

Working Paper
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PUBLIC R&D PROJECTS IN
TELECOMMUNICATIONS
TECHNOLOGIES IN DEVELOPING
COUNTRIES**

Sunil Mani

November 2004

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I acknowledge with thanks the support that I received from United Nations University-Institute for New Technologies, Maastricht, The Netherlands towards preparing this paper. However the paper is written after I joined the faculty at Centre for Development Studies, Trivandrum, Kerala, India. Thanks are due to V. Santhakumar for comments on an earlier draft. The usual disclaimer holds good.

ABSTRACT

The paper focuses on the response strategies of public research systems in various advanced developing countries (Brazil, India and Korea) to specific challenges posed by increasing integration of their respective host economies with rest of the world. These challenges have dented holes in the traditional support mechanisms for supporting such public R&D projects. The traditional support mechanisms had two integral components: (i) supporting the organisation and conduct of these public R&D projects through the provision of targeted research grants and other fiscal incentives; and (ii) providing an assured market for the output of these R&D projects through subscription to public technology procurement. Admittedly increasing deregulation and economic liberalisation meant that it has become very difficult to continue support public R&D projects through these traditional support instruments. The new international governance rules imposed by multilateral agencies such as the WTO on R&D subsidies and government procurement have added further constraints. Most developing countries, consequently, cop out while a few have managed to put in place, albeit through an iterative process, ingenious support instruments that can continue to facilitate such public R&D projects. The paper surveys these various ingenious, but credible instruments that serve as an important lesson for other developing countries which are in exactly the same situation. In short the paper focuses on practical policy concerns that can easily be replicated elsewhere in the developing world.

Keywords: innovation capability, R&D policy, telecommunications equipment industry, telecom software exports, public technology procurement, Brazil, India and Korea

JEL Codes: L63, O31, O32, O38

Introduction

Developing countries typically import technologies from firms in the north. Given the location specificity of technology meant that borrowed technologies may have to adapted local conditions. Otherwise the process of technology transfer is deemed to be unsuccessful and not contributing to development of technological empowerment of sorts in the importing country. Experience has shown that some technologies than others are very difficult to be adapted to local conditions in view of their complexity. Telecommunications technologies fall into this category. Brazil, India and Korea are three such developing countries which had initiated large publicly funded R&D projects for developing modern state-of-the-art telecommunications technologies that are consistent with the usage pattern prevailing in their respective home countries. The strategies employed by these countries were identical: set up stand alone public laboratories which developed modern digital switching technologies and then transfer these to domestic private and public sector enterprises. All the three countries have had varying degrees of successes with the development and transfer of these complex technologies. On the contrary, China appears to have followed a totally different strategy of locating the R&D project in an enterprise and then supporting this enterprise to grow larger and stronger. The increasing external integration of their telecom economies, the deregulation or privatisation of telecom

services and the phenomenal growth of mobile telephony all implies that this traditional strategy of technology development through public R&D has come under severe threat in all these countries. And the countries have responded to these strategies in different ways. In the present paper, the vastly differing responses in strategies, of three of the countries namely Brazil India and Korea, to cope with the challenges posed by globalisation, in a systematic and comprehensive manner, is attempted. The study focused on identifying the direction of movement of innovation capability in telecommunications equipment industry in all the three countries especially during the post privatisation phase and then discussing the instruments put in place by the countries to maintain this capability against heavy odds to the contrary. These instruments could broadly be 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. However the existence of certain other factors such as the availability of deferred credit facility especially under the umbrella head of bilateral credit and continued reduction in tariff protection have sought to vitiate or nullify the positive effect of these instruments. The ensuing analysis shows that while the Brazilian innovation system is learning to adjust to the changes in its external environment the Indian one is struggling to exist and the Korean one is marching forward. The main policy conclusion that emanates from the study is that sectoral systems of innovation can be dynamic and self-sustaining if and only if the firms (which actually manufacture and sell the equipments employing the technologies developed locally) are made central to it.

The paper is structured into six sections. The first section delineates the conceptual framework used in the study and identifies the main research questions. The second section surveys the main structural

changes in the world telecommunications equipment industry and draws out the implications of these changes for public research systems in developing countries. The third section presents some basic facts about the telecommunications industry in Brazil, India and Korea. An index for measuring changes in the innovation capability of the industry is presented in the fourth section. Employing the index the section also analyses the changes in innovation capability of the telecommunications equipment industries of Brazil, India and Korea. The fifth section contrasts the instruments of state support put in place by these countries to maintain and progress with innovation capability. The sixth section concludes with a speculation on the future scenario for the sector in each of the three countries.

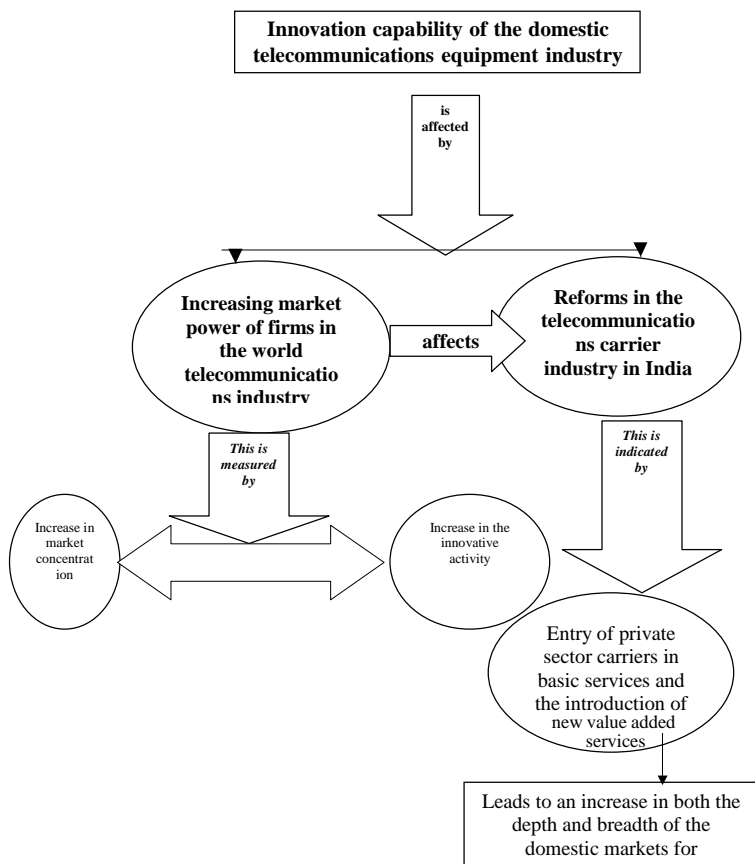
I. Conceptual framework: The study employs a sectoral system of innovation perspective (Edquist, 2003). The innovation systems for telecommunications consist of four main components. The first component is the government which provides the overall policy framework within which innovative activities are carried out by firms and research institutions. The in-house R&D centres attached to business enterprises and government research institutes constitutes the second or the most important component of the innovation system. The telecom services providers, both fixed and mobile, constitutes the third component. In very many cases it is the service providers which have actually financed the innovative efforts of firms and government research institutes. The agencies dealing with standards and regulatory issues form the fourth component. It is the complex interaction of all these four agents that results in innovation in equipment production.

II. Structural changes in the World telecommunications equipment Industry

It was argued by Mani (1995) that the innovation capability of developing countries in areas of high technologies such as

telecommunications equipment sector are influenced in a significant manner by not only the domestic policies and support systems which favour such activity but also by the external environment. In current times, this external environment has two main components (Figure 1). First is the pressure exerted by powerful MNCs. These MNCs have become more powerful in the period since the mid 1990s and this can be measured in terms of one indicator namely increase in the market power of the MNCs which in turn is measured by their hold over the market for their products and secondly in their ability to make rapid technological innovations. The second component of the external environment is the deregulation of the telecom network or carrier industry (or the distribution of telecom services segment). This part of the industry used to be the exclusive preserve of a state-owned monopoly, but has been gradually opened up to private sector carriers. Consequent to this the market for telecommunications equipment has widened and many value added services, which were hitherto not available, has been introduced for the first time. The new private sector carriers (some times these too are affiliates of MNCs) would like to purchase state-of-the-art equipments from abroad. Given this, despite the possible increase in the size of the domestic market, the domestic telecommunication equipment vendors may face tough competition from international vendors. Thus faced with increasing competition, it is possible that the innovative capabilities of the domestic agencies are adversely affected. Towards understanding this line of argument, I first present the changes in the world telecommunications equipment industry to show that the market power of the various firms in the industry has increased significantly in recent time.

