability to choose a second fixed line local provider across the three regions, 2000-2001
(percentage of the population with the ability to choose)

| Region | 2000 | 2001 |
|---------------|-------------|-------------|
| I | 37 | 54 |
| II | 31 | 72 |
| III | 52 | 92 |
| Brazil | 39 | 67 |

Source: ANATEL (2001), pp. 23-27.

This increase in competition has also translated into significant improvements in both quality and price.

According to the data provided in ANATEL (2002), only 25 per cent of the indicators for the quality of fixed telephone services were satisfactorily fulfilled in 1998 but this increased significantly to about 95 per cent in 2001, with practically no variations across the average.

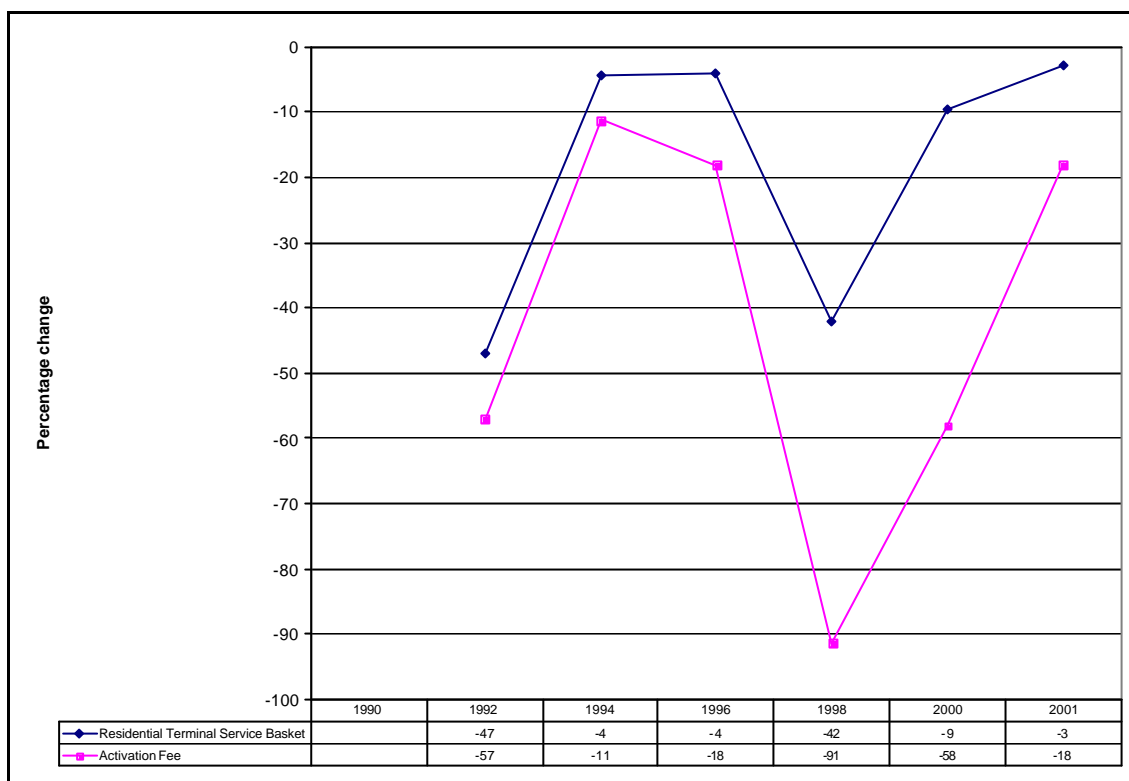


Figure 8: Percentage change in prices and tariffs of fixed telecommunication services
Source: Computed from ANATEL (2001) and ANATEL (2002)

With regard to changes in the price of fixed telecommunications, I considered two kinds of prices. The first is the average price of a residential terminal service basket²⁹ and the second is the activation fee. Both are tax excluded current prices and are unadjusted for inflation. The source of data for both these prices was ANATEL (2001 and 2002). Rates of change of the prices are computed and presented in Figure 6 (note that the data are available for only every alternate year during the period 1990-2000 and for 2001, the latest year for which data are available). The figure shows two very interesting trends. Although there has been secular decline in both the prices, over the entire period under consideration, the activation fee has actually fallen more significantly. The second, even more noteworthy trend, is the fact that both the prices show a sharp decline during the pre-privatisation phase (1990-1998). Considering the data on prices of digital switching equipment contained in Mytelka (1999), it is reasonable to speculate that there is indeed a strong positive correlation between the price of telecommunications equipment used by the provider and the prices at which telecom services are offered by the same provider. In other words, it is the fall in the cost of telecommunication switching equipment (especially) consequent to their successful local development, that has

²⁹ The basket comprises of the following: (a) activation fee (paid over 36 months); (b) subscription rate; (c) pulse-based charges in excess of the allotted allowance; (d) per minute

driven down the price of telecom services and not merely the effect of competitive pressure resulting from an increase in the number of service providers following privatisation. Stated in still another way the available data on movements in prices of telecommunication services does not allow one to conclude that the significant reduction in prices is just due to competitive pressure emanating from privatisation. It is equally important to consider the possible positive effects of local technology development.

I had already discussed the effect of this fall in prices on the increased access to telecommunications services (Tables 2 and 3). However, what has been the effect of this enlarging of the market on the sales performance of the new service providers? The combined sales revenue of the service providers (fixed and cellular) does indeed show an increase although the worldwide telecom bust of 2000 seems to have caught up with them in 2002 (Table 8). This sales performance reflects also some trade off between social obligations and financial performance. Promoting competition in the provision of telecommunications services is sometimes inconsistent with the need to establish universal service. This is best illustrated by ANATEL's firm requirement that incumbent service providers provide universal service³⁰. Consequently based on computations by some of the services providers (Deolitte, 2003), only 35 per cent of the customers actually provide the company with a profit. When competition, especially non-facility based type; is introduced the competitors vie for this set of customers leaving the facility-based provider with an unsustainable customer base. This implies that universal service should be attempted in a monopoly or duopoly environment and that competition should only be allowed when teledensity is sufficiently high to support reduced investment.

charging for international calls; and (e) a monthly average of 81 minutes for domestic long distance calls.

³⁰ In May 1998, the General Plan of Universal Service Goals (PGMU) was approved and it imposed certain obligations on the licensees of fixed telephony. The law for establishing the Universal Telecommunications Service Fund came into force from January 1 2001. The fund is intended to collect resources to stimulate and broaden the universalisation of telecommunications services. By 2005 the last of the goals of the PGMU, namely the provision of at least one public telephone in all localities with at least 300 inhabitants and the installation of individual fixed telephone services in all localities with 300 inhabitants. For a critical review of the PGMU, see Tapaia, Dalmazo and Bessa (2000).

Table 8: Combined Sales Revenue of the Fixed and Cellular Line Providers, 1998-2002

| | Combined net sales revenue in Millions of US \$ |
|------|--|
| 1998 | 14224.00 |
| 1999 | 16331.50 |
| 2000 | 20315.82 |
| 2002 | 17302.36 |

Source: Anuario Telecom (Various issues)

Finally, a recent study by the credit rating agency Fitch IBCA has also found that, ANATEL has been able to control the incumbent companies in the market and thereby foster competition.

Entry of MNCs in Telecommunications Service Provision

The privatisation of telecom services, as noted before, did bring in significant divestiture proceeds to the Brazilian state. However, it also paved the way for a number of foreign companies to enter both the fixed and mobile telephone sectors. In fact, as seen earlier in Table 3, all the major players such as Telesp and Embratel have significant foreign equity participation. During the period 1999-2001, the telecommunications services sector emerged as one of the significant recipients of foreign direct investments to the country (Figure 9). Furthermore the winning bidders in the Telebras auction of 1998 (the larger bids) were foreign providers such Telefonica of Spain, Portugal Telecom, Telecom Italia and MCI (Worldcom). In fact only about 20 per cent of the old Telebras system ended up in Brazilian hands. These foreign-owned service providers are very likely to source their equipment requirements from abroad. This is because procuring equipment for their Brazilian subsidiaries can be an integral part of their international equipment procurement strategy and such a strategy is likely to be conditioned by the availability of deferred credit facilities from both the equipment suppliers and home countries of these equipment suppliers. Recognising this tendency the Brazilian state has put in place a number of legal and tariff measures (I provide a comprehensive survey of these measures in the fifth section) specifically designed to encourage the use of locally developed and manufactured equipment. Although it is still too early to assess the effectiveness of these measures there is adequate preliminary evidence to substantiate the view that this “buy Brazil” policy has had some successes (Box 1).

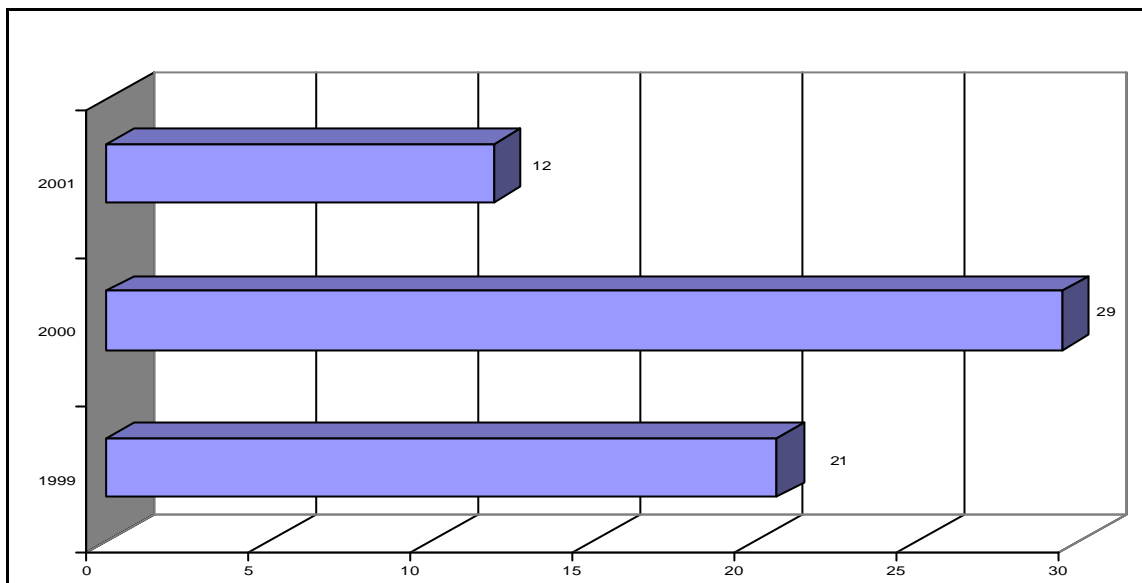


Figure 9: Percentage share of telecommunications and mail services in total FDI to Brazil

Source: Computed from ANATEL (2002)

Box 1: TELESP and the Soft Switches

After the announcement that Siemens and Tropicó will be the major suppliers for their Next Generation Networks (NGN), Telesp (owned by Telefonica Spain) started the implementation of their long distance, national and international network and the creation of their first NGN in Latin America. In the first phase of the project, long distance national and international, Telesp intends to interconnect the largest cities in Brazil including São Paulo, Rio de Janeiro, Belo Horizonte, Vitória, Salvador, Curitiba, Florianópolis and Porto Alegre through an IP convergence network based on the SURPASS NGN manufactured by Siemens. In a second phase Telesp will also provide services to other countries in Latin America. The contract signed with Siemens includes the implementation of the SURPASS platform, a national IP routers backbone, network integration services and operational professional services as well as network maintenance. The soft switches and gateways systems that are part of the SURPASS family will manage Telesp's long distance national and international traffic and create a convergent Voice Over IP network (Virtual Trunking).

