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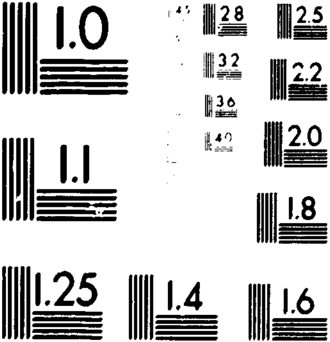

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TELECOMMUNICATIONS AND INFORMATION TECHNOLOGY IN LATIN AMERICA: PROSPECTS AND POSSIBILITIES FOR MANAGING THE TECHNOLOGY GAP**

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* Co-sponsored by SELA/ECLAC.

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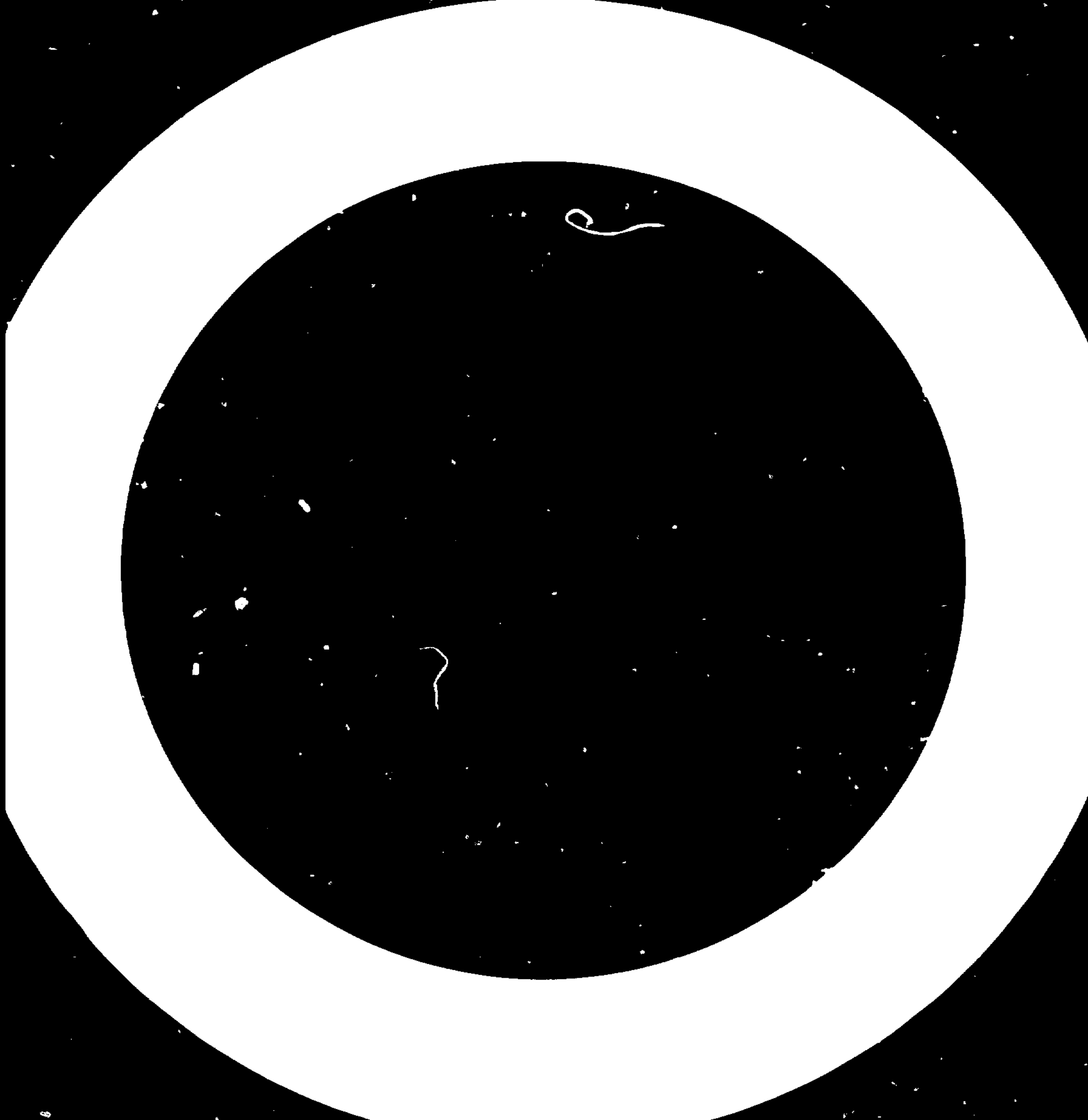