Figure 1: External environment obtaining to the domestic telecommunications equipment industry



Source: Own compilation

The international telecommunications industry has been in a state of flux especially after the burst of the telecom bubble in 2000. The industry has become so complex that it is convenient to invoke a "layer model" to understand what we mean by the telecommunications industry in the present century. Fransman (2002) divides the evolution of the

Table 1: Characterisation of the old and new telecommunications industry**Layers of the Old Telecom Industry Layers of the New Infocommunications**

Layer	Activity	Layer	Activity	Example Companies
III	Service Layer (voice, fax, 0800 services)	VI	Customers/consuming	
II	Network Layer (circuit-switched network)	IV	Application Layer, including contents packaging (e.g., Web design, on-line information services, broadcasting services, e-commerce etc)	Bloombergs, Reuters, AOL-Time Warner, MSN, Newscorp
I	Equipment Layer (switches, transmission systems, customer premises equipment)	III	Navigation & Middleware Layer (e.g., browsers, portals, search engines, directory assistance, security, electronic payment, etc)	Yahoo, Netscape, Vizzavi, Google, Genie etc.,)
TCP/IP Interface				
		II	Network Layer (e.g. optical fiber network, mobile network, DSI, local network, radio access network, Ethernet, frame relay, ISDN, ATM. Etc)	AT&T, BT, NTT, WorldCom, Qwest, Colt, Energis, Vodaphone, NTT DoCoMo etc
		I	Equipment and Software Layer (e.g. switches, transmission equipment, base stations, routers, servers, CPE, billing software etc)	Nortel, Lucent, Cisco, Ericsson, Nokia

Source: M.Fransman, <http://www.TelecomVisions.com>

industry into two separate phases: the old-telecoms industry up to the mid 1980s and the new telecoms industry which was born towards the beginning of the 1990s. Employing a layer model he identifies the main differences between the two phases. The new telecoms industry is very often referred to as the infocommunications industry. See Table 1 for a characterization of the old and new industries.

The model helps us to understand the evolving structure of the telecommunications industry. In the present paper, our concern is primarily with the first two layers of the new infocommunications industry. There are at least two trends in the industry that is worth noting, namely (a) the industry is becoming very oligopolistic consequent to a wave of mergers and acquisitions; and (b) there has been significant increase in the innovative activity of these enterprises. These two trends put together have meant that telecom manufacturers and research agencies in developing countries have been completely dwarfed by these developments.

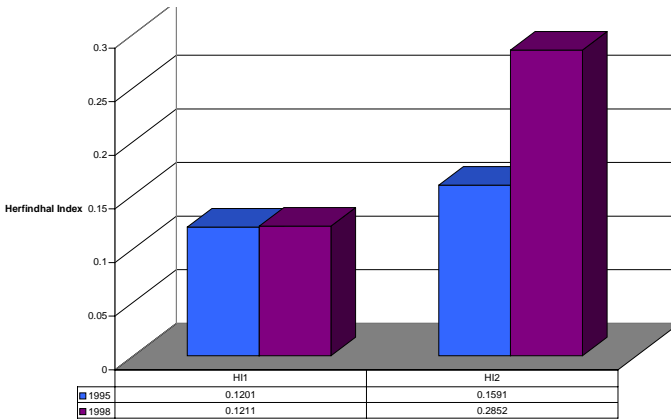
(a) The World telecoms equipment industry is becoming more oligopolistic over time

Owing to its natural monopoly status the telecommunications industry (especially the network or carrier segment) has always been monopolistic. The recent wave of liberalization of the industry has sought to make the industry more competitive in terms of increasing the number and size distribution of firms constituting the industry. While there has been some deconcentration of the carrier segment across the world, the degree of concentration in the equipment sector has increased significantly. This is an interesting finding as the equipment sector was largely in the private sector across the world excepting in some developed and most developing countries. In order to measure the degree of concentration over time, I employ the familiar Herfindhal Index

(H-index).¹ Even the equipment sector is not a homogeneous one: it can be decomposed into at least three segments, namely switching, transmission and terminal equipment segments.

Based on this, I define two variants of the H-Index. The first one to be denoted as H_1 measures the degree of concentration in the whole equipment industry and the second one to be denoted as H_2 measures the degree of concentration in just the switching equipment segment. Based on the data provided in Dorrenbacher (2000), the two variants of the H-Index have been computed for 1995 and 1998. See Figure 2.

Figure 2: Degree of concentration in the world telecommunications equipment sector, 1995 and 1998



Source: Dorrenbacher (2000)

The following inferences can be drawn:

- The level of concentration in the overall telecoms industry has virtually remained the same over the two periods under consideration;

1. This index is computed by summing the squared market shares of all the firms in a specific industry. The index ranges from zero to one, and higher the value of the index higher is the degree of concentration.

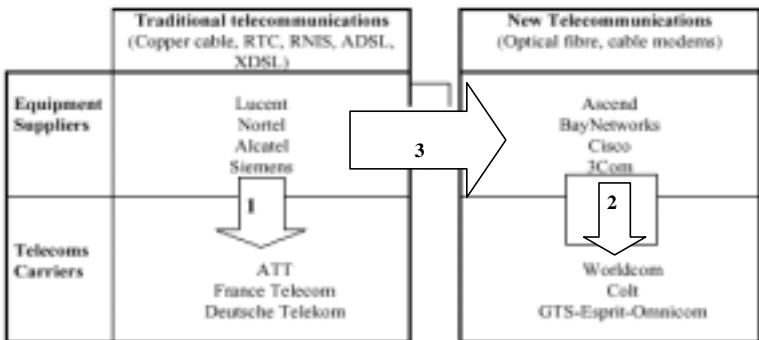
- However the level of concentration in the switching equipment industry has registered a significant increase of about 79 per cent. In fact in 1998, the top four firms in the industry, namely Lucent, Ericsson, Alcatel and Nortel accounted for about three quarter's of the total switching equipment sales in the world.
- Also the level of concentration in the switching equipment segment has always been higher than in the overall industry.

In fact through a recent wave of mergers and acquisitions, the traditional equipment suppliers whose core-competencies and activities are in switching and transmission for traditional telecommunications infrastructures have extended their control over the new equipment suppliers whose core competencies are in switching and transmission for new telecommunications infrastructures. Thus the leading switching equipment manufacturers such as Lucent, Alcatel and Nortel have not only consolidated their position in their traditional fields of competence but also have amassed considerable technological and market clout in the new technologies. Thus the traditional equipment companies have become even more formidable as they have access to a wide variety of markets. Gaffard and Krafft (<http://www.wu-wien.ac.at/inst/vw1/gee/emaee/emaee0~1.pdf>, Accessed on 19/11/02) have mapped out this complex vertical integration strategy of the traditional equipment manufacturers (Figure 3). According to them the different arrows contribute to explain the different stages of evolution of the vertical structures between telecommunications carriers and equipment suppliers.

They identify three stages in the evolution of vertical structures in the industry. In the first stage, represented by Arrow 1, describes the initial situation when the traditional equipment suppliers at the upstream level have only one category of customers, namely the

telecommunications carriers at the downstream level². The second stage is represented by Arrow 2 and it represents the role played by the new telecommunications equipment suppliers on the entry of new firms at the downstream level. Finally in the third and final stage represented by Arrow 3 represents the merger strategy of the traditional equipment suppliers to have access not only to the core competencies of new equipment suppliers but also to extend their share of the new market created by the new carriers. In short the world telecommunications equipment industry have become more oligopolistic and thereby increased its market power by a considerable measure.

Figure 3: The characteristics and evolution of vertical structures in telecoms industry



Source: Gaffard and Krafft, <http://www.wu-wien.ac.at/inst/vw1/gee/emaee/emaee0~1.pdf>

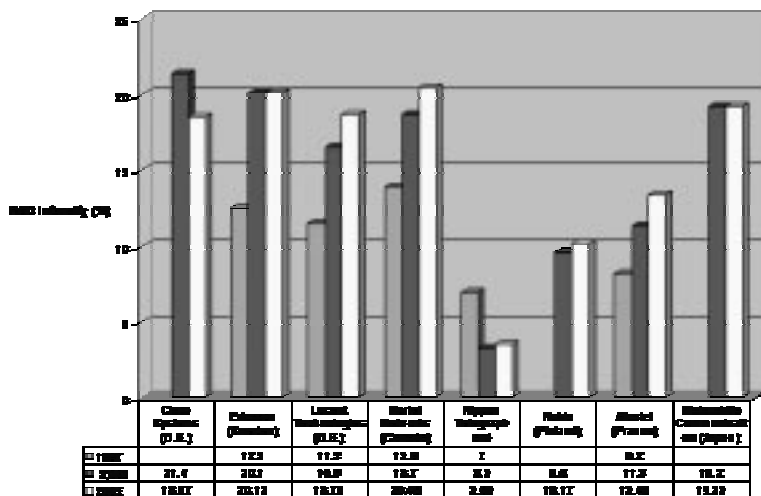
(b) Innovative activity in the world telecom equipment industry has increased significantly

Telecommunications equipment industry is one of the most research intensive industries in the world. The research intensity of the

2. During this time both ATT and Lucent is the same company.

sector has averaged over 7 per cent of the sales revenue per year³. I measure the innovative activity of the sector in terms of two standard indicators, namely an input indicator such as R&D expenditure (Figure 4) and output indicator such as the performance of these companies with respect to patenting (Table 2). Both the indicators show that there has been significant increase across the board in the innovative activity of these enterprises especially during the period since the mid 1990s. An interesting feature is the fact that the increase in the number of patents secured by all the companies is better than their performance with respect to R&D investments.