Tropicó is the largest Brazilian telecom equipment manufacturer. It is owned by Promon, CPqD and Cisco systems.

Source: U.S Commercial Service,

<http://www.buyusainfo.net/info.cfm?id=121356&keyx=972ABDA25AD8A7A485230AC18636E693&dbf=imil&loadnav=no>

5.0. INNOVATION SYSTEM AND ITS PERFORMANCE: POST PRIVATISATION

The purpose of this section is to map out the present structure of Brazil's sectoral system of innovation and to track its responses to the fundamental changes in the external environment brought about by economic liberalisation and privatisation. Since the previous writers have focused on the history and achievements of CPqD until 1998, the primary focus here is in identifying the response of the main actor in the innovation system, namely CPqD. This subsection is further divided into two parts. In the first part the focus is on measuring the innovation capability of the sector especially during the post privatisation phase and this is followed by a discussion of the changes in the sectoral system of innovation of this sector during this phase.

a) Index of innovation capability

In an earlier analysis (Mani 2003) I had introduced an index of innovation capability based on revealed market shares of domestically developed switches. The index embodies the following conceptualisation of innovation capability: namely the ability to conceptualise, design, manufacture and sell state-of-the-art telecommunications equipment. However the situation in Brazil is slightly different. Hence I have adapted the index to suit the specificities of the Brazilian case where the total demand for switching equipment is met through both domestic production and imports. Domestic output emanates from domestically developed technologies and from imported technology by affiliates of MNCs. Based on this idea, I introduce two different types of indices. The first, denoted as IIC_v , is based on the share of domestic production in total net availability of switching equipment. Equation 1 explains this further:

$$IIC_v = \frac{P_d^s}{\{(P_d^s + I^s) - E^s\}} * 100 \quad \longrightarrow \quad (1)$$

Where

IIC_v = Index of innovation capability based on value terms

P^s_d = Domestic output of switching equipment in value terms. This data are taken from Vainsencher (2003)

I^s = Imports of switching equipment

E^s = Exports of switching equipment

Both the import and export data are taken from the U N Comtrade Database. In this database trade data are classified according to six different classification systems. I have chosen the Standard International Trade Classification, Revision 3 (SITC Rev. 3) as under this classification system data are available at five digit level over the period 1989 through 2002. Further in SITC Rev. 3 code 76415 denotes telephonic or telegraphic switching apparatus. Hence in my view this dataset is the most direct one for measuring imports and exports of telephone switching equipment to a country.³¹ Switching equipment on average accounted for only 18 per cent of imports and 36 per cent of total telecommunications equipment exports. Based on the data and using equation (1), IIC_V have been computed and this is presented in Figure 10. There are, however, three important caveats. First, as mentioned before data on domestic output (namely P^s_d) is available only at the aggregate level. Ideally speaking one should use only that part of the total domestic output that is produced with domestic technology. These data are not easily available, however. Hence we are interested in only the broad trends in the movement of the index. Second, even the data on domestic output of switching equipment are available only for the period since 1998. Third, it is very likely that the import data (especially) on switching apparatus³² includes both fixed line and mobile switching centres as well. Once again a break up of the two is ideally needed and in very specific terms one should

³¹ All the scholars who have computed net exports of telecommunications equipment to Brazil have relied on the trade data on total telecommunications equipment provided either by the industry association ABINEE or by the BNDES. See for instance Schjolden (1999), Szapiro and Cassiolato (2003).

³² This reasoning is based on the fact that according to SITC Rev.3, telecommunication equipment consists of the sum of three codes namely 7641 (Line telephone etc equipment), 7648 (Telecommunications equipment, nes) and 7649 (Parts an accessories for use with telecom equipment). The first code 7641 is further disaggregated into five 5 digit codes namely 76411 (Telephone sets), 76413 (Teleprinters), 76415 (telephonic or telegraphic switching apparatus), 76417 (other apparatus for carrier-current line systems) and 76419 (other telephonic or telegraphic apparatus).

be using only the import data on fixed line switching. But with these caveats in mind, the following inferences can be drawn.

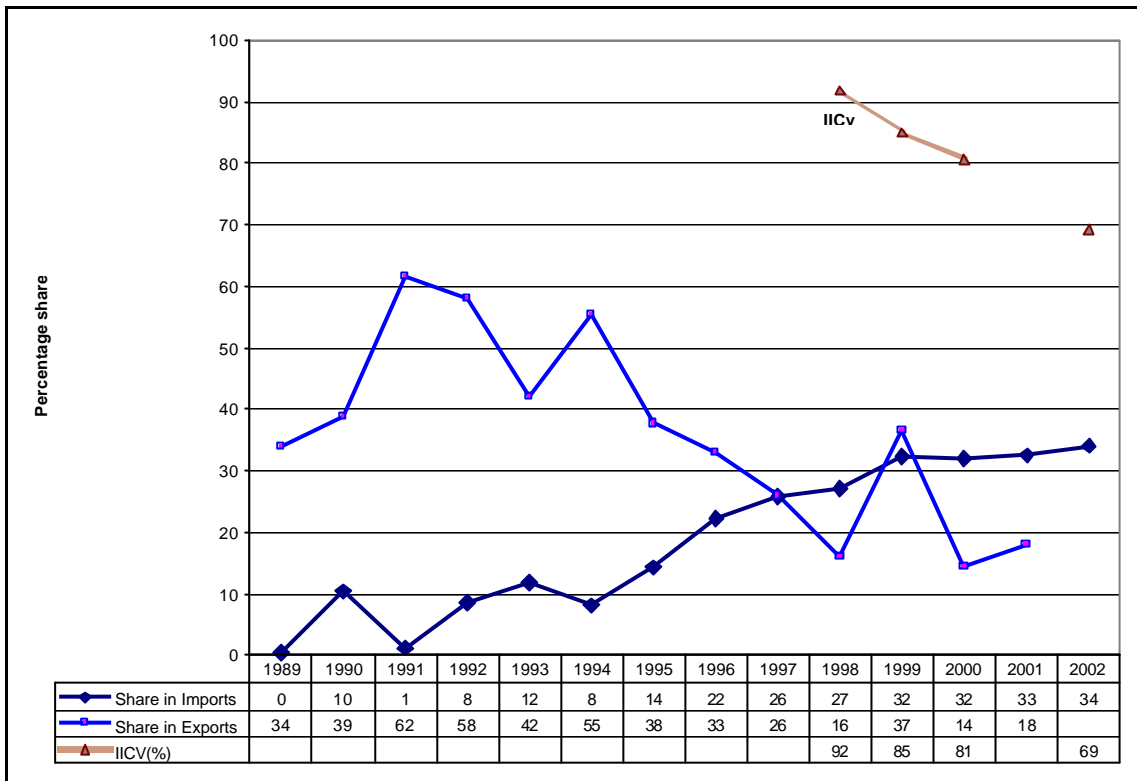


Figure 10: Index of Innovation Capability in Switching Equipment, 1989-2002

Source: Computed from UN Commodity Trade Statistics Database

(i) The IIC_v shows a declining trend. However one should not be hasty in interpreting this to a decline in innovation capability. This is because, as noted before, the index is based on domestic output manufactured with both domestic and foreign technology. From the scattered evidence that is available (to be seen in detail below) installed capacity based on domestic technology did not at any time during the 1976-2003 period account for more than 30 per cent of the total installed capacity for switching equipment in the country. The three affiliates of MNCs, namely Ericsson, Siemens and NEC accounted for a larger share. Based on this, my conjecture is that while the market share of domestically manufactured switching equipment (in total consumption) has suffered a decline, especially with increasing imports, the relative share of switching equipment manufactured using domestic technology has been maintained at about the same level. Since precise data on this share, especially during the 1998-2003 period, is not available, a fall in the IIC_v cannot be interpreted to mean a fall in innovation capability. Of course, based on other pieces of evidence to be presented in our discussion on changes in the innovation system, it was indeed subjected to a major structural transformation during the period and these changes may have adversely affected the performance of the system. But the

Brazilian government has indeed responded to these challenges by putting in place a whole package of legal and fiscal instruments designed to continue to support the domestic development of technology. I will be discussing this package of measures in the next section. In short given the transitory nature of the phenomenon it is not easy to draw firm conclusions about movements in innovation capability either way.

(ii) Even though imports of switching equipment increased during the 1990s, it was mainly during the pre-privatisation phase (1991-1997). The average rate of growth of imports during this period was 238 per cent per annum as compared to only 22 per cent per annum during the post-privatisation phase (1998-2001).³³ The initial increase might have been associated with the phenomenal growth of mobile telephony. Once again it may not be very prudent, therefore, to link the increased imports to privatisation of telecom services in the country.

(iii) It is interesting to note that there have been exports of switching equipment, although these have tended to decrease over time. My analysis of the UN data shows that most of these exports have been to other Latin American countries. However, once again since the export data is not disaggregated into those that are based on domestic technology and those that are not, one cannot use this data for drawing any conclusions about the direction of movement in innovation capability.