CONTENTS

Abbreviations Used Throughout

DC	Developing Country
IAC	Industrially Advanced Country
IT	Information Technology
MNC	Multinational Corporation
PABX	Private Automatic Branch Exchange
PTT	Ministry or Administration in charge of Posts, Telegraph and Telephones
R&D	Research and Development
TC	Telecommunication

Also see glossary of technical terms.

INTRODUCTION

Within the now substantial body of literature concerning microelectronics and the trends towards information based technology (IT), little attention so far has been payed to telecommunications. This is quite surprising given a) the size and growth of the market, b) the importance of telecommucications (TCs) as infrastructure for IT, and c) the role of TCs as a 'leading edge' in the accumulation of capabilities in IT. Even within the studies concerning the industrially advanced countries (IACs) there is very little analysis of the infrastructural and cutting edge properties of TCs. Nevertheless several IAC governments are actively supporting their locally based manufacturing industries, in an effort to gain national advantages over their competitors in the rapidly growing IT markets.

This is a matter of grave concern for the developing countries (DCs) in their efforts to develop the necessary skills and technological capabilities to understand and use microelectronic technology. Without well orchestrated and informed policy responses to changes brought about by digital innovation there is a very real danger of the loss of international competitiveness, worsening comparative advantage, and exclusion from many information intensive economic activities. The main purpose of this paper is to examine the prospects for the Latin American region in gaining a 'foothold' in IT in view of the rapidly changing technological and economic environment worldwide. The question of whether specific DCs can use existing TC facilities and planned infrastructural investments as a cutting edge in IT development will require detailed country by country analysis. The aim here is therefore to provide a general assessment of the issues and to point to possible TC related strategies of managing the technology gap between Latin America and the IACs.

Part 1 begins by briefly discussing the stategic importance of TCs both as infrastructure for IT and as a leading edge in the accumulation of microelectronic capabilities. This section goes on to suggest that existing demand for digital TC facilities in the DCs could, potentially, be employed as a means for 'leapfrogging' intermediate forms of communications infrastructure, and for gaining vital capabilities in the broader area of IT. In order to assess the prospects for technology transfer and local development of TCs Part 2 examines the international market structure of the industry and the impact of digital technological diffusion accross the major sub-sectors of the industry. It is argued that the process of microelectronic diffusion has opened up various 'technological opportunities' for entry by the DCs, in a number of important areas of the industry.

Part 3 broadly examines the current and forecasted market demand for the Latin American region and attempts to show that the very large market, and the planned adoption of fully digital TCs, does indeed present a potential for exploiting the leading edge properties of TCs. Finally Part 4 looks selectively at individual countries of the region and stresses the importance of differentiating clearly between economies of different overall size and different levels of economic and technological infrastructure. An effort is made to point to possible areas of mutually beneficial international collaboration especially for the smaller countries of the region. Ultimately though, much will depend on individual and cooperative government policy initiatives in successfully managing the technology gap.

(A glossary is also provided to define such terms as information technology, telecommunications, and other necessary technical terms.)

PART 1 THE STRATEGIC IMPORTANCE OF TELECOMMUNICATIONS IN THE DIFFUSION OF INFORMATION TECHNOLOGY.

1.1 Telecommunications as IT infrastructure and a 'leading edge'in the accumulation of technological capacity.

There now exists a substantial body of literature regarding the diffusion of microelectronic, information-based technology. (See Forester 1980, Bessant et al 1981, and Leppan 1983, for reviews). Two of the most widespread findings concerning the IAC's are first, the rapid rate of diffusion of micro technology, and second, the astonishing pervasion covering virtually all economic sectors. For example a study conducted by the OECD (1981) shows that, broadly defined, information-based occupations now constitute the largest share of employment in the majority of the OECD countries, and is providing the fastest rates of employment growth in the IAC's. In spite of severe economic recession the sales of IT products have continued unabated (Rothwell 1984). The extent and speed of IT diffusion as well as implications for employment and output growth are subjects comprehensively studied in the IAC literature. What is not nearly so well covered is the role and importance of telecommunications in the shift towards IT.