Figure 4: R&D expenditure of leading world telecommunications equipment manufacturers, 1997-2003



Source: MIT Technology Review (2004)

3 While the R&D-to-sales ratio reflect the relative tendency of companies within an industry to devote their own resources to R&D activities, they do not reflect the additional resources provided by governments that increase the actual amount of R&D performed. Such governmental support for R&D varies by industry to

Table 2: Patenting performance of world telecommunications equipment manufacturers, 1998-2000 (Number of patents granted in the USA)

	1998-99	2000
Lucent	881	1443
Motorolla	1193	1241
Ericsson	320	775
Cisco	25	133
Alcatel	285	423
Qualcom	63	111
Cabletron	17	41
Ciena	6	26
JDS Uniphase	36	52
Qwest Communications	33	29

Source: MIT Technology Review (2004)

Based on the data presented in the two tables, it could safely be concluded that the leading telecom equipment manufacturers have not only increased their share of the market but also of their control over the technology.

From the above analysis, the following points emerge: (i) The world telecommunications equipment industry is becoming more oligopolistic; and (ii) the industry is becoming more innovative and hence more powerful. It is against this background that one has to analyse the innovative behaviour of relatively speaking small public research organisations in the developing world.

industry. But since telecommunications equipment industry has many dual applications, both in defence and civilian, situations, they are very likely to receive large doses of governmental funding. Therefore, any study of the broader question of how much total R&D is performed by industry would require supplemental data on governmental support which is very often difficult to obtain. I have obtained an average of 7 per cent by taking the average R&D to sales ratio of all the U.S communications equipment industry during the 11 year period 1986 through 1996. Given the fact that most of the telecommunications equipment firms are U.S based this is a very plausible assumption to be made. See National Science Foundation (1999).

III. The three cases for in depth examination

Brazil, Korea and India are three developing countries, which attempted to establish large public R&D systems in their respective host economies to create new technologies in especially telecommunications technologies. Although the three countries differ from each other on many grounds, there are at least two points on which they are roughly similar. First all, three of them followed the same strategy of establishing a large public R&D laboratory to generate local capability in design and manufacture state-of-the-art telecom switching equipments and then transfer the technology to local public and private sector enterprises. Second, all three of them have a sizeable domestic market for telecommunications equipments, which is fast growing as well (Table 3). On these grounds all the three cases are eminently suitable for an

Table 3: Main features of the telecommunications sector in Brazil, India and Korea

	Brazil	India	Korea
• Population (Millions, 2001)	172.39	1048	47.34
• Per capita GDP (PPP Current International 2001)	7360	2840	15090
• Number of Fixed telephone lines (in million, 2004)	38.91 (22.52)	43.82 (4.40)	23.26 (49.13_)
• Number of mobile telephone subscribers (in million, 2004)	34.88 (20.23)	42.97 (4.30)	32.34 (68.31)
• Size of telecommunications services market (in millions of US \$, 2002)	20990	5665	22663
• Domestic production of telecommunications equipment (in millions of US \$)	4395	3176	26778

Notes: Figures in parentheses indicate density of telephone per 100 people.

Source: Own compilation

Table 4: Relative rate of investment in telecommunications in Brazil, Korea, India

(Telecom investment as a percentage of Gross Fixed Capital Formation)

	Brazil	Korea	India
1986	2.42	5.57	1.27
1987	2.29	3.55	1.47
1988	2.43	3.31	2.39
1989	2.78	4.24	2.53
1990	2.31	3.16	2.24
1991	4.12	2.87	2.49
1992	4.42	2.73	2.90
1993	3.65	2.66	3.19
1994	3.31	2.67	3.06
1995	3.05	2.43	2.83
1996	4.55	3.05	2.57
1997	4.32	4.84	2.51
1998	6.83	4.74	2.53
1999	6.52	6.24	3.01
2000	7.87	5.93	3.45
2001	6.69	5.81	
2002	6.10	5.10	3.30

Source: Computed from International Telecommunications Union (2004)

in-depth comparison of their differing experiences in the creation and maintenance of innovation capability in telecommunications equipments. Further I make a comparison of the three countries on five dimensions of their respective telecom economies. They are: (i) the relative rate of investments in telecommunications industry; (ii) the growing importance of mobile communications; (iii) declining importance of public switching in Brazil and Korea; (iv) relative size of telecom equipment industry in relation to the services segment; and (v) structural changes in the services segment of the industry in all the three countries.

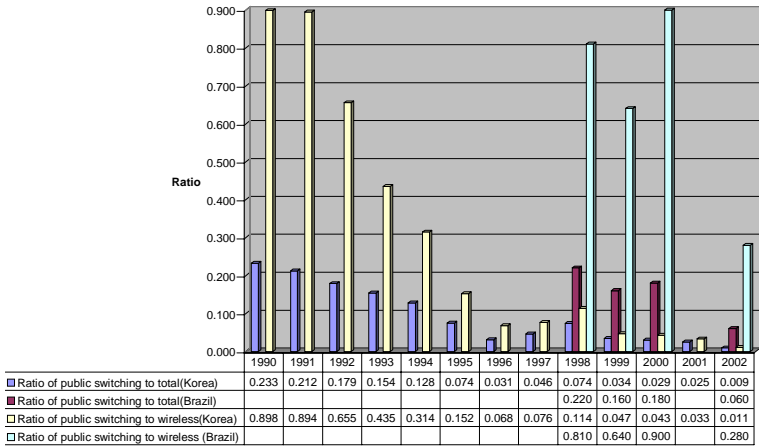
(i) Relative rate of investments in telecommunications: Both in Brazil and India investments in telecommunications were not given due importance during the early period up to the 1990s (Table 4). In Brazil the investments

in telecommunications as a percentage of gross fixed capital formation shot up to 6 per cent per annum since 1998 consequent to privatisation: it used to be only 4 per cent per annum in the period up to privatisation. In India the situation was even worse off with telecom investments averaging just about 2 per cent of overall investment. This has since been reversed with relative investment touching a little over 3 per cent. This low investment in telecommunications manifested itself in the form of low teledensities, an ever-burgeoning waiting list for new telephone connections and a long and growing waiting period for these new connections. All these were set to change with the privatisation and deregulation of services in late 1990s. Korea, on the contrary, has a better history of telecom investments, although the relative rate of investment had come down to about 2 per cent during much of the first half of the 1990s.

(ii) Growing importance of mobile communications: An important feature of telecommunications services segment across the world is the relative faster growth of mobile communications compared to fixed telephony. This general trend is reflected in all the three countries as well (Table 5). Of the three, the ratio of mobile communication to fixed telephony has crossed unity much earlier in Korea in 1999 itself followed by Brazil in 2003 or so. The important point is that mobile communications is going to be very important in all the three countries and so a mastery over mobile communications technology is likely to be a major asset. Of the three, as will be discussed below, it is only Korea, which has this competence.

(iii) Declining importance of fixed line public switching: As a corollary of the above there has been a decline in the relative production of public switching equipments in all the countries⁴ (Figure 5). This once again,

4 Since data on public switching production is not easily available for India, the analysis here is restricted just to Brazil and Korea. But my understanding is that it holds good for India as well.

Figure 5: Declining importance of public switching, 1990-2002

Source: Computed from Mani (2004 a) and Mani (2004b)

has important implications as in all the countries considerable capacity had been built up only in fixed line switching technology excepting for Korea where considerable capacity has been built up in mobile switching and handsets as well. So this decline in the importance of public switching

Table 5: Growing importance of mobile communications in Brazil, India and Korea (Ratio of mobile to fixed)

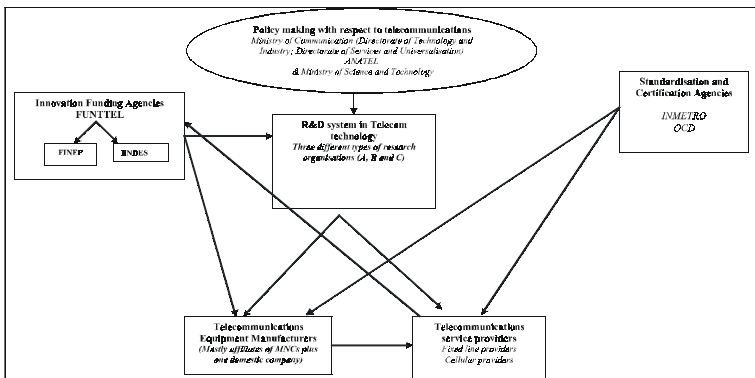
	Brazil	India	Korea
1996	0.165	0.023	0.162
1997	0.267	0.050	0.337
1998	0.369	0.055	0.698
1999	0.602	0.071	1.143
2000	0.750	0.110	1.223
2001	0.768	0.167	1.278
2002	0.899	0.306	1.391
2003	0.990	0.681	1.460

Source: Mani (2003) and Mani (2004 a and b)

does not have any negative implications for Korea while it has serious implications for the research systems in both Brazil and India.

(iv) Relative size of the telecommunications equipment market: The telecommunications industry in any country has two components: manufacturing of telecommunications equipments and distribution of telecom services. In most countries there has been a phenomenal growth of the services segment consequent to the introduction of mobile telephony and other value-added services. The three countries present three different scenarios. In Korea the equipment sector has become more important than the distribution of services segment in 1997, in Brazil there has been considerable erosion in the relative size of the equipment sector while in India the equipment sector's share has more or less been maintained. This picture is quite understandable as both Korea and India have a, relatively speaking, stronger history of manufacturing telecom equipments than Brazil.