The second variant of my index of innovation capability is the actual share of domestically developed switches in the Brazilian telecommunications network. This share is computed on the basis of the share of Tropic switches in the total Brazilian network. Unfortunately time series data on this indicator during pre and post privatisation is not available. In fact I could obtain this data for only one year, namely the pre privatisation year of 1997. See Table 9. The Table shows that Tropic accounted for one third of the total Brazilian network. In fact it had the single largest share, although there are some regional variations. It had a share of only 24 per cent in the most important market of Sao Paulo region and this factor is bound to affect its future market share as well. Although hard quantitative evidence is lacking, based on our discussion with experts in the field, the share of Tropic switches was almost constant at around 30 per cent throughout the 1990s.

³³ The growth rate during the post liberalisation phase (1998-2002) plummets to just 2 per cent if one includes the abnormal year of 2002. Owing to the telecom bust of 2000, 2002 was a very bad year for the world telecommunications industry.

Table 9: Percentage share of Domestically Developed Switching Technology in the Total Brazilian Telecommunications Network, (Cumulative 1987-1997)

| Telebras Company | Domestic Technology (Tropico) | Other Technologies |
|-------------------------|--------------------------------------|---|
| 1. Telenorte | 35.95 | |
| 2. Telecentro | 34.62 | |
| 3. Telesp | 24.25 | |
| Total Telebras System | 32.03 | Simens (Equitel)- 22; Eicsson- 17; NEC- 17; Zetax and Batik* - 5; Others- 5 |

Notes * In 1999, Lucent Technologies acquired the two Brazilian switching manufacturers, Batik Equipamentos S.A. and Zetax Tecnologia S.A. Batik Equipamentos, founded in 1979 is a global telecommunications equipment manufacturer and integrator. The company, which employs 400 people, is a manufacturer of compact digital switching equipment systems. Zetax Tecnologia, which has about 200 employees, develops, markets and supplies telecommunications infrastructure equipment to network operators, including public and private operators, emerging service providers and specialised operators such as public telephony providers. Products include digital central office switching equipment and special technology such as analog to digital conversion equipment.

Source: Melo and Gutierrez (2002), p. 30 and 32.

I had earlier discussed the possibility that this share may experience some erosion during the late 1990s due to a variety of factors. Increasingly with the opening up of the market, Brazil is also facing serious competition from other low cost technology producers, especially China.³⁴ But this does not necessarily mean that the innovation capability of the country will be reduced. A variety of non-technical factors and especially the inability of the domestic manufacturer to

³⁴ A Chinese telecommunications equipment manufacturer, Huawei Technologies (founded in 1988), is proving a credible low cost competitor to Brazilian technology in Brazilian markets. The competitor has now won several contracts for the supply switching equipment especially to the newly privatised providers. The company's switching equipment have very many Tropico like features. The company employs approximately 8500 R&D scientists and engineers as against CPqD's 469. Its total sales turnover is US \$ 2.5 billion. Through a combination of technological capacity building and carefully thought out strategic partnership with US based telecom equipment manufactures(familiar with the Latin American markets), it is to be expected as a serious and credible threat to Tropico.

provide credit facilities have played an important part as well. This point will further be analysed in the next section. Innovation capability, namely the ability to design and manufacture state-of-the-art switching systems, may remain at the same level or perhaps increase if the steps taken by CPqD to adjust to the new rules of the game are successful. Further it will also depend on the successful implementation of the legal and fiscal instruments that the Brazilian state has put in place.

b) Innovation system in the post privatisation phase: Learning to adjust

The sectoral system of innovation in the country has undergone some structural changes in the post 1998 phase. The increasing integration of the Brazilian economy meant that the following changes took place in the 1990s.³⁵

- i) The telecommunications manufacturing industry in Brazil is now largely dominated by affiliates of MNCs. Almost all the wholly-owned Brazilian telecommunications manufacturing firms have either been acquired by MNCs or have closed down. This has resulted in three of the world's leading telecommunications equipment manufacturing firms entering the Brazilian market (for instance, Alcatel and Nortel Networks in 1991³⁶ and Lucent in 1997). Tropicó is the sole remaining Brazilian manufacturer. Even then, 10 per cent of Tropicó's equity is now held by a foreign company - Cisco systems.
- ii) The R&D system of the telecommunications equipment sector has undergone a major structural shift and now comprises three different types of organisations: stand alone public laboratories, R&D departments attached to production enterprises (mostly foreign companies) and university departments (Figure 11). The main R&D organisation - the Telebras owned CPqD - has been turned into a private foundation. This means that for a large proportion of its budget, the laboratory will have to increasingly engage itself in income generating activities, which can affect its forays in to long-term research issues. However, the Brazilian state has put in place a number of legal and fiscal instruments to assure a steady and minimum market for the output of this laboratory. Another notable feature is the entry of private laboratories to telecom research in the country. It is equally interesting to note that of the four foreign labs, three are attached to foreign equipment

³⁵ For somewhat of a similar, but incomplete, charting of this change in the innovation system of the Brazilian telecommunications sector see Schjolden (1999), Szapiro (2000) and Szapiro and Casiolato (2003).

³⁶ Of these three Nortel Work's Brazilian subsidiary is very active in data transmission and wireless markets in the country. It is not an active player in central office switching equipment.

manufacturers and one to a leading fixed line provider. The only Brazilian private sector lab is the Genius Institute of Technology,³⁷ which is undertaking at least one collaborative research venture with CPqD in the area of digital terrestrial television. Nevertheless CPqD remains the major actor in the R&D system and has put in place a number of strategies designed to sustain its research activities within the constraints imposed by the changed external environment. I will be discussing these strategies, in some detail below.

- iii) As discussed in Section 2, there have been two main changes in the distribution of telecom services sector. The first was privatisation, which gave the new telecom operators - some of who are affiliates of foreign providers - the choice of procuring their equipment from abroad. A recent legal instrument, however, has increased the probability that they will consider domestically manufactured equipment. I will discuss this point in the next section. The second, the major growth area is in the equipment for cellular telephony. This is an area where most of the Brazilian R&D organisations including CPqD do not have much capability.
- iv) Consequent to privatisation the centre of gravity in decision-making has changed to the regulator, ANATEL from the Ministry of Communications. Almost all the major decisions with respect to the industry and the responsibility for monitoring effectiveness rest with ANATEL, although after the elections of 2002, the newly constituted Ministry of Communications is slowing attempting to regain its lost 'position' with respect to decision-making. There are now two directorates in the Ministry, one dealing with industry and technology and the other with services and diffusion.
- v) The financing of R&D projects in the telecommunications equipment sector has been streamlined with the establishment of the Fund for Technological Development of Telecommunications (Fundo para Desenvolvimento Tecnológico das Telecomunicações - FUNTTEL) in 2000. The fund is maintained by the service providers and administered simultaneously by BNDES and by FINEP. In addition to this fund there are of course the R&D incentives provided under the Informatics Laws 8248 of 1991 and the more recent Law 10176 of 2001.

³⁷ Genius is part of large Brazilian consumer electronics company called Gradiente.

A. Stand alone Public R&D Laboratories

1. Fundação CPqD – Centro de Pesquisa e Desenvolvimento em Telecomunicações
2. Instituto Atlântico
3. CITS - Centro Internacional de Tecnologia de Software
4. Centro de Estudos em Telecomunicações (CETUC)
5. Inatel - Instituto Nacional de Telecomunicações
6. Centro de Estudos e Sistemas Avançados do Recife – C.E.S.A.R.
7. Instituto de Pesquisa Tecnológicas (IPT)
8. Laboratório de Pesquisa em Sistema de Telecomunicações
9. Centro de Pesquisas Renato Archer

B. University Departments

1. Universidade Estadual de Campinas (Unicamp)
2. Instituto de Engenharia Elétrica (IEE) da Universidade Federal de Itajubá (UNIFEI) Grupo de Telecomunicações -
3. Universidade de São Paulo (USP)
4. Universidade Federal de Minas Gerais (UFMG)
5. Instituto Alberto Luiz Coimbra de Pós-graduação e Pesquisa de Engenharia (COPPE) da Universidade Federal do Rio de Janeiro (UFRJ)
6. Centro de Informática da UFPE

C. R&D Departments attached to Production Enterprises

1. Genius Instituto de Tecnologia
2. Instituto de Pesquisas Eldorado
3. Centro de Pesquisa e Desenvolvimento da Ericsson - *MNC*
4. Instituto Nokia de Tecnologia - *MNC*
5. Telefônica Pesquisa e Desenvolvimento - *MNC*
6. Siemens - GSM - *MNC*

Figure 11: Telecommunications Research Organisations in Brazil (2003)

Source: Own compilation based on CPqD (2003)

Based on the above discussion, the structure of the present system of innovation is mapped out in Figure 12. Needless to add, central to the innovation system is the R&D system and within it CPqD continues to occupy an important position. In the following subsection, I track the response of CPqD to the changes in the innovation system and attempt to make some comments about the direction of movement of its innovation capability

CPqD: Learning to adjust

As mentioned before CPqD has undergone major transformation being a public laboratory with assured funding in the form of research grants from its parent organisation, Telebras, to a private research foundation having to raise a large proportion of its budget from the market. The laboratory has responded to this difficult challenge rather well, although this transformation has definitely affected the morale of the various scientists and engineers working in it (Olenski, 1997) for most of whom this change has been quite painful.

R&D strategy and new company formation

An examination of CPqD's R&D strategy before and after 1998 shows that there has been a clear break with the pre-1998 situation. During this former period (namely 1976-1997) CPqD was primarily concerned with hardware technology for the design and manufacture of a family of digital switching systems (the Tropico family), transmission products such optical fibres and terminal equipment like payphones and inductive card technology. The technologies were first developed through a judicious mix of own efforts combined with carefully selected collaborative ventures - primarily with university departments - and then transferred to a host of Brazilian private sector enterprises. With the opening up of the Brazilian economy in the 1990s, however, most of these enterprises were acquired by the new MNCs entering the Brazilian market. During this period we also see that the distribution of telecom services was almost entirely in the hands of CPqD's parent firm. For much of this period CPqD either did not charge any royalty for the technologies that it transferred to the private sector manufacturers or only charged a pittance,³⁸ on the rationale that the ultimate beneficiary of the technology was its own parent firm and indeed the Brazilian state at large.³⁹ This rationale of rendering technology transfer at reduced rates of royalty was facilitated by assured research grants from its parent firm, but at the same it also meant that the lab become very vulnerable to the vicissitudes of

³⁸Telebras charged a royalty between 0.5 and 5 per cent. I am grateful to Mr. Graciosa for pointing this out to me.