When one considers the size and role of the TC sector this is indeed surprising. Overall TC activities in the EEC, the USA and Japan, represent around 3% of GDP which places the dimensions of the industry on roughly the same footing as the largest industries worldwide (eg.the motor vehicle industry, electricity supply, aerospace and chemicals). As a consequence of continued rapid growth TC activities are expected to reach about 4.4% of GDP by 1990, and by the year 2000 will surpass the other largest industrial sectors forming approximately 7% of total GDP. Also the closely related telematics sector, based on the convergence of digital TCs with computer technology, will probably match the overall dimensions of TCs by the early 1990's (A.D. Little).

As mentioned above TCs are also playing a fundamental role in the shift towards digital, information based activities.

First, as basic infrastructure for IT telecommunications actually represent a determining constraint on the diffusion of informatics and telematics technologies. Second, TCs are proving extremely important in national efforts to accumulate capabilities in IT. Again, the scant attention paid to TCs from these perspectives is a matter of urgent concern. It is now common policy practice for governments in the IACs to exploit the cutting edge properties of TCs in order to help ensure their relative international positions as IT diffusion proceeds. This is carried out principally through investment programmes or support to national TC equipment manufacturers (Bessant 1983), and by legislation to promote increased competition in the introduction of new IT services. (Note the recent anti-monopoly legislation in the USA and UK).

As infrastructure for IT the role of TCs is made all the more important especially when one considers the various forecasts concerning the next sustained economic upswing, widely suggested to be based on, or certainly led by microelectronic IT diffusion. As Barron and Curnow (1979) argue in their assessment of the UK position:

> "The major obstacle to the development of the information society will be the provision of adequate telecommunications capability...... From a national point of view the greatest leverage might be obtained by an active programme of investment in an advanced telcommunications system. This would provide the infrastructure for an information society and would generate a positive market for the information technology industry in the U.K.".
>
> (Pages 18 and 20)

In terms of the developing countries it is crucial that appropriate policy responses are designed to meet the challenges posed by digital information technology, not only to prevent a widening of the technology gap, but also to gain any possible advantages from the technology. A failure to respond to these changes may well threaten a shift in comparative advantage away from the DCs, and the exclusion from many IT activities.

1.2 Microelectronics, telecommunications and the developing countries - a possibility of managing the technology gap.

If we turn to the literature regarding microelectronics and the developing countries even less attention has been paid to TCs. While a great deal of study has been invested in the general role of TCs in economic development (Hobday 1982 provides a review), there is no empirical study of the potential role of TCs as information technology infrastructure, or as a means of gaining vital skills and knowhow in digital technology.

Most study of microelectronic diffusion and the DCs has been confined to a very narrow range of industrial technologies, and an even narrower range of process technologies across sectors such as CAD and software applications (reviewed by Leppan 1983). The primary concern of most observers is the possible negative economic implications of microelectronic diffusion and the difficulties facing DCs in acquiring such an advanced form of technology (Rada 1982, Kaplinsky 1982). Among the main economic concerns are 1) the possibility of erosion of comparative advantage of the more advanced DCs. The argument holds that existing comparative advantage based on cheap labour may be eroded as automation technology makes it both technologically feasible and more profitable for MNCs to relocate production facilities in the IACs. 2) The possibility of a new and harmful phase of emerging DC technological dependency on the IACs and especially the multinational suppliers of equipment and technology. 3) The inappropriateness of digital technology both in terms of skills and factor endowment, especially in view of the labour-saving nature of the technology and the sophisticated knowhow required in its manufacture and application.

More recently though there have been indications that the early widespread pessimism may have been overemphasised. The rate of conversion to fully automated digital systems is both slow and uneven in the IAC's, and relocation to the north has not proceeded as expected (Bessant 1983, Leppan 1983). Indeed there may well be a 'breathing space' for DCs to assess their positions and organise strategic responses to the challenges posed by microelectronics (Perez 1984).