Figure 6: Present Innovation System of the Brazilian Telecommunications Industry



Source: Own compilation

(v) **Structural changes in the distribution of services segment:** The telecom services industry being the main consumer of telecom equipments is one of the main components of the innovation system. The segment has undergone a radical structural change in all the three countries (Table 6). Three issues stand out. First the sector has been completely deregulated reducing the natural monopoly status of incumbent PTTs. Although only in Brazil, the sector has been completely privatised in the sense that the incumbent PTT, namely Telebras was sold in 1998 through a major divestment exercise. In Korea although Korea telecom was privatised, it still accounts for a large share of the fixed telecom services. Finally in India, the incumbent PTT was corporatised, but continue to hold a major chunk of the market.

Table 6: Structure of Telecommunications services industry in Brazil, India and Korea (c2003)

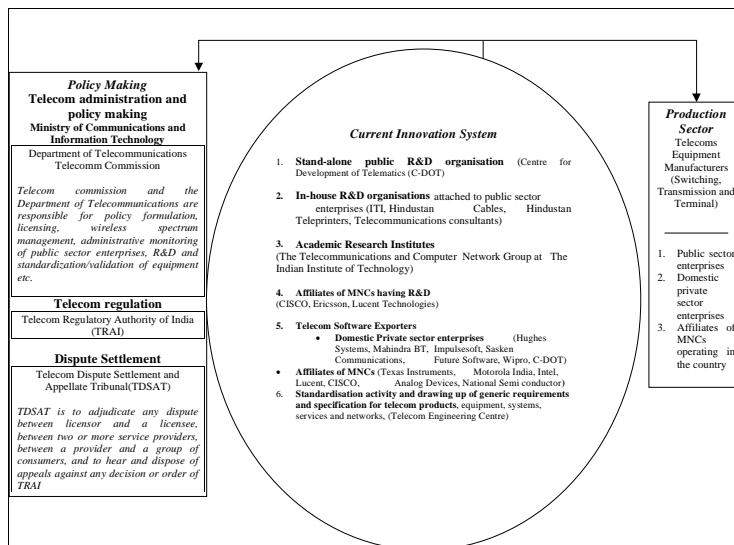
	Fixed Telephone Industry	Mobile Telephone Industry
Brazil	<ul style="list-style-type: none"> ? Industry was privatised in 1998 ? Divided into four regions ? Duopoly in each of the regions (One major player plus a mirror concessionary) 	<ul style="list-style-type: none"> ? There are five operator groups, two small regional operators and a new entrant soon in the form of Brasil Telecom.- A fractured market. <li style="text-align: center;">Market Shares, 2003 (%) ? Vivo 45.2 Claro 20.4 TIM Brasil 17.9 Oi 8.4 Telemig/ Amazon as Celular 7.3 CTBC 0.7 Sercom 0.2
India	<ul style="list-style-type: none"> Haphazard privatisation. Although the fixed market is open to competition, the market for local calls is dominated by the state-owned BSNL International and long distance incumbent VSNL (now privatised) is steadily losing market share to aggressive new entrants Reliance Infocomm, Data Access and Bharti Telesonic 	<ul style="list-style-type: none"> Market is competitive. There are five service providers: <li style="text-align: center;">Market Shares , 2003(%) Reliance: 28; Bharti: 24 BSNL: 21 Hutchison: 17 Idea: 10
Korea	<ul style="list-style-type: none"> Industry was privatised in 1997 KT Corp, the former monopolist, has a tight grip on the market. Three smaller players, Hanaro, Dacom and Thrunet have struggled to loosen KT's dominance but have made little impact 	<ul style="list-style-type: none"> Only three service providers with a dominant service producer <li style="text-align: center;">Market Shares , 2003 (%) SK Telecom: 55 KT Free Tel: 31 LG Telecom: 14

Source: Own compilation

IV. Innovation system and its performance: Post privatisation

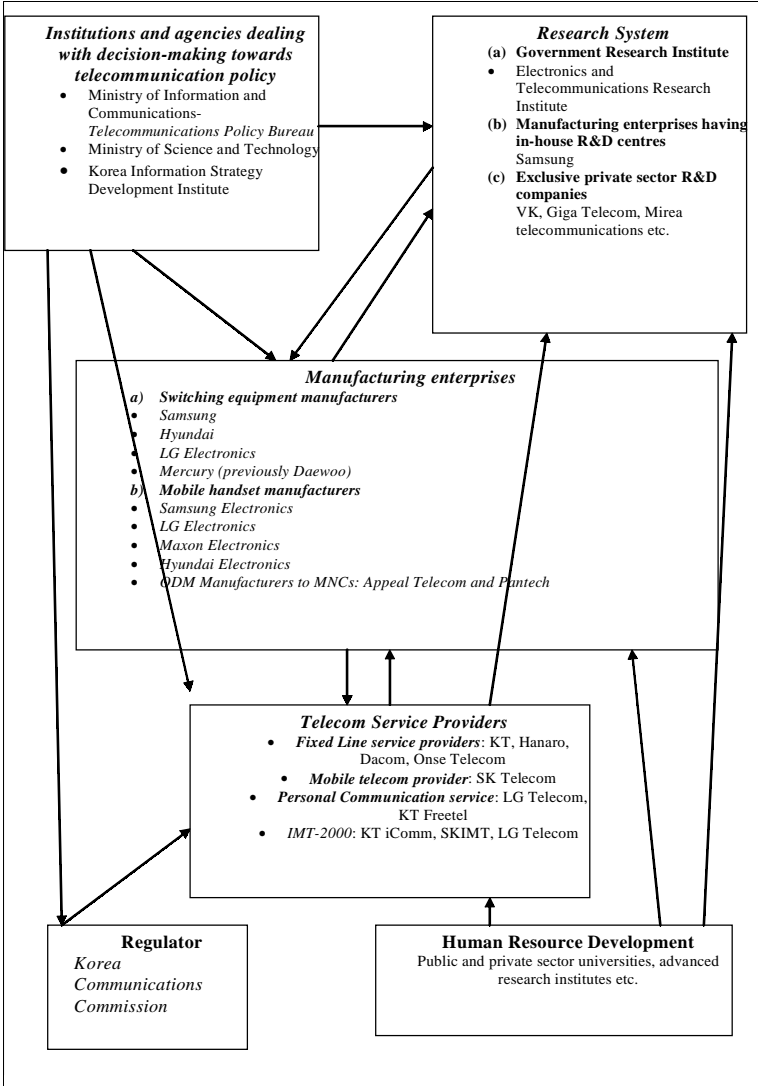
The sectoral system of innovation of all the three countries is broadly similar (Figures 6, 7, and 8). Central to the innovation system are the three public laboratories, CPqD in the case of Brazil, C-DOT in the case of India and the Electronics and Telecommunications Research Institute (ETRI) in the case of Korea. But there is one fundamental difference between Korea on the one hand and Brazil and India on the other. The main difference is in the importance and capability of manufacturing enterprises. In Korea the manufacturing enterprises too are an integral component of the innovation system and the main manufacturers all have relatively stronger in-house R&D centres. As can be seen from my subsequent discussion this meant that the Korea's sectoral system for telecommunications has been much more resilient in dealing with the negative effects of globalisation.

Figure 7: Present innovation system of the Indian Telecommunications Industry



Source: Own compilation

Figure 8: Present innovation system of the Korean Telecommunications Industry



Source: Own compilation

Following Mani (2003, 2004 a and b), the term innovation capability in a particular technology is defined as the ability to conceptualise, design and manufacture state-of-the-art telecommunications equipments and also to keep pace with changes in the world frontier in that technology. Transliterating this definition of innovation capability into measurable indicators is attempted by employing four separate but related indicators. They are: (a) two separate indices of innovation capability which measures innovation capability of both fixed and cellular telecom equipments respectively; (b) market share of domestically developed switches in the total Brazilian, India and Korean network; and (c) an analysis of patents granted to local inventors in four US patent technology classes, namely in 370, 375, 379 and 455. However due to data limitation the third indicator is computed only for Korea, while for both Brazil and India the total number of patents secured is indicated; and (d) other indicators of innovation capability. This is presented only for India.

(a) Index of innovation capability: There are two such indices: Index of innovation capability in fixed telephone equipment, IICFT and Index of innovation capability in mobile telephone equipments, IICMT. They are computed as follows:

$$IIC_{FT} = \frac{\text{Domestic production of public switching equipments} * 100}{\text{Domestic production} + \text{Imports-Exports of public switching equipments}} \quad (1)$$

$$IIC_{MT} = \frac{\text{Domestic production of wireless telecom terminals} * 100}{\text{Domestic production} + \text{Imports-Exports of wireless telecom terminals}} \quad (2)$$

Where wireless telecom terminals is composed of cellular phones + PCS+ IMT-2000 terminal+ TRS terminal.