³⁹ I obtained this information during my field research in September 2003. In fact the questions dealing with actual amount of royalty received by CPqD in my questionnaire (CPqD, 2003) was left blank by CPqD. However Schjolden (1999) quoting a study by Vianna (1993) indicates that the laboratory used to charge royalties to the tune of 5 per cent of the total income and does provide some numbers on royalty during the period 1988 through 1991. This data appears to be faulty, however, as the royalty received by the lab ranged from US \$ 1875 million in 1988 to US \$ 711 million in 1991. Mr. Graciosa (current head of CPqD) has confirmed (written communication dated January 20 2004) that these data are plainly wrong. See Schjolden (1999), Figure 5.5 on p. 74. According to Schjolden's own figures investments in CPqD averaged around US \$ 100 during the same period.

globalisation⁴⁰. So in the latter period (1998-2003) we see that the lab has reoriented its research and marketing strategies (Table 10). In terms of research it has started to focus on Next Generation Networks (NGN)⁴¹ along with its main physical components such as fibre and wireless media, routers, switches, gateways, servers, and edge devices that reside at the customer premise. In terms of marketing the company established its own companies: spawn four different companies (Figure 13) two of them focusing on equipment manufacturing (Tropico and Padtec) and two of them focusing on software development and other service-oriented assignments (CPqD USA, and Cleartech). I first discuss the details of this new company formation and then will go on to measuring the performance of the laboratory in terms of its new R&D programme and its over all financial performance.

Table 10: CPqD's strategy before and after privatisation

| Before privatisation (1976-1997) | After privatisation (1998-2003) |
|--|---|
| <ul style="list-style-type: none"> • Budget: assured research grants from Telebras; • R&D strategy: technology development for hardware (Tropico Family of digital switching systems, optical fiber for Transmission, terminal equipment such as payphones Telephone cards) • Marketing strategy: transfer of technology to Brazilian private sector enterprises at nil rates of interest. | <ul style="list-style-type: none"> • Budget: Up to middle of 2001 largely based on self generation. From middle of 2001, 30 per cent from FUNTTEL research grants and 70 per cent through self generation. • R&D strategy: Generation of both software and hardware technologies for NGN, Business and Operation Support System and optical communication technology. • Marketing strategy: Establishing four companies and through strategic partnerships between these companies and clients. CPqD also makes a direct commercialisation of its systems and technologies. |

Source: Own compilation based on CPqD (2003) and interview notes

One of the most interesting aspects of this new company formation is the creation of a new company, Tropico in 1999. This was undertaken in partnership with one of the remaining

⁴⁰ This is in sharp contrast to its Indian counterpart C-DOT. C-DOT charged a royalty not only from its licensees in the private sector but also from public sector as well and over time accumulated royalties accounted for as much as 25 per cent of its accumulated research grants received from the Indian state. See Mani (2003) for the details.

⁴¹ A NGN is a high-speed packet or cell-based network that is capable of transporting and routing a multitude of services including voice, data, video, and multimedia, and a common platform for applications and services that is accessible to the customer across the entire network, as well as outside the network. See Goleniewski (2003), pp. 298-9.

Brazilian switching equipment manufacturer, Promon and CPqD. Later one of the most innovative US telecom equipment company CISCO systems⁴² too joined this new company with an equity holding of 10 per cent. The fact that CISCO joined this partnership is itself a clear indication of the potential innovation capability of CPqD. The new company Trópico S.A. is recognized as a leader in the migration from the traditional time division multiplexing (TDM) into NGN. In order to effectively utilise its R&D capacity the laboratory transferred approximately 100 of its scientists and engineers in 1998 to the new company. Unfortunately within two years Brazil too started experiencing the ill effects of the telecom bust of 2000⁴³. This meant that until the end of 2001, the number of R&D scientists and engineers ranged from as low as 1 per cent in 1998 and 1999 to 14 per cent at the end of 2001 (Table 11).

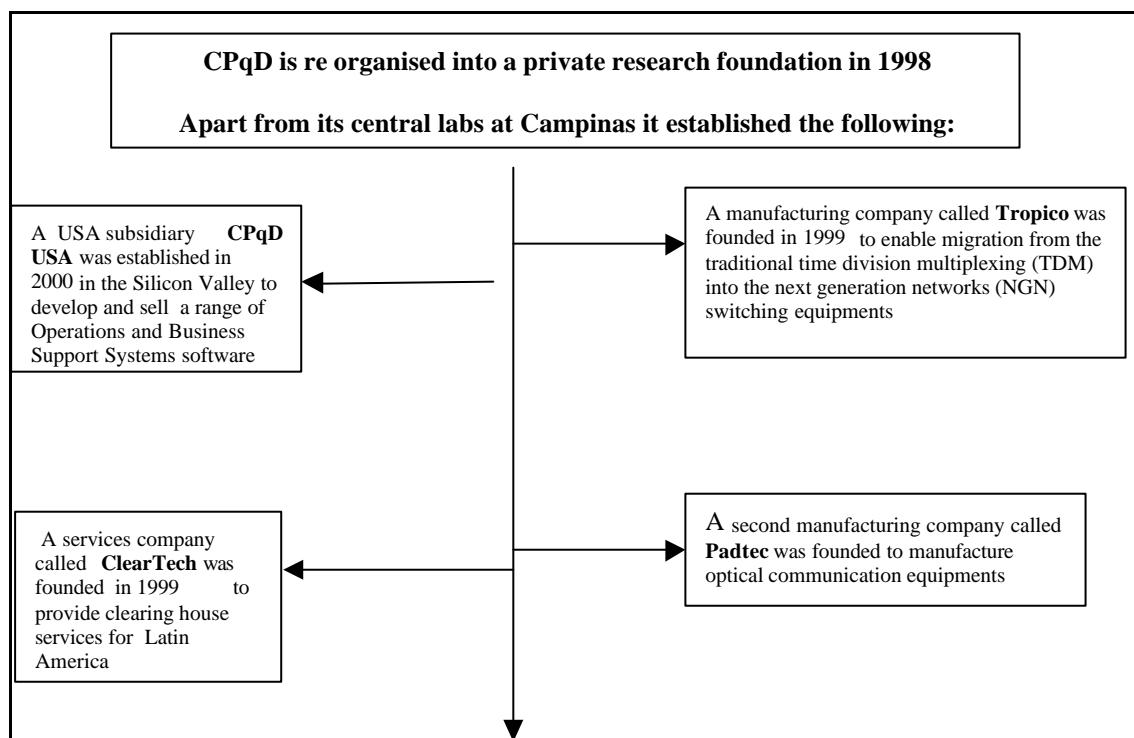


Figure 13: New company formation by CPqD

Source: Own compilation

⁴² CISCO Systems is world's largest manufacturer of networking solutions for the internet.

⁴³ For an excellent review of the boom and bus in the world telecoms industry, see especially Chapter 1 of Fransman (2002).

Table 11: Changes in the professional workforce of CPqD, 1998-2003
(number of employees)

| | R&D | Client Operation | Administration and Support | Total |
|------|----------------|-------------------------|-----------------------------------|--------------|
| 1998 | 6 (1) | 601(67) | 288(32) | 895 (100) |
| 1999 | 6 (1) | 589 (68) | 277 (32) | 872 (100) |
| 2000 | 40 (4) | 712 (71) | 248 (25) | 1000 (100) |
| 2001 | 149 (14) | 671 (65) | 220 (21) | 1040 (100) |
| 2002 | 382 (41) | 338 (36) | 211 (23) | 931 (100) |
| 2003 | 469 (43) | 419 (38) | 215 (19) | 1103 (100) |

Source: Figures in parentheses indicate percentage share of the total

Source: CPqD (2003)

Consequently in 2003 these R&D scientists and engineers were brought back to the central laboratory at Campinas so that they could continue to develop the NGN switches. Another reason that is attributed to this return of the scientists and engineers to the parent laboratory is the availability funding from FUNTTEL from the middle of 2001. FUNTTEL research grants are available only to the central laboratory (it being a private foundation) and not to private companies. Even though this initial exit and eventual return of scientists may give an impression of the laboratory not being in control of itself, it may not indicate that the innovation capability of the lab is under any threat. This becomes more evident when one examines the successful adaptation of two new optical transmission equipment Raman amplifier⁴⁴ and Dense Wave length Division Multiplexing with Forward Error Correction⁴⁵ (DWDM with FEC) equipment by the second manufacturing company Padtec. Further the successful forays to telecom

⁴⁴ Raman amplifier is developed by scientists at the Bell Labs of Lucent Technologies. It is a device that boosts the signal in an optical fiber by transferring energy from a powerful pump beam to a weaker signal beam. This novel approach to boosting signals in fibres relies on the interaction between light and atoms in the fiber. Current DWDM systems depend on erbium-doped-fiber amplifiers, which boosts signal power every 80 km along a fiber. Because the amplification process takes place more slowly as the signal propagates, this approach greatly diminishes the problem of signal crosstalk between channels. DWDM systems have had to struggle with an effect known as "four-wave mixing," a non-linear interaction between signals in nearby wavelength channels that generates additional spurious signals .

⁴⁵ Dense Wave Length Division Multiplexing (DWDM or WDM) with Forward Error Correction (FEC) is a technology that uses multiple lasers and transmits several wavelengths of light (lambdas) simultaneously over a single optical fiber. Each signal travels within its unique color band, which is modulated by the data (text, voice, video, etc.). WDM has dramatically increased the carrying capacity of the fiber infrastructure of the telephone companies and other carriers. Vendors have introduced systems that can support hundreds of wavelengths, each carrying 10 Gbps. That means terabits of data per second can travel over one optical strand, thinner than a human hair. FEC is a communications technique that can correct bad data on the receiving end. Before transmission, the data are processed through an algorithm that adds extra bits for error correction. If the transmitted message is received in error, the correction bits are used to repair it.

software and especially Operations and Business Support Systems (BOSS) through primarily the establishment of its American subsidiary CPqD USA in Silicon Valley is yet another example of its innovation (if not growing) capability. The establishment of the US operations meant that the foundation could directly tap into one of the single largest markets in the world for BOSS. My discussion thus far shows that CPqD has in a relatively short time managed to learn to change and reinvent itself as a laboratory capable of generating an idea, manufacture it and a sell it in the increasingly competitive markets both inside Brazil and abroad, although its reach in the latter is limited.