In terms of the labour saving nature of electronic technology, research by Soete and Dosi (1983) shows that the technology is also capital saving and this may prove beneficial in overcoming capital constraints in DCs. As far as skills are concerned, although traditional means of acquiring mechanical and electromechanical technologies (eg. learning-by-undoing or reverse engineering) may not be suitable for IT, other information-based learning mechanisms may be available (Hobday 1985 part 3.3). In fact a number of the larger DCs including India and Brazil have already established fairly sophisticated capabilities in software and CAD technology. The shift to information-based, digital technology may actually assist in overcoming the common DC bottleneck problems in fine engineering and electromechanical interfacing. Indeed many of the larger DC are well endowed with high level information and design skills at universities and other research centres.

The very narrow base of empirical research in this area means that generalisation across economic sectors is not yet possible. Nevertheless recent study does suggest that well-informed and pragmatic policy intervention may assist in overcoming the difficulties faced in the acquisition and use of digital technology. Rather than passively accepting any potentially harmful consequences of microelectronic diffusion, DCs may be in a position to by-pass or 'leapfrog' older, less efficient forms of technology and move directly to more flexible and lower cost digital technology (Soete 1984). By strategically gaining the necessary skills and knowhow many DCs may be in a position to effectively manage the technology gap. Certainly in TCs this appears to be the case as discussed below.

However, in order to assess the prospects for DCs in the overall area of IT it is imperative to distinguish clearly between a) DCs of different market sizes and levels of technological infrastructure, and b) the specific sector undergoing digital innovation. As the various case studies show

(Jacobsson and Sigurdson 1983 provide a collection of papers), the pattern, rates and effects of microelectronic innovation vary considerably according to the sector under discussion and in particular, the 'information intensity' of the sector. Rates of diffusion have been highest in information related products and processes such as computing, data processing and TCs. In traditional manufacturing sectors diffusion has been considerably slower and the impacts less dramatic partly due to the heavy existing investments in previous forms of technology.

It is also vital to distinguish between DCs at different levels of economic and technological development, as the opportunities for aquiring and developing digital technology will depend very much on existing infrastructure. So too, market size will be an important variable in determining an appropriate level of manufacturing and technological capacity for the economy. Before examining these issues in the context of Latin America it is first necessary to analyse the changing international market structure in TCs as this too will exert a considerable influence on the general prospects for technology transfer and local development by the DCs.

PART 2 THE CHANGING INTERNATIONAL MARKET STRUCTURE IN TCs AND THE IMPLICATIONS FOR DEVELOPING COUNTRIES

The diffusion of microelectronic technology throughout the TC industry has dramatically altered both the size of the industry and the international competitive environment. Digital innovation and the convergence with other IT based industries has given rise to many new entrants to the market and profoundly changed the nature of the products and processes involved in TC manufacturing. This rapidly changing technological and economic environment has, not surprisingly, radically affected the prospects for DC's in their efforts to transfer technology and develop products and processes locally. To help assess the implications of these changes it is useful to begin by outlining the structure of the industry.

2.1 Microelectronic diffusion, market growth and competition.

Table 1 presents worldwide sales of TCs by major product lines for 1980 and 1985.

Table 1 Shares of Major Telecommunications Product Lines in World Sales 1980-1985 (estimated).

	Value of World Sales ($billions)		% of Total	
	1980	1985	1980	1985
Switching	12.6	18.4	31.9	31.7
Transmission	12.2	17.4	31.0	30.0
Terminals	5.8	8.0	14.7	13.8
Private Systems	4.3	6.4	10.9	11.0
Mobile Radio	3.8	4.9	9.6	8.5
Other	0.7	2.9	1.8	5.0
Totals	39.4	58.0	100	100

Source OECD 1983 p20 (amended) assumed to be constant prices.

In 1980 total product sales stood at just under $40 billion and by 1985 will reach , $58 billion. While growth estimates vary there is general agreement that rapid growth will continue throughout the industry during the '80s and the '90s. Arthur D. Little for example estimates that the annual average growth of roughly 8.5% during the early '80s will only slow slightly to 8.0% in the latter half of the '80s. And this is despite forecasts of continuing economic recession.