While (1) is computed for all the three countries (2) is done only for Korea. A few further comments about the indices are in order, given the quality and availability of data at individual country levels. In the case of Brazil, (1) is computed in a slightly different manner. Hence I have adapted the index to suit the specificities of the Brazilian case where the total demand for switching equipments is met through both domestic production and imports. Domestic output emanates from domestically developed technologies and from imported technology by affiliates of MNCs. . Equation 1 a explains this further:

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

Where

$IICv$ = Index of innovation capability based on value terms

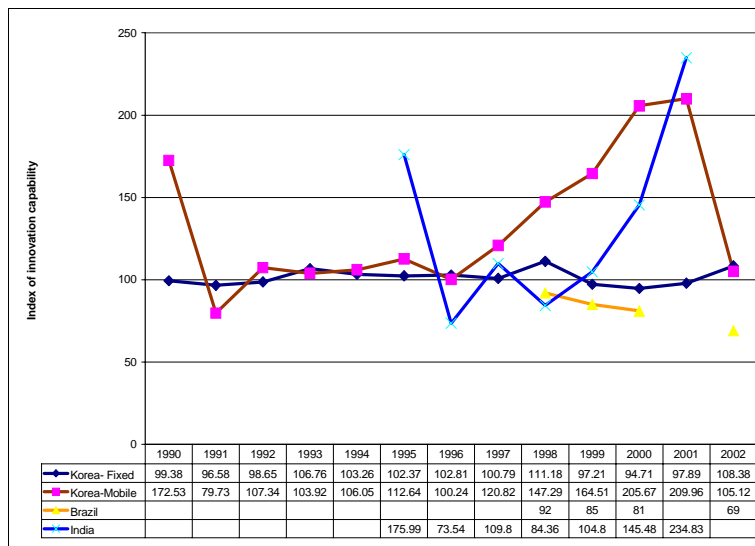
P_d^s = Domestic output of switching equipments in value terms.
This data are taken from Vainsencher (2003)

I^s = Imports of switching equipments

E^s = Exports of switching equipments

Both the import and export data are taken from the UN 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

Figure 9: Index of innovation capability in Brazil, India and Korea, 1990-2002



Source: Mani (2003, 2004 a and b)

equipments to a country⁵ : switching equipments, on an average accounted for only 18 per cent of imports and 36 per cent of total telecommunications equipment exports. Based on the data and using equations (1) and (1a), index of innovation capability is computed and is presented in Figure 9.

Before interpreting the Figure, it is important to state two major limitations of the index. First, it is rather difficult to interpret short-term movements in the index. Second, the index is defined in terms of

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

production figures, and not in terms of number of working connections: problems in domestic production may bring down the value of the index for that year, but this may not mean that the innovation capability is decreasing. It is important that one should be using the index to form an informed opinion about the over all movements in innovation capability over a period of time. In other words the index is not robust enough to track year to year movements in innovation capability. But I argue that this will only affect the level of the index and not its direction of movement. This will become clearer when one analyses the actual market share of domestically developed switches in the total network. The performance of the three countries with respect to this index is discussed below:

Korea: Korea has innovation capability in both fixed and mobile telecom equipment although its capability in mobile equipments appears to be stronger than in fixed telephones. The successful implementation of both the TDX digital technology in fixed telephones and CDMA technology in mobile telephones are clearly reflected in the upward movements in both the indices.

Brazil⁶: The index 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 scattered

6 There are, however, three important caveats. Firstly, as mentioned before data on domestic output (namely P_{dt}^s) 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. This data, however are not easily available. Hence we are interested in only the broad trends in the movement of the index. Secondly, even the data on domestic output of switching equipments are available only for the period since 1998. Thirdly, it is very likely that the import data (especially) on switching apparatus⁸ includes both fixed line and mobile switching centres as well. Once again ideally speaking a break up of the two is needed and in very specific terms one should be using only the import data on fixed line switching.

evidence that is available (to be seen in detail below) installed capacity based on domestic technology at no time in the history (precisely during the 1976-2003 period) was more than 30 per cent of the total installed capacity for switching equipments 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 even though the market share of domestically manufactured switching equipments (in total consumption) have suffered a decline especially with increasing imports, the relative share of switching equipments manufactured with domestic technology has continued to maintain its previously acquired share at about the same level. Since precise data on this share especially during the 1998-2003 period is not available, a fall in the IICV 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 have indeed responded to these challenges and have put 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. Even though imports of switching equipments have been increasing during the 1990s, much of the increases have happened during the pre privatisation phase (1991-1997). The average rate of growth of imports during this period was 49 per cent per annum as compared to only 22 per cent per annum during the post liberalisation phase (1998-2001)⁷. Much of this increase in the pre privatisation phase

7 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.

might have been contributed by the phenomenal growth of mobile telephony. Once again it may not be very prudent, therefore, to link the increases switching equipment imports to privatisation of telecom services in the country. It is interesting to note that there has been some switching equipment exports, although it has tended to come down 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 broken 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.

India: Excepting for the initial year, the index has been showing a continuous rise over time implying a rising capability. This finding is quite significant as this has been happening at a time when the industry was going through a flux: the service segment was getting deregulated and MNCs were entering the equipment industry. So despite these factors which can militate against the usage of domestically designed switches one sees a systematic and continuous increase in its market share. This could largely be explained by the public technology procurement policy of the largest consumer, the Department of Telecommunications (DoT).

(b) Market share in the telecom network

The share of domestically developed switches in the total network range from 32 per cent in the case of Brazil to about 75 per cent in the case of Korea (Table 7). In all the three countries domestically developed switches are used primarily in the local call segment of the services industry. In India an irregular import of switching equipments (Mani, 2003) during the 1990s reduced the share of domestically developed switches to about 30 percent of the annual intake of switching equipments

in the network⁸. Thus from this evidence too it is clear that Korea's innovation capability is very much intact although both in Brazil and India, the share of domestically developed switching equipments have suffered some erosions.

Table 7: Domestically developed switching equipments in the total telecom network of Brazil, India and Korea (Cumulative)

	Period	Type of technology	Market share in per cent
Brazil	1987-1997	Tropico family of digital switching systems	32.03
India	1986-2003	C-DOT family of digital switching systems	50.00
Korea	As on December 31- 2003	TDX family of digital switching systems	75.56

Source: Mani (2003) and Mani (2004 a and b)

8 It is also clear from an answer to an unstarred question (Rajya Sabha Unstarred Question No: 4125, <http://164.100.24.219/rsq/quest.asp?qref=21560>) in the upper house of the Indian parliament that the DoT procured almost five times the tendered quantity of switching equipments during the same period, supposedly for modernising the network with ISDN facility¹¹. But the number of subscribers using ISDN in the whole country was just 309¹². So it is clear that DoT appears to have purchased these 'overspecified' equipments far in excess of its actual requirement and this 'excess purchase' appears to have eroded the market share of C-DOT. Further the Comptroller and Auditor General of India (2000) found number of other irregularities with this tendering process. For instance, although most of the components of these switching equipments were imported by the suppliers, DoT assumed the import content as low as 23 per cent while working out reduction on rates on account of fall in customs duty in the 1995-96 budget. This inaccurate assumption by DoT led to excess payment of Rs 405 million to the suppliers with corresponding loss to the government exchequer. DoT also had to make an avoidable expenditure of Rs 639 million in the procurement of these exchanges against 1997-99 tender due to failure of the Tender Evaluation Committee (TEC) to submit its report within the bid validity period. TEC took 190 days in finalisation of its report against the prescribed limit of 42 days;

(c) Patenting performance

The number of patents granted, especially abroad, is a good indicator of innovative capability. However, as mentioned earlier, consistent time series data on foreign patents exists only in the case of Korea. Korean institutions, primarily, Samsung and ETRI has been particularly active in patenting in four areas directly connected with telecommunications technologies, namely US patent technology classes 370, 375, 379 and 455 (Table 8). It is seen that there has been a significant acceleration in patenting since 1998. Although the patents secured in year 't' is the result of research done in 't-1' period, it is interesting to note that there has been no deceleration in the number of patents secured by Korean institutions in the US since the period of globalization. In terms of the number of patents in these four classes, Korea compares very favourably with three European countries such as France, Germany and Sweden.

Table 8: Patenting performance of South Korea Inventors in the US for Telecommunications technology classes, 1990-2001

(Number of patents granted)

	370 Multiplex communication	375 Pulse of digital communications	379 Telephone communications	455 Telecom munications
1990	0	0	4	2
1991	4	5	9	3
1992	1	4	9	3
1993	3	8	8	8
1994	3	12	5	8
1995	3	19	4	4
1996	20	45	7	7
1997	19	43	6	5
1998	36	80	46	18
1999	46	77	64	45
2000	53	76	28	58
2001	63	89	11	76

Source: US PTO

The Brazilian CPqD has secured over 100 patents within Brazil and about 50 abroad, while India's C-DOT did not focus on patenting its innovation, but has managed to export its small rural exchange equipments to over twenty developing countries. Further the USPTO has granted C-DoT a patent for Asynchronous Transfer Mode (ATM) switch fabric implementation, which enables higher speed data transmission.