I now consider the performance of the laboratory. Two separate indicators are used. First I consider the technological performance of the laboratory but once more encounter the problem that disaggregated data are not available for the post privatisation phase (what is actually available refers to the entire period 1976 through 2003). During this period the lab was granted 109 patents within the country and 50 abroad, of which nine were in the US. The second indicator refers to the financial performance of the lab (Figure 14). Two caveats are in order. First, it is to be noted that of the four full years of operation, out of a total of four and half years of existing as a private, foundation, two of the more recent years namely 2001 and 2002 were bad years for the entire world telecoms industry. Second, the total receipts from the middle of 2001 include FUNTTEL receipts as well: FUNTTEL grants accounted for 22 per cent of the total receipts in 2001 and as much as 49 per cent in 2002.⁴⁶ So my discussion of performance is based on the surplus that is available for ploughing back into the funds for future operations. Using this indicator one can define a profit margin, which is the surplus taken as a percentage of gross revenue. The profit margin thus computed is at its peak in 2000 and thereafter it has suffered significant reductions. But as mentioned above this fall is largely due to exogenous factors and as such cannot be used to judge the performance of the laboratory. Additionally as a private foundation it was not even expected to make profits. The important point to be noted is that the lab has made positive surpluses every year since its privatisation.

⁴⁶ See Ministry of Communications, http://www.mc.gov.br/funttel/rel_gestao_2002.htm

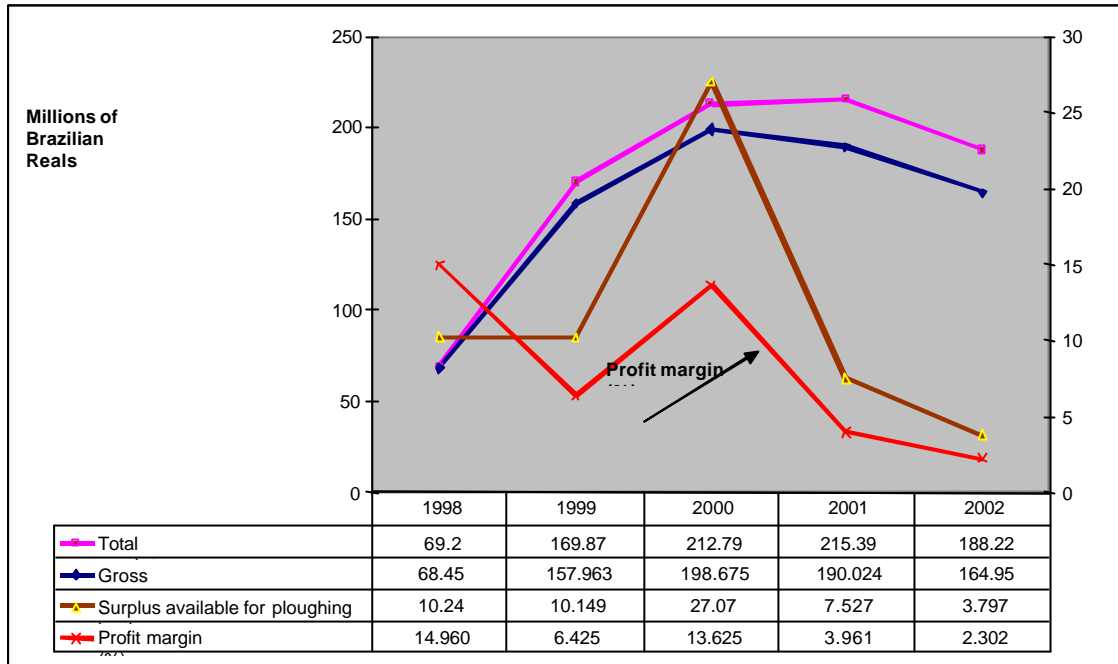


Figure 14: Financial performance of CPqD, 1998-2002

Source: CPqD (various issues)

My analysis thus shows that in spite of the tumultuous economic environment in the period 1998-2002, which makes it difficult to evaluate the performance a lab exclusively specialising in telecommunications equipment, there is no hard evidence to show that its innovation capability has come down during the period. In fact our analysis shows that the lab has been able to maintain its innovation capability and improve its capabilities in areas like manufacturing and marketing, which it did not have previously.

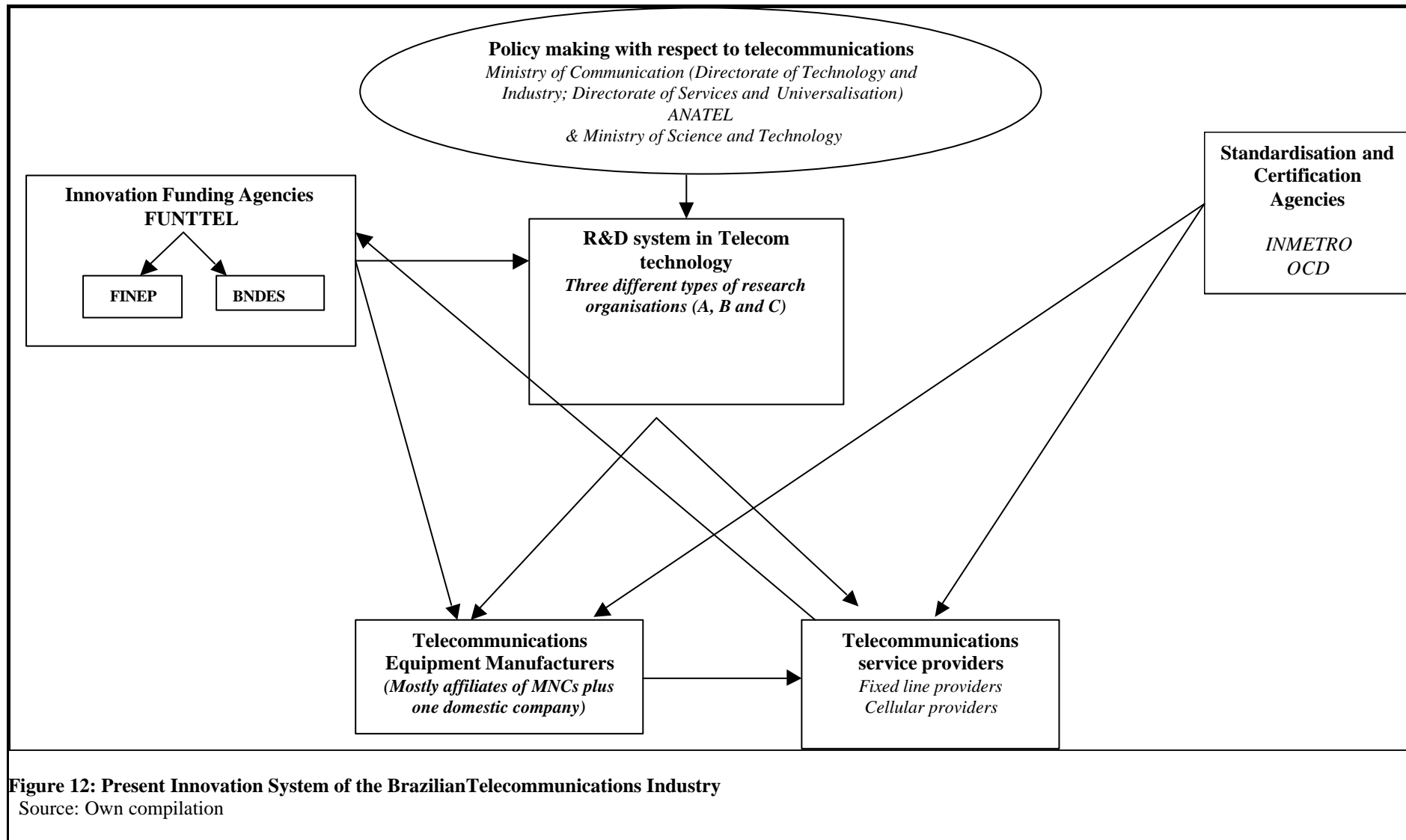


Figure 12: Present Innovation System of the Brazilian Telecommunications Industry

Source: Own compilation

6.0. INSTRUMENTS OF STATE SUPPORT

In this section, I am concerned with surveying the various instruments that the Brazilian state has put place since 1976 to initiate and build innovation capability in the telecommunications equipment industry. These instruments can be broadly divided into: (a) those leading to more R&D investments through essentially fiscal instruments; and; (b) those leading to an assured market for the output of this R&D through essentially legal instruments stipulating the procurement of these products by service providers. Historically speaking the latter type of instruments was more important during the pre privatisation phase while in the post privatisation phase the former type is more important. While this categorisation is, by and large, water tight and mutually exclusive, there are notable exceptions. For instance the Laws of Informatics of 7232 and especially its amended version of 8248 involve both public technology procurement and provision of fiscal incentives for R&D. But since it is more of a legal instrument although with fiscal implications, I treat it in the former category. I begin with the latter type of legal instruments and then discuss the fiscal instruments.

i) Legal instruments facilitating public technology procurement in historical perspective⁴⁷

Beginning with 1978 and ending with 2003, I could identify 7 different legal pronouncements (Figure 15) that have a bearing on creating a protected market for telecommunications equipment manufactured with local know-how. All of them, with the exception of the three Informatics laws of 1984, 1991 and 2001 deal explicitly with telecommunications equipment.

⁴⁷ In working out the ideas contained in this section I am basing myself on the legal interpretation of equipment procurement provided in a number of sources and especially in Kujawski and Brancher (2000).