(d) Other indicators

India has demonstrated innovation capability in a Wireless in Local Loop (WiLL) access equipment called corDECT. In most countries the telecoms boom left an oversupply of fibre-optic cable along trunk routes, but this links directly only to the largest customers. Homes and small offices that want high-speed internet access usually subscribe to either a digital subscriber line (DSL) or a cable-television service. Both are far from ideal: the phone wires used by DSL and the television cables tend to be owned by monopolies, and neither was designed for surfing the web. Retrofitting a 1950s telephone line for broadband takes a lot of work, making cheap DSL hard to supply profitably. In principle, the new WiLL has no such drawbacks. Indeed, many see it as an ideal solution to the local access problem as it is based on radio waves. Of course, most WiLL systems require their own dedicated radio frequencies, but regulators have been fairly generous with these-selling enough licences to competing WiLL operators at a fraction of the prices paid by mobile-phone operators. Some can even use the same free, unlicensed frequencies in the 2.4 and 5 gigahertz bands. In the real world, wireless has so far lagged behind both cable and DSL. CorDECT is a WiLL access technology developed by two Indian research organisations namely IIT Chennai, Midas Communication Technologies, Chennai and a US semiconductor manufacturer. The project started towards the end of 1993 and was completed in 1994. The innovation system for this technology

consisted of three different types of entities, namely (a) Indian Institute of Technology, Madras and Midas Communications; (b) Four private manufacturers who funded the project through advanced licences; and (c) Semi conductor manufacturer which included a MNC from the U S. Royalty from their equipment sales goes to IIT, Chennai. The total development cost of the project was Rs 750 million financed mainly through, as mentioned before, advanced licensing. Currently between the four manufacturers there is an installed capacity to manufacture 1 million lines per annum. This technology offers relatively low cost and rapid installation of telecom services in areas with even high subscriber density environments. This system relies on a modest bandwidth of 20 MHz for the entire country and is very useful for rural areas where subscriber density is low and laying of cable is not economical. The following description of this technology helps one to understand the significance and utility of this technology ⁹.

In very simple terms, corDECT technology will reduce significantly the access cost of telecom service especially in rural areas¹⁰. This will hasten the diffusion of internet services in the country and especially in the rural areas and is also eminently suited to other developing countries as well. The system has also been exported to fourteen different countries namely Madagascar, Kenya, Fiji, Iran,

9 This description is largely based on the information contained in Asian Technology Information Program (1997) and Jayaraman (2002).

10 CorDECT technology effectively and inexpensively addresses the problems of distance and lack of infrastructure in rural areas. Installing a fixed wireless local loop does not require expensive digging, and the system consists of only 4 major components. Because the central base station/ direct interface unit (CBS/DIU) handles traffic from 200-1000 subscribers, it works ideally in small, dispersed markets and does not require the large subscriber base that traditional landline or cellular systems require for profitability. This low infrastructure investment, combined with low usage costs, makes the proposition affordable both for suppliers and customers in capital-constrained economies. See World Resources Institute, Digital Dividend, http://www.digitaldividend.org/action_agendaaction_agenda_01_nlogue.htm

Nigeria, Argentina, Singapore, Brazil, Tunisia, Egypt, Nepal, USA, South Africa and Angola. But there is very little quantitative data on its actual diffusion within the Indian network: about 100, 000 lines are said to be in operation within the country. Its diffusion within the domestic sector has received a major fillip in 2002 when one of the recent private entrants namely Reliance Infocomm¹¹ (which is building one of the largest broadband networks in India) decided to use corDECT to roll out its network in rural areas. However the same company has chosen a rival foreign technology, namely CDMA 2000 1X¹² to provide services in especially urban residential areas. CorDECT has thus an uphill task against this imported technology for two reasons. First, the owner of this technology also has an equity position in one of the largest telecoms operators in the country and this is likely to influence the technology purchase decisions of the latter. Second, the leading vendors of the CDMA technology are all MNCs and they are able to give deferred credit facilities to the operators while the vendors of corDECT which are all domestic companies are not in a position to do so. Thus corDECT is yet

11 Reliance Infocomm is part of a large Indian conglomerate namely Reliance Industries. The American telecoms company, Qualcomm which pioneered the CDMA technology, holds about 4 per cent of the shares of Reliance Infocomm. Qualcomm makes money from royalties every time a chipset is inserted into CDMA phones and other network equipment as well as from license fees. Further based on my discussions with Midas Communications, it could be seen that the order from Reliance Infocomm has led to a large quantum of orders from both elsewhere within the country and from abroad. For instance, following test-run with 25,000 CorDect systems in 24 cities across nine states for over an year, Bharat Sanchar Nigam Limited (BSNL) has recently awarded a contract for over 0.6 million CorDect lines. The BSNL contract is worth around Rs 7 billion and is divided among Himachal Futuristic Communications Ltd (HFCL), Indian Telephone Industries Ltd (ITI), Electronic Corporation of India (ECI), Shyam Telecom and Hindustan Teleprinters Ltd (HTL) The BSNL contract for CorDect systems is mainly for smaller towns and rural areas in these states, according to Midas Communications director Shirish B Purohit.

12 According to reliable sources, CDMA 2000 1X has a much faster data transferring capacity at 144 kbps as against coDECT's capacity of 35-70 kbps. See India Bandwidth, <http://www.indiabandwidth.com/dir1/wireless8.html>

another instance of the country demonstrating its innovation capability despite severe competition from MNCs.

India's software exports have been showing some spectacular performance during the 1990s. But the oft-repeated complaint is that much of the software exports from India is of low technology. But over time, the enterprises involved in this effort have been attempting to move up the value chain. A clear manifestation of this effort is the emergence of telecom software exports from the country. It is generally believed that the impetus for this originated from C-DOT. This fledgling sector of the software industry consists of three different types of firms:

- (i) Indian companies (some with foreign collaboration) focused only on telecoms software. Examples of this would be Hughes Software Systems, Future Software, Sasken, Mahindra-BT etc.
- (ii) Information Technology companies (domestic) working on telecom software. For example WIPRO, Infosys, HCL Technologies, Satyam Computer, Tata Consultancy Services etc., and
- (iii) Subsidiaries of MNCs. Examples of this would be Alcatel, Cisco systems, Lucent technologies etc.

Telecoms software fall into three areas: (i) embedded software (ii) system software; and (iii) application software that are used by service providers. A wide variety of telecoms software such as SDH, DWDM and optical networking, soft switches and intelligent networking, VoIP, ATM and SS7 gateways, Wireless networking, Broadband, home gateways and access network solutions, operations support systems etc are being developed. According to the Telecommunications Equipment Manufacturers Association (2002), the total size of the telecom software industry in India is about Rs 41 billion. This includes export of telecom software as well as domestic sales. While the export revenue includes embedded systems software, domestic sales refers only to the software that is sold to Indian

service providers like OSS/BSS and network management. An indirect evidence to show that much of these exports are in the value added segment is given by the fact that over 94 per cent of the exports of telecoms software are meant for telecoms equipment manufacturers and only about 6 per cent are meant for telecoms carrier industry¹³.

Consistent time series data on telecom software exports from India are not available: it is estimated that over 97 per cent of the output of this sector is exported¹⁴. However available data from industry- sources (Table 9) shows that telecoms software exports form about 14 per cent of total software exports from the country and have also registered more or less the same rate of growth. It is of course projected to touch about 20 per cent of India's software exports by 2003.

Table 9: Telecoms software exports from India (Millions of US \$)

	Software exports from India	Estimated telecoms software exports from India
1998-99	2626	262.60 (10)
1999-2000	4015	461.73 (11.5)
2000-01	6341	883.09(14)
2001-02	7174	993.83 (14)

Note: Figures in parentheses indicate percentage share of total software exports

Source: Reserve Bank of India (2002), Indiatel (2002)

Thus our discussion of the above shows that country has built up considerable innovation capability in the area of both telecom hardware and indeed in software too.

13 See Laishram (2002), pp. 74-5.

14 See Laishram, *op. cit.*, pp. 74-5.

Another important dimension of India's capability in the telecoms software industry is the fact that a number of MNC telecom companies has established their software development centres in India. Of late some of them have closed down their own R&D centres in India, but have outsourced their telecoms R&D to Indian software companies. The first such initiative was the recent deal between Ericsson and Wipro. See Box 1 the details.

Box 1: Innovation capability in India's telecom software industry: case of the Ericsson-Wipro deal in outsourcing of R&D

According to the letter of intent that Wipro has signed, the deal will involve Wipro picking up assets, including personnel, of Ericsson's R&D centres in Bangalore, Hyderabad and New Delhi. Around 300 software professionals who were part of Ericsson's units would now be on Wipro's payroll. This would take Wipro's overall Ericsson-related team size close to 400 software professionals, as the software major already has around 100 people working on Ericsson's projects. While the financial terms of the agreement are yet to be worked out, the deal does throw up interesting pointers on what Indian companies can do to gain a competitive edge.

Rather than term this deal as an acquisition, Wipro is calling it an 'outsourcing deal'. Wipro intends to run the centres in the form of an outsourcing contract, wherein it will undertake the entire responsibility for all the R&D work of the Swedish firm done in India by taking over assets and people.