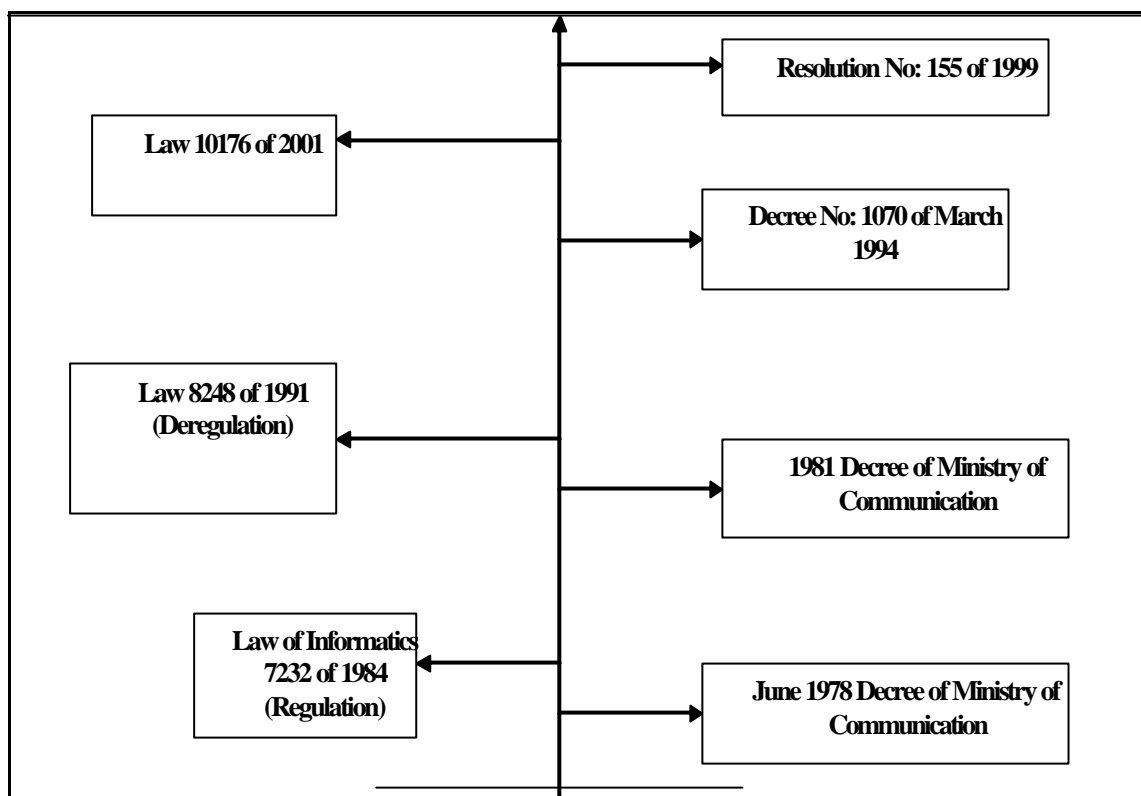


Figure 15: Legal instruments for supporting domestic technology procurement in telecommunications

Source: Own compilation

The two Informatics laws deal with information technology products in general of which telecom equipment are an integral component. First of all I present a synoptic picture of the various laws. Since Resolution 155 of 1999 is the most relevant and recent among the legal instruments, its implications for future build of local innovation capability is discussed

- (a) In June 1978 a decree enforced by the Ministry of Communications established some rules for the acquisition of equipment by the Telebras operating companies. These rules ensured that equipment made by local companies would be given preference;
- (b) Secondly a decree in 1981, once again enforced by the Ministry of Communication, reserved 50 per cent of the market for the Tropic family of digital switching systems even before technology was actually available⁴⁸;
- (c) The Law of Informatics (7232) of October 1984 created market protection (or market reserve) for information technology products manufactured by Brazilian companies. A

⁴⁸ According to Fiorentino (1996), as an immediate consequence of the criteria set out by these decrees, MNCs transferred most of their voting shares to private domestic groups.

"domestic company" was defined as one incorporated under the laws of Brazil, and headquartered in the country. Additionally, to qualify as a domestic company, its management as well as technological and capital control had to be held exclusively by individual residents domiciled in Brazil. Brazilian nationals must hold 70% of the total corporate capital, and no voting rights could be granted to any alien. In 1984, Brazilian Congress approved this Law and it established the principles, objectives and guidelines for the Brazilian Informatics Policy. It empowered the Federal Government to set restrictions on the manufacture, operation, marketing, and import of information technology (IT) products and services. Although the Informatics Law did not expressly establish the market reserve, the Brazilian Federal Government used to monitor imports of IT goods and services and to determine on plans for development and production of such goods. Companies not considered domestic (or national) could only manufacture IT products and qualify for the benefits granted by the law, if the Brazilian Informatics and Automation Council (CONIN) approved their plans.

- (d) In 1991, however, as part of the opening up of the Brazilian economy, Law No: 8248 was enacted, introducing several modifications in the regulation of the IT field in Brazil. This new Law thus effectively amended the Informatics Law of 1984. These incentives were basically tax incentives, applicable to any company producing IT products. The specific fiscal incentives are: (a) exemption from the Tax on Manufactured Products (IPI) until October 22, 1999 with regard to products manufactured following certain criteria. (This exemption probably will be extended until 2005. However, it is still under discussion in the Brazilian Congress); (b) deduction of all R&D expenditures up to the limit of 50% of the income tax owed by the company; and (c) deduction of up to 1% of the income tax owed by legal entities investing in domestic technology companies. Companies established in Brazil that do not qualify as domestic companies may be eligible for the same benefits, provided they demonstrate every year to the Brazilian Informatics and Automation Council (CONIN) that they are carrying out: (a) a programme for effective training of the technical staff, (b) a research and development plan; and (c) export of computer goods and services. The law established certain incentives applicable exclusively to domestic companies: (a) preferential treatment for purchase of goods and services by government agencies; and (b) financing priority from official institutions. The benefits cited above were assured up to 1997 for such companies that complied with the requirements (except the exemption from the Tax on Manufactured Products),

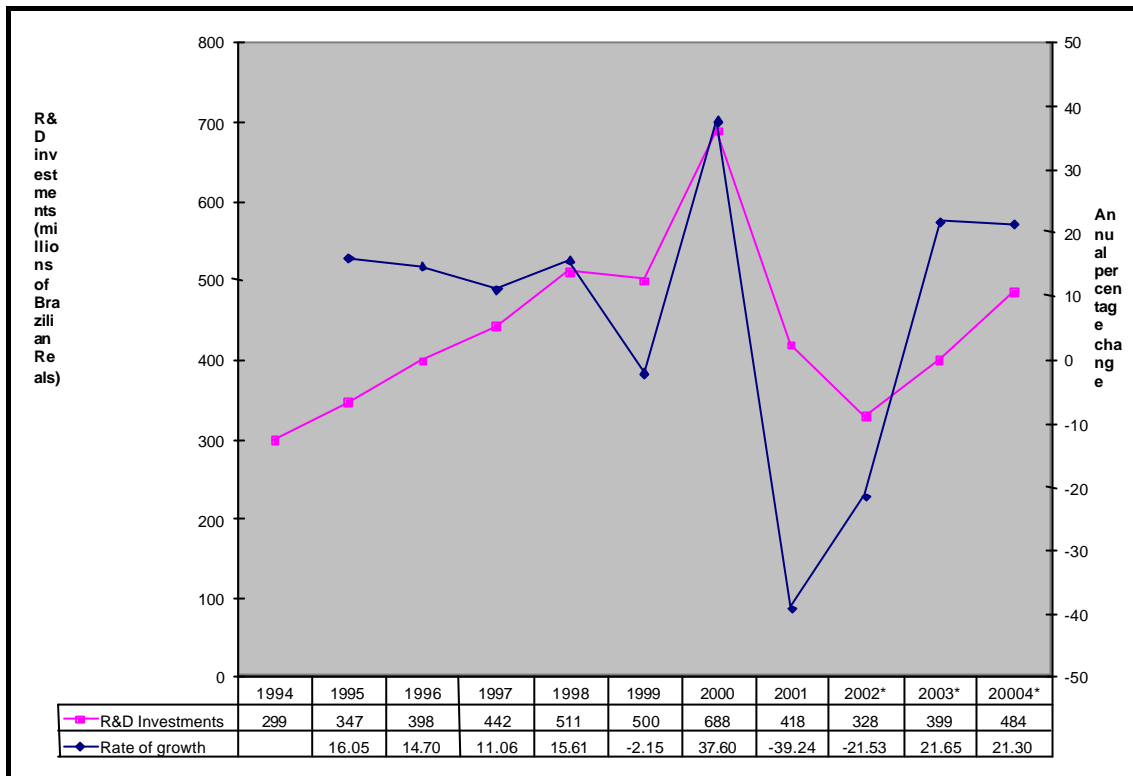


Figure 16: Growth performance of R&D investments in Information Technology products in response to the incentive laws

Notes: Data on R&D investments during 2002 through 2004 are projections.

Source: Brazilian Ministry of Science and Technology

Finally in 2001 still another law (Law no: 10176 of 11/01/2001) was created to provide further fiscal incentives for R&D. In specific terms, the following incentives are available ⁴⁹:

- Taxation incentives, implying in 15 per cent final prices reduction, are offered to companies that invest in R&D activities a minimum of 5 per cent of its gross sales of IT products.
- The 5 per cent investments have to be:
 - minimum 2.7 per cent internal.
 - minimum 2.3 per cent external as below:
 - 1% in authorised Institutions,
 - 0.5% in Government projects,
 - 0.8% in North, Northeast or Center West regions of the Country.

⁴⁹ I am grateful to Mr Fernando Aragao da Silva Costa of Ericsson's Research and Development Centre at Indiatuba, Brazil for supplying this data.

It would be instructive to find out if R&D did increase as a result if these two incentive schemes. Data, however, are not available to track the response of telecom R&D to this law, but data are available for R&D investments in IT products (Figure 16) and this can help one to understand some broad trends. R&D investments grew at a steady rate until 1998. Investments since then show some fluctuations, but no overall growth. Specifically in the telecom industry, many foreign equipment manufacturers began to locate their R&D centres in Brazil. From my field research, it became clear that the availability of fiscal incentives under this law is cited as one of the more proximate reasons for Ericsson to establish its R&D centre in Brazil.

(e) Although the Law 8666 of 1993 was applicable to government procurement, it did not cover informatics and telecommunications. It required non-discriminatory treatment for all bidders, regardless of the nationality or origin of product or service. However, the law's implementing regulations allow consideration of non-price factors, give preferences to certain goods produced in Brazil, and stipulate local content requirements for eligibility for fiscal benefits. The procurement of informatics and telecommunications goods and services was governed by the decree 1070 of March 1994, requiring federal agencies and parastatal entities to give preference to locally-produced IT products based on a complicated and non-transparent price/technology matrix. However no further data are available on the actual implementation of this law.

(f) The most important piece of legislation, which is currently in force, and which explicitly governs the procurement of telecommunications goods is the Resolution No: 155 of 1999⁵⁰ ANATEL. Through this resolution ANATEL enacted the regulation on service contracting procedures and the purchase of equipment or materials by telecommunications service providers. This resolution provides further discipline on clauses included in the *Concession Contracts and Authorisation Terms for the provisioning of Fixed Switched Telephone Service - FSTS*, and similar clauses contained in the *Brazilian Satellite Exploitation Rights Term entered into by the Providers of Telecommunications Services* and ANATEL. As regards the Concession Contracts and Authorisation Terms, the Provider shall base its purchase/contracting decisions, with respect to the various offers presented, on the satisfaction of the objective price criteria, delivery terms and technical specifications established in the pertinent regulations.

In the event of equivalence of proposals presented by duly qualified companies, the Provider shall apply as tie-breaking criteria:

- Preference to services offered by companies located in the Brazil; or

⁵⁰ In interpreting this Resolution no: 155 I have relied on the commentary on it provided by Kujawski and Brancher (2000)

- Preference for equipment and material produced in the Brazil, among which, those with domestic technology (See Box 2).

The equivalency mentioned above will be determined when the following conditions are cumulatively present:

- The domestic price is lower or equal to the price of the imported product, placed in national territory, including the taxes incurred;
- The delivery term is compatible with the requirements of the service; and
- The technical specifications established in the pertinent regulations are satisfied, including relatively to ANATEL's certification patterns, when applicable.

The Resolution does not apply to Providers, whose legal nature is that of a public company or mixed capital company, for which specific Law governs the procedures for the acquisition of services, equipment and materials.

Box 2: Definition of concepts under the Resolution

I - Equipment and materials

Are those classified in categories I, II and III, defined in the Communications Equipment Certification Model Guidelines, approved by Resolution 47 of ANATEL's Board of Directors, of August 7, 1998, and those stipulated in the list of products for telecommunications attached to ANATEL Act 1522, of October 7, 1998.

It is possible to notice that the equipment and materials referred to in categories I, II and III are the ones subject to ANATEL's certification process. This could always work as a reference to those products subject to Resolution 155. In cases the Provider is not sure whether certain equipment requires ANATEL's certification, it is provident to file a consultation before the Agency, in order to clarify whether Resolution 155 should be adopted or dismissed.

II - Services

Are those related to research and development, planning, design, physical implementation and installation, operation, maintenance, supervision and evaluation tests of telecommunications systems.

In what concerns the definition of Services, more specifically, the extent of "telecommunication system" it was possible to verify that Decree n. 97,057/88 has defined such expression, as follows: "the gathering of telecommunication network and other components organized to the exploitation of telecommunication services."

Said Decree is no longer enforceable since it was conceived to regulate Law n. 4,117/62 (Brazilian Telecommunication Code), which was almost completely revoked by the General Telecommunication Law (Law 9,472/97). However, since this is the only legal text, which defines such term, it is important to consider it as a reference in the extent of telecommunication system.

As it can be observed, there are two expressions of such definition, which are relevant to the comprehension of telecommunications system: "telecommunication network" and "telecommunication services". General Interconnection Regulation (Resolution 40/98 - ANATEL), Article 3rd, VII, sets forth that Telecommunication Network is the gathering of continuous operational circuits and equipment, including transmission, switching and multiplex functioning or any other which is essential for the provisioning of telecommunication service.

Telecommunication Services Regulation (Resolution 73/98 - ANATEL), Article 2nd, establishes that Telecommunication service is the group of activities which enables the offering, transmission, emission or reception of symbols, characters, signs, writings, images, sounds or information of any nature, by wire, radio-electricity, optical or any other electromagnetic means.

Unfortunately, within the scope of Resolution N.º 155, it is possible to conclude that ANATEL did not adopt an objective criteria for Services definition, which could be very simply accomplished by a single list of services, as it was partially made in what refers to the definition of Equipment.

Given these facts, Telecom Service Providers shall file a consultation before ANATEL, so as to assure that a certain service is in or out of the scope of Resolution N.º 155.

III - Equipment and materials produced in the Country

Are those processed in industries established in Brazil, resulting from the plant's production line, and submitted to the assembly, part and component integration and laboratory test stages ?.

IV - Equipment and materials produced in the Country with Brazilian technology

Are those designed, developed and submitted to laboratory and field tests by technicians residing and domiciled in Brazil, who are knowledgeable and master the technologies involved, and which meet the technical and legal specifications, rules and standards prevailing in the Country.

Source: Kujawski and Brancher (2000)

According to the third article of the Resolution, for the purpose of contracting services or purchasing equipment or materials, the Telecom Service Provider shall disclose, during at least five consecutive working days, on its Internet site, the intention to undertake the purchase or contracting, clearly indicating the subject matter thereof and the place from which further information may be obtained, in order to enable presentation of offers by suppliers established in Brazil. However, the Provider will not be required to abide by the procedures established in the main provision of said article:

- a. when the contracting or purchasing amounts of the services or equipment or materials are less than one million Brazilian Reals;
- b. in cases of emergency or public catastrophe, when urgency of service is construed in a situation that may occasion damage or jeopardise the safety of persons, works, services, equipment and other public or private goods.

In case of non-compliance with the Resolution, the provider can be subject to the application of a fine of up to thirty million Brazilian Reals. Consequently, violation of any provision contained in the Resolution will be considered a serious nature infringement. It must be mentioned here that the Association of Fixed telephone providers, named ABRAFIX, filed a lawsuit before the Brazilian Federal Supreme Court, in September 1999, aiming at suspending the legal effects of Resolution. Fixed line providers feel that the Resolution causes serious delays in the Companies' purchasing/contracting process, as well as represents an illegal interference of the public power in private-owned companies. However, Court decisions so far did not concede any provisional measure to suspend the effects of Resolution although the lawsuit is still in course.

Thus it can be seen that this Resolution when properly implemented has sufficient teeth to ensure that products based domestically developed technologies will continue to have a market. However everything depends on the actual monitoring of purchase decision of the fixed line providers and also the countervailing power of certain other factors such as the availability of deferred credit facilities. This point will be seen in detail below.

(g) According to the Regulation for the Certification and Homologation of Telecommunications Equipment (Resolution 242 of November 30 2000) all the telecommunications equipment to be used in the Brazilian network will have to be certified as conforming to certain prescribed standards. ANATEL publishes a list of accredited laboratories that will perform tests required for the conformity assessment process for telecommunications to operate in the country. These organisations are called Organismos de Certificação Designados (OCD).⁵¹ They will issue

⁵¹ These OCDs are (a.) Tüv Rheinland Brasil ; (b.) Associação Ncc Certificações Do Brasil ; (c.) Fundação Cpqd ; (d.) Uciee - União Certificadora ; (e.) Fundação Vanzolini; (f.) Ipde - Instituto De Pesquisa, Desenv. E Educação; (g). Ocp-Teli - Organização Certificadora; (h).

reports, pursuant to the regulations, procedures, and rules governing the certifications and standards in force. Certificates provided by the OCDs are a prerequisite for obtaining final approval by ANATEL for the use and commercialisation of any telecommunications product in Brazil. According to this new regulation, all products classified under categories I, II and III (see details below) will need a Certificate of Technical Conformity for Telecommunication Products to enter the Brazilian Market. This certificate will also be necessary for products already in use by the time their licenses are renewed.

The three categories as defined by ANATEL are:

Category I – Telecommunications products comprising terminal equipment intended for use by the general public for purposes of accessing public-interest telecommunications services.

Category II – Telecommunications products comprising equipment not covered under Category I, but which use the electromagnetic spectrum for the transmission of signals, such as antennas and those products characterized in specific regulations as restricted radiation radio-communication equipment.

Category III – Telecommunications products comprising any products or equipment not covered by Category I and II, the regulation of which is required to –

- a) Ensure the interoperability of networks that support telecommunications services;
- b) Ensure the reliability of networks that support telecommunications services;
or
- c) Ensure electromagnetic compatibility and electrical safety.

Products already certified by the US Federal Communications Commission (FCC) are not automatically certified by ANATEL and will need to be submitted for testing by one of the designated OCDs. However, a product that already has a foreign certification may be licensed more quickly.

According to the information that I have, CPqD is the only OCD that is designated by ANATEL to certify all the products that request certification.

Ibrace - Instituto Brasileiro De Certificação ; (i.) Acta - Supervisão Técnica Independente ; and (j.) Tecpar - Instituto De Tecnologia Do Paraná.

(ii) Fiscal instruments for promoting R&D

(a) Provision of research grants for technological development of telecommunications

Although the Brazilian government had privatised CPqD, it did put in place a national fund called the Fund for Technological Development of Telecommunications (Fundo para Desenvolvimento Tecnológico das Telecomunicações–FUNTTEL). The Fund was established by Law 10,052 of November 28, 2000, in order to stimulate the process of technological innovation, enhance human resources capacity, generate new jobs and promote access by small- and medium-sized companies to capital resources, in order to amplify the competitiveness of the Brazilian telecommunications industry. Contribution to Funttel, by all telecommunication services companies, started on March 28, 2001, at the rate of 0.5% of the amount of gross operating telecommunication services revenue.

Subsequently the Decree 4733 of 2003⁵², concerning telecommunications sector development, provides for the use of FUNTTEL for R&D as well as for incentives for research institutions to develop technologies that improve access to telecommunications services. The decree also announced policy goals, to be met effective Jan. 1, 2006, concerning methods for setting and adjusting rates, billing procedures, portability of local numbers for residential and non-residential customers, defining a “locality” and clarity as to direct or indirect stockholdings by Brazilian or foreign legal entities so as to permit knowledge of the composition of the capital of the company and to verify compliance.

FUNTTEL is managed by BNDES and FINEP. Thirty per cent of its funding is to be given to CPqD. The fund became operational from the middle of 2001. So it is too early to assess its performance. Based on the initial data available (Table 12), up to the end of 2002, 16 projects were approved of which 2 belonged to CPqD. Based on the value of approved projects it could be seen that 88 per cent of the total budget could already be allocated and with a portion of the remaining projects which are under evaluation becoming successful, the total budget for the year would be successfully allocated. This rather high success rate in applications may also be an indirect measure of the innovation capability that is resident in the country.⁵³

⁵²See <http://www.natlaw.com/brazil/topical/cm/dcbrcm/dcbrcm20.htm/>

⁵³ This is of course based on the assumption that both FINEP and BNDES employ very rigorous selection criteria for choosing the research projects.