While MNCs have been outsourcing R&D requirements for a long time to Indian software companies, the current competitive scenario has changed things a bit. At present, the R&D outsourcing services market is taking on a hue similar to the IT services scenario. For instance, when companies first began outsourcing their R&D services to India, the billing rates quoted were premium rates. But as more and more Indian companies ventured into this market, billing rates fell drastically and MNCs started dividing their work between their own Indian R&D centres and a handful of Indian software companies. Due to the turmoil in the global telecom industry these MNCs have been looking at the best way to cut costs without compromising on R&D. For instance, a year ago Ericsson had announced that it wanted to increase investments in its Indian R&D arms. The telecom giant had plans of scaling up manpower in these centres even though it cut manpower requirements massively in other centres. But in the light of the massive slowdown in the telecom sector, Ericsson thought it prudent to write off its assets in the Indian centres, while still retaining its competitive advantage by selling the centres and the people working there to its partner, Wipro. As a result the deal has created a win-win situation for both companies, or so it seems.

Source: Srikanth R P (2002) Express Computer,
<http://www.expresscomputeronline.com/20021111/cover.shtml>

V. Instruments of state support

In this section, I am primarily concerned with contrasting various instruments of state support. These can be broadly classified into two

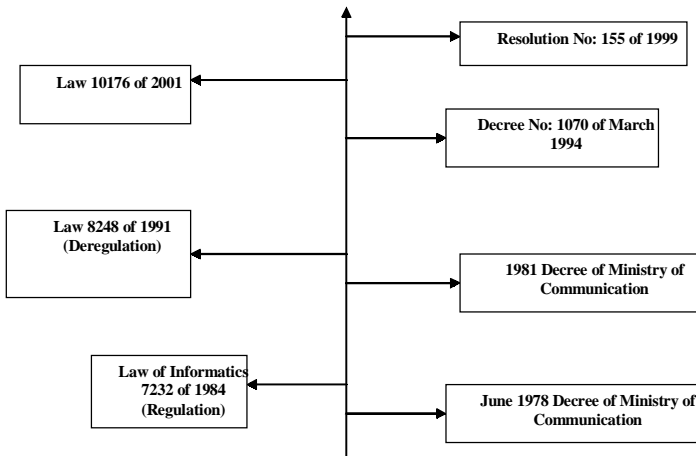
main categories. First, is a set of financial instruments such as research grants and tax incentives designed to encourage the generation of new technology. Second, is a set of legal and quasi-legal instruments that assure a market for the output of such generation. In the following I undertake a survey of these various instruments across the three countries in our sample.

Brazil: Brazil has used both legal and financial instruments to support domestic technology generation. These are discussed below.

Legal instruments facilitating public technology procurement in historical perspective ¹⁵

Beginning with 1978 and ending with 2003, I could identify 7 different legal pronouncements (Figure 10) that has a bearing on creating

Figure 10: Legal instruments for supporting domestic technology procurement in telecommunications



Source: Own compilation

15 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).

a protected market for telecommunications equipments manufactured with local know-how. All of them, excepting for the three Informatics laws of 1984, 1991 and 2001, deal explicitly with telecommunications equipments.

The two Informatics laws deal with information technology products in general of which telecom equipments 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, the implications of this one for future build up 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 equipments made by local companies were preferred;
- (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 available ¹⁶;
- (c) The Law of Informatics (7232) of October 1984 created market protection (or market reserve) for information technology products manufactured by Brazilian companies. A "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

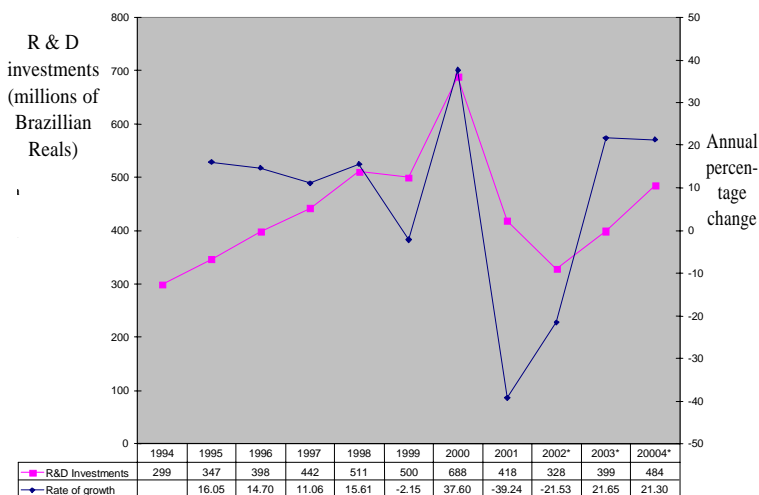
16 According to Fiorentino (1996), as an immediate consequence of the criteria set out by these decrees, MNCs transferred most of their voting shares to private domestic groups.

residents domiciled in Brazil. Brazilians must hold at least 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, as well as 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 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 per cent of the income tax owed by the company; and (c) deduction of up to 1 per cent 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 11: 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 ¹⁷:

- Taxation incentives, implying in 15 per cent reduction of the final price 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.

It is now 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 11) and this can help one to understand some broad trends. R&D investments grew at a steady rate until 1998. Investments since then do not show any growth but only fluctuations. Specifically in the telecoms industry, many foreign equipment manufacturers began to locate their R&D centres in Brazil. From my field research, it is very 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

17 I am grateful to Mr Feranando Aragao da Silva Costa of Ericsson's Research and Development Centre at Indiatuba, Brazil for giving me this data.

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 were 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 1999¹⁸. ANATEL, through this resolution 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 Authorization 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 Authorization 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.

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

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 Brazil; or
- Preference for equipment and material produced in Brazil, among which, those with domestic technology.

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.

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 the 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 (approximately US \$ 15 million). 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 on domestically developed technologies will continue to have a market. However everything depends on the actual monitoring of purchase decisions 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 equipments 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 organizations are called Organismos de Certificação Designados (OCD)¹⁹. They will issue 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 commercialization 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 -

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

- 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, the only OCD among the total list of ten that is capable of performing all the tests prescribed by ANATEL is CPqD.

(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 a place a national fund called the Fund for Technological Development of Telecommunications (Fundo para Desenvolvimento Tecnológico das Telecomunicações-FUNTTEL) 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 job positions 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 2003²⁰, 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.

BNDES and FINEP manage FUNTTEL. 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 10), 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 country²¹.

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

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

Table 10: 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: Unpublished data from 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 just based on price-performance criteria, but also based on the availability of credit facilities. Small equipment manufacturers based in developing countries do not usually have the financial wherewithal to facilitate such deferred credit facilities and this can hamper the sale of especially 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 shows²².

22 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

It must however be noted that the BNDES has put in place, during 1999-2002, a credit facility known as “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 equipments by both fixed line and cellular providers (BNDES, 2000).

(c) Tariff protection

Although Brazil joined the World Trade Organisation (WTO) in 1995 but has yet to sign the WTO's Information Technology Agreement that reduces tariffs on information and communications products to zero.

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 privatization 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 liberalization in 2002, all the domestic carriers have a strong desire for capital investment to bolster their business operations. It was 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.

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 lowering tariff mean 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 equipments have shown significant increases during this period.

Thus it is seen that Brazil's effort 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 accentuate as the country gets effectively absorbed into NAFTA.

(ii) India: has essentially used only the latter instrument namely public technology procurement policy to assure a ready market for domestically developed technologies²³. Several developed countries such as Sweden, France etc have used this specifically in the realm of digital switching systems. In fact I argue that it is the procurement policy of the DoT which has to a large extent promoted domestic innovation capability

23 The WTO already has the Government Procurement Agreement (GPA), with detailed rules on procurement. However, this agreement only binds 26 parties out of the 135 WTO Members. For this reason the WTO has pursued a work programme on transparency in government procurement (TGP). The aim is to draw up an agreement to which all WTO Members will be party. In principle the agreement does not seek to eliminate preferences to domestic suppliers, it simply aims to make these preferences transparent.

in the sector²⁴. The DoT purchases switching equipments only from local manufacturers and does not allow imports of finished switching products²⁵. This really does not afford any protection to domestically assembled switches, but in fact quite the contrary. There are two types of evidences for this. First, imported equipments attract a customs duty of 15 per cent ad valorem (2002-03). At the same time the imported components for domestically assembled switches also attract customs duties and given the nearly fifty per cent import content of domestically assembled switches, the procurement policy does not afford any specific protection to domestically assembled or manufactured switches. Second, as noted earlier in Figure 8, the fall in price realisation of domestically manufactured equipments signal increased competitive pressures. Further in the past the rate of rejection of indigenously manufactured switching equipments by the DoT has been as high as 25 per cent in the early 1980s²⁶.

The country has a decentralised telecom switches procurement policy. In order to simplify the procurement process, the department receives tenders and sets a fixed rate through a tendering process

24 The procurement policy of the main telecom consumer, namely the DoT (or the BSNL) needs to be distinguished from the procurement policy of other government departments. In the former case the telecoms products are selected on the basis of price-performance ratios (or the rate performance contract) while in the latter cases it is very often through a fiat. The procurement policy of the DoT (or the BSNL) especially for non-switching telecoms equipments have drawn some flak in recent times. Owing to pressure from the Parliamentary Standing Committee, BSNL constituted a committee — *Shift in Procurement Policy of BSNL* —, which is to submit its report soon (in late 2002). On a more general note, following the Singapore Ministerial Meeting of the WTO, the Central Government constituted an Inter-Ministerial Working Group on Transparency in Government Procurement at the level of additional secretaries and headed by the Additional Secretary (Commerce).