Table 12: Performance of FUNTTEL funding, 2002-2004
(Value in thousands of Brazilian Real)

| | Total FUNTTEL | Approved projects | Average funding per project | Total value of proposals received | Value of projects under evaluation | Value of projects rejected |
|------|----------------------|--------------------------|------------------------------------|--|---|-----------------------------------|
| 2002 | 166.065 | 128.788(16) | 00.775 | 174.145 (31) | 40.93 (13) | 4.445 (2) |
| 2003 | 201.860 | | | | | |
| 2004 | 224.967 | | | | | |

Note: Figures in parentheses indicate the number of proposals
Source: Ministry of Communication

As noted before, the amount of funds available under FUNTTEL is a function of the sales revenue of the service providers. Since this is bound to increase in the future, there should not be a problem for financing this scheme. Thus it is seen that the establishment of this financial instrument is yet another instrument of support imposed by the Brazilian state to maintain its innovation capability.

(b) Provision of deferred credit facilities

It is well known that the sales of equipment and machinery are not merely based on price-performance criteria, but on the availability of credit facilities. Small equipment manufacturers in developing countries do not usually have the financial wherewithal to facilitate such deferred credit facilities and this can particularly hamper the sale of products based on domestic technology. The issue is all the more complicated by the availability of bilateral credit as the Telemar- Japan Bank for International Co-operation loan episode of 2001 shows (Box 3)

Box 3: An Untied loan?

Japan Bank for International Cooperation signed (June 25 2001) at its head office a protocol for providing an untied loan totalling US\$300 million to a Brazilian telecommunications carrier, Tele Norte Leste Participações S.A. (TELEMAR). The loan will be financed by JBIC with the participation of private financial institutions. It is anticipated JBIC will have a 70% share of the total amount and the cofinancing partners will assume a 30% share. This protocol set forth the basic terms and conditions of the loan for TELEMAR, the largest telecommunications carrier in Brazil, which was founded in the wake of the divestiture and privatisation of a state-owned enterprise, TELEBRAS, in 1998. Subsequently a loan agreement will be signed after negotiations that work out detailed provisions based on this protocol. The purpose of this loan is to provide long-term financing for the expansion of fixed telecommunications networks to be undertaken by TELEMAR in the northern, north eastern and south eastern regions of Brazil. Specifically, the project includes installation of communications cables, construction of exchanges, bases and data centers. The ratio of fixed telephones to the population remains low in Brazil. At the end of 1999, this ratio was 16.8% compared with 40% in the industrial countries (and 50% in Japan). And this figure is by no means high even relative to the comparable figures in the neighbouring countries such as Argentina and Uruguay. Meanwhile, as the Brazilian telecommunications industry is heading for liberalisation in 2002, all the domestic carriers have a strong desire for capital investment to bolster their business operations. It is against this background that TELEMAR is planning extensive capital investment in fiscal 2001. The proceeds of this loan will finance part of its planned capital investment this fiscal year. This loan will help Brazil in its effort to expand domestic telecommunications networks, which form the basic economic infrastructure, thereby contributing to the country's economic development. *The loan is also expected to assist Japanese firms, which have direct investment in Brazil, to foster their smooth and efficient business operations. The loan is further expected to give such Japanese firms the opportunities for participating in competitive tenders for TELEMAR's procurement of equipment and services in its future capital investment.* Thus, the loan will be extended as part of "Japan's Comprehensive Co-operation Package to Address the International Digital Divide," an initiative announced by the Government of Japan at the Kyusyu-Okinawa Summit in July 2000.

Source: Japan Bank for International Corporation Press Release NR/2001-11

It must be noted, however that between 1999-2002, BNDES put in place a credit facility known as the "Programme for Support of Investments in Telecommunications". Over two-thirds of the amount sanctioned under this credit facility has gone towards purchase assembly and installation of equipment by both fixed line and cellular providers (BNDES, 2000).

c) Tariff Protection

Although Brazil joined the World Trade Organisation (WTO) in 1995 it has yet to sign the WTO's Information Technology Agreement that reduces tariffs on information and communications products to zero. The average import duty for telecommunications equipment

is 15-17 percent, although it is expected to come down over time (the average mean applied tariff for all goods was 11.8 per cent in 2002). In switching equipment it ranges from 8-21 per cent in 2003 and is expected to decrease to 8-16 per cent by 2006. This lower tariff means that Brazilian telecom equipment industry will have to increasingly compete with foreign imports as seen earlier in Figure 10, imports of switching and other telecommunication equipment have shown significant increases during this period.

Thus it is seen that Brazil's efforts to maintain its innovation capability through the operation of legal and fiscal instruments are sometimes effectively challenged by the availability of bilateral credit and the continued reduction in import duties. This may become accentuated as the country gets effectively absorbed into NAFTA.

7.0. SUMMING UP

This paper focused on identifying the direction of movement of Brazil's innovation capability in telecommunications equipment industry especially during the post privatisation phase and then discussing the instruments put in place by the Brazilian state to maintain this capability against heavy odds to the contrary. My discussion showed that the main actor in Brazil's sectoral system of innovation for telecommunications, namely CPqD, is learning to respond to the changes in its external environment in a rather admirable fashion. Apart from attempting to maintain its traditional innovation capability in switching equipment by progressively migrating to NGN switches and transmission equipment, it has sought to build considerable capabilities in actual manufacturing and marketing- two elements of larger technological capability that it did not previously have. Further, conscious efforts have also been made to tap the growing telecom services market and especially in telecom software. However this learning experience has been to a certain extent adversely affected or constrained by two external factors, namely the bust in the world telecommunications industry and the phenomenal growth of mobile communications within Brazil. The latter factor may adversely affect its future growth possibilities, although the lab appears to be conscious of this scenario.

At the same time, the Brazilian state has put in place or continued, under severe external constraints imposed by WTO and other trade agreements, with a number of legal and fiscal instruments to maintain this innovation capability. The instruments while laudable are sometimes vitiated by other factors such as the availability of deferred credit facility especially under the umbrella head of bilateral credit and continued reduction in tariff protection. Although far from being perfect, the innovation system is responding positively to cope with the ill effects of globalisation and that is indeed a lesson for other developing countries that are attempting to do similar capability maintenance. The best way to assess the Brazilian experience is to compare it with the Indian one (Table 13). While on a number of parameters, including their external environment, the two experiences are comparable, the Brazilian experience seems to hold much more promise for success in the future.

Table 13: Comparison of Brazilian and Indian R&D initiatives in Telecommunications Technology

| | Brazil | India |
|--|---|--|
| | CPqD | C-DOT |
| 1. Year of establishment | 1976 | 1984 |
| 2. Mode of organisation | <ul style="list-style-type: none"> • Two phases • Phase 1: 1976 to June 30 1998: Stand alone public laboratory. Technology developed by the lab is transferred to Brazilian private sector companies at nil rates of royalty • Phase 2: July 1 1998 onwards: Private Foundation. It consists of the central laboratory, two manufacturing companies and two service oriented companies | <ul style="list-style-type: none"> • Stand-alone public laboratory. Technology developed is licensed to Indian public sector enterprises and private sector laboratories at a price (royalty plus technical know-how fees) |
| 3. Annual budget (Average amount in US \$ during 1992-2002) | <ul style="list-style-type: none"> • US \$ 81 million (<i>Ratio of CPqD 's R&D budget to the R&D expenditure of Ericsson in 2002- 0.0179</i>) | <ul style="list-style-type: none"> • US \$ 21 million (<i>Ratio of C-DOT's R&D budget to the R&D expenditure of Ericsson in 2002- 0.0047</i>) |
| 4. Mode of financing | <ul style="list-style-type: none"> • Phase 1: 100 per cent research grants from its parent telecom service provider, Telebras • Phase 2: 70 per cent self generation through sale of technology and services; 30 per cent research grants from the government. Has now beginning to learn to stand on its own feet. | <ul style="list-style-type: none"> • 100 per cent research grants from its parent and the main telecom service provider, the Department of Telecommunications. But cumulative royalties received (1984- 2002) account for 25 per cent of the total cumulative grants received. Royalties received in 2002 accounted for 75 per cent of the total budget of the lab. Can stand on its own feet |
| 5. Number of R&D scientists and engineers (as of 2002) | <ul style="list-style-type: none"> • 469 (41 per cent of total employees) | <ul style="list-style-type: none"> • 780 (62 per cent of total) |

| | | |
|--|--|---|
| 6. Main areas of technological strength | <ul style="list-style-type: none"> • Family of digital switching systems of varying capacities best suited to Brazilian conditions. • Has a clear strategy for migrating to New Generation Network Switches • Optical Networking Products • Telecom software development | <ul style="list-style-type: none"> • Family of digital switching systems of varying capacities best suited to Indian conditions, especially in the smaller Rural Automatic Exchanges. Sizeable amount of this have been exported to other developing countries • Could be credited with the development of the telecom equipment manufacturing industry in India • No telecom software manufacturing on its own, but has jump started the development of the telecom software industry in India in an indirect manner. Telecoms software now accounts for approximately 14 per cent of total software exports, which itself is growing very rapidly, from India. |
| 7. Capability in mobile telecommunications technology | <ul style="list-style-type: none"> • Weak. Traditional strength only in Fixed Telephony. No clear strategy. Appears to have lost out to MNCs | <ul style="list-style-type: none"> • Weak. Traditional strength only in Fixed Telephony. No clear strategy. Appears to have lost out to MNCs |
| 8. Patenting record and exports (cumulative since inception) | <ul style="list-style-type: none"> • 109 patents were granted within Brazil and 50 were granted abroad. No major exports. | <ul style="list-style-type: none"> • Patenting record is not known. But considerable exports of the smaller capacity exchanges to nearly 22 developing countries |
| 9. Instruments of state support | <ul style="list-style-type: none"> • Fiscal instruments for supporting R&D • Legal instruments for continuing to assure a potential markets for its technology within the domestic economy | <ul style="list-style-type: none"> • Fiscal instruments for supporting R&D; Ambiguous and ambivalent stand of the Ministry of Finance with respect to continuation of this strategy. Laboratory risk being closed down. • Public procurement under strain owing to privatisation of telecom services |
| 10: Future scenario | <ul style="list-style-type: none"> • Learning to adjust to the external environment characterised by increased competition from MNCs and freer imports | <ul style="list-style-type: none"> • Struggling to exist. Much dithering on the part of the government. Several attempts on its very existence by the government. No clear government policies despite being very competent in coping with MNC competition and imports. |

Source: Own compilation based on Mani (2003)

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