25 It must of course be added that the new private entrants are not governed by this stipulation and are free to import switching equipments.

26 See Mani (1992), p. 97.

commonly known as “rate contract”²⁷ after which the Chief General Managers of the various telecom circles are authorized to purchase their requirements from approved vendors. The Telecommunications Engineering Centre (TEC)²⁸ within the department sets the technical standards of all telecom products including switches. Thirty per cent of the total requirements of switching equipments are reserved for the public sector enterprise. However the price at which this thirty per cent is procured is at the lowest price quotation received for the remaining seventy per cent for which open tender is invited. This reservation price is referred to as the L1 price. It is thus seen that the public sector producer of switching equipments have actually to bid for thirty per cent of the switching requirements without actually knowing the price at which the bid is going to be made. Thus it is clear that the public procurement process followed in the case of switching equipments does not afford any protection to the public sector producer which in this case is ITI Ltd. at Bangalore. The price-performance ratio is thus the main criteria for selection and not other non-technical considerations such as deferred credit facilities. At least for some more years, given the near monopoly position of the government carriers public procurement policy will be

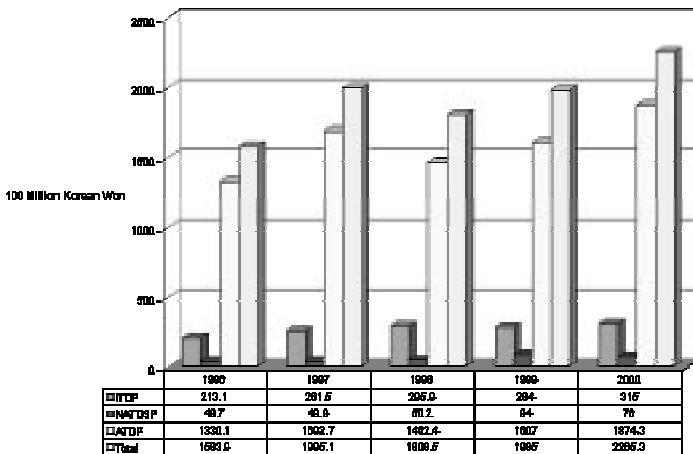
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- 27 The DoT receives and evaluates bids from domestic firms (including affiliates of MNCs) and awards rate contracts based on price and performance.
- 28 TEC through its core group is responsible for drawing up the Standards' and Generic Requirements (GR's) for networks, systems, equipment and products to be used in the Indian telecommunications network. The Centre through its regional offices is also responsible for co-ordinating and evaluating these products, equipment and systems. TEC also provides advice to the DoT in respect of products and networks used by DoT. Switching division of TEC is responsible for all activities related to the switching products either working in the DoT's network or inter working with the DoT's network. This includes preparation of specifications of state-of-the-art digital switching systems, validation of switching systems to be inducted in the DoT's network, interface testing of PABX and switches for GSM and basic service, testing of hardware and software upgradation of various switching systems, providing software maintenance support and field support to switching systems working in the DoT's network.

an effective instrument for stimulating local R&D activities. However with the growth of private service providers this will be less effective, especially when the private sector providers, who are in the initial years of establishment, would also take into account deferred credit facilities which only the MNC vendors can offer.

(iii) **Korea:** has used both financial instruments and public technology procurement to support local R&D activities.

(a) **Financial incentives for technology creation:** One of the main components of Korea's innovation system is the public laboratory, ETRI. As seen earlier ETRI's budget largely comes from the Korean government in terms of research grants. In addition the Ministry of Information and Communication maintains three separate research grant schemes and the disbursements under these three have been continually increasing. See Figure 12.

Figure 12: Financial incentives for domestic technology creation in telecommunications industry in Korea, 1996-2000



Source: Ministry of Information and Communication.

In addition fiscal incentives are available to private sector enterprises in the form of R&D tax credits etc.

(b) Public technology procurement: Korea too has used this especially during the development of TDX fixed telephone equipments. Prior to the financial crisis 1997, Korea was one of the fastest growing telecommunications markets in Asia. However, Korea has always been a difficult market for foreign companies to penetrate. Historically, the Korean government has protected and fostered the growth of the Korean telecommunications industry through strict regulation of equipment type approval procedures, the setting of standards that are unique to Korea, implicit and explicit "buy local" policies.

VI. Future Scenario

In this paper, I was primarily concerned with analysing the creation and maintenance of innovation capability in three different developing countries with respect to telecommunications technologies and the strategies employed by the respective governments of these countries towards coping with the challenges posed by globalisation. The three country experiences fall into three categories. At the best end of the spectrum is Korea, which has given a proper strategic direction to its public laboratory by successfully identifying future growth potential in mobile communication and then systematically building up its innovation capability in this area. The country has now become an important world player in the manufacturing of mobile handsets. Towards the middle of the spectrum is Brazil, which has sought to maintain its domestic innovation capability through a variety of legal and fiscal instruments although the very process of globalisation has attempted to reduce the effectiveness of these instruments. At the bottom end of the spectrum is India, which despite possessing tremendous innovation capability, has not bothered to support its domestic research system especially when

compared to Brazil and Korea. The study thus shows that the state still has an important pro-active role to play to minimise the negative consequences of globalisation on its public research systems.

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References

- Asian Technology Program (1997). CorDECT- A New Indian Wireless Local Loop System, ATIP97.002.
- BNDES (2000), BNDES News, Quarterly Report for BNDES Partners, No: 9, (January-March).
- Dorrenbacher, Christoph (2000), 'Between global market constraints and the national dependencies: the internationalisation of world's leading telecommunications suppliers', *Transnational Corporations*, Vol. 9, No: 3, pp. 1-32.
- Edquist, Charles (Ed.), *The Internet and Mobile Telecommunications System of Innovation*, Cheltenham, U.K., and Northampton, USA: Edward Elgar.
- Fiorentino, Luiz Del (1996), 'Telecommunications in Brazil', *IEEE Communications Magazine*, Vol. 34, Issue 5, pp. 34-39.
- Fransman Martin (2002), 'Mapping the evolving telecoms industry: the uses and shortcomings of the layer model', *Telecommunications Policy*, Vol. 26, Issues 9-10, pp 473-483.
- Indiatel (2002), *India Telecom Software Report*, Mumbai: Indiatel.
- International Telecommunications Union (2004), *World Telecommunications Indicator*, Geneva: International Telecommunications Union.
- Jayaraman, K.S (2002), 'India online', *Nature* 415, pp. 358-9.
- Kujawski, Fabio and Paulo Marcos Brancher (2000), 'Brazilian regulation on service contracting procedures and the purchase of equipment or materials by telecommunications services providers', Paper presented at the PTC 2000, Sao Paulo.
- Laishram, Nareshchandra (2002), 'For the focused', *Voice and Data*, July, pp. 74-75
- Mani, Sunil (1992), *Foreign Technology in Public Enterprises*, New Delhi: Oxford and IBH.
- Mani, Sunil (1995), 'Technology import and skill development in the micro-electronics-based industry: The case of India's Electronic Switching Systems', in Bagchi, A (ed.), *New Technology and the worker's response: microelectronics, labour and society*, Delhi and London: Sage, pp. 98-122.

- Mani, Sunil (2003), Deregulation, Entry of MNCs, Public Technology Procurement and Innovation Capability in India's Telecommunications Equipment Industry, UNU-INTECH Discussion Paper Series, DP 2003-1, Maastricht: United Nations University-Institute for New Technologies.
- Mani, Sunil (2004a), Coping with Globalisation An Analysis of innovation capability in Brazilian telecommunications equipment industry, Discussion Paper 2003-1, Maastricht: United Nations University-Institute for New Technologies.
- Mani, Sunil (2004b), Marching forward with globalisation Innovation capability in Korea's telecommunications equipment industry, Maastricht: United Nations University-Institute for New Technologies.
- MIT Technology Review (2004), "The TR Patent Scorecard"
- National Science Foundation (1999), U.S. Corporate R&D: Volume 1. Top 500 Firms in R&D by Industry Category, NSF-00-30, VA: Arlington.
- Reserve Bank of India (2002), Annual Report 2001-02, Mumbai: Reserve Bank of India.
- Schjolden, Ane(1999), Globalization, Liberalization, An Restructuring of the Brazilian Telecommunications Industry: The End of Technological Capability?, Unpublished MA Thesis, Department of Geography and Regional Development, The University of Arizona.
- Szapiro, Marina Honorio de Souza and Jose Cassiolato (2003), 'Telecommunications system of innovation in Brazil: Development and Real Challenges', Paper presented at the first Globelics conference on Innovation Systems and Development Strategies for the Third Millennium, Rio de Janeiro, [http://www.sinal.redesist.ie.ufrj.br/globelics/pdfs/GLOBELICS_0075_Szapiro% 20 Cassiolato.pdf](http://www.sinal.redesist.ie.ufrj.br/globelics/pdfs/GLOBELICS_0075_Szapiro%20Cassiolato.pdf).
- Telecommunications Equipment Manufacturers Association (2002), Directory of Telecommunications Equipment Manufacturers, New Delhi: Telecommunications Equipment Manufacturers Association.

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