Switching or exchange equipment constitutes nearly 32% of the overall market. This equipment represents the heart of public and private TC systems,switching messages within and between networks. Transmission systems rank alongside exchange equipment with 30% of the market. Transmission systems are responsible for sending information, now usually in digital format, from one geographical location to another. The balance (or peripheral equipment) includes all other devices involved in forming a TC network and includes terminals, telephone handsets, modems and other input/output devices. The above data do not, unfortunately,seperate out the rapidly growing private exchange market (PABXs). PABX's now represent one of the most dynamic areas of the market with the shift towards digital technology and more private applications.

Throughout the '70s and into the '80s digital technology has had a profound affect on the market structure of the industry. What was once a stable, oligopolistic industry has been transformed into a highly competitive, rapidly growing and changing market. In many areas a great deal of uncertainty surrounds the prospects for existing suppliers. As the technological base of the IT industries in computing, informatics, telematics and some areas of consumer electronics converge around digital technology new competitors have entered the TC industry. As new manufacturers enter, the stable position of many of the traditional suppliers is being threatened.

Part 1 argued that the effects of microelectronic innovation need to be examined on a sector by sector basis. Even within the TC sector there are conflicting and complex trends which have a direct bearing on the prospects for DCs attempting to acquire and develop the technology. It is therefore necessary to examine the likely impact of these changes in terms of the three main subsectors - exchange, transmission and peripheral equipment.

2.1.1 Exchange Technology.

In the exchange sub-sector massive R&D investments have led to fully automatic, stored programme controlled, solid-state digital exchanges. The generally accepted superiority of these systems is leading to the gradual replacement of less efficient, less flexible and more costly electromechanical exchanges. In the DCs there exists a very real possibility of by-passing or 'leapfrogging' older vintage technologies and moving directly to fully digital technology. In terms of communications infrastructure this represents a great benefit to DCs who, typically, will pay three to five times less (for installing say 1 million lines) than the now developed economies did 30 to 40 years ago (Jequier 1977). The most modern fully digital exchanges are today roughly one half of the price of equivalent electronic analogue and electromechanical public exchanges.(Saunders et al 1983). Most DCs are in the attractive position of installing and expanding their basic TC networks, while the IACs are generally heavily committed to less efficient, lower capacity, previous technological forms. At the level of IT infrastructure DCs potentially have an <u>advantage</u> over the IACs now faced with the daunting task of replacing inappropriate infrastructure and the enormous economics of scrapping problem this entails.

These leapfrogging advantages in terms of the <u>use</u> of the technology apply equally to transmission and peripheral equipment, where there is no doubt that digital diffusion has radically impoved the cost/performance ratio of existing electromechanical systems - as well as introducing a wide range of new applications. However, in terms of the <u>manufacture</u> of the systems and the development of the technology, at first sight the shift to digital switching appears to pose very severe financial and technological barriers to entry for DCs.

R&D investment costs in public exchanges reach staggering proportions, with estimates ranging from $400 million up to $1 billion for the major public exchange systems. These huge R&D thresholds have acted to prevent entry from other closely related industries, and there is very little chance of even the largest computer manufacturers entering the competition in the near future. As well as financial barriers there are very substantial technological barriers to entry. Very complex, TC specific software is required to develop exchange systems and this has proved a major difficulty even for experienced TC manufacturers.

Microelectronic diffusion has generated fierce technology based competition among the existing international suppliers. There are currently 16 major systems in the market developed at a cost of over $6 billions competing for annual uncommitted export markets of only $2-to $3 billions. This degree of market saturation will probably mean that some of the systems will not realise a positive return on investment (OECD 1982).

At first sight these very daunting financial and technological barriers to entry would indicate very poor prospects for DCs wishing to aquire and develop exchange technology. However this may not be the case for three main reasons. First, the fierce international competition has placed the DCs in a very good bargaining position and they are able to obtain the systems at very low prices. PTTs in the DCs can often buy the latest equipment on better terms than users in the developed countries, who are often contractually obliged to financially support local manufacturers. Many of the large R&D investments are justified in terms of export markets and it is in the DCs where the largest non committed export markets lie. Hence the increasing importance attatched to third world markets.

Second, when sales of equipment are linked to setting up manufacturing and technological facilities the open bidding for orders is even more intense as the financial stakes are that much higher. The competition for the recent Indian contract testifies to this. Ten major suppliers competed and eventually the well established French system won the orders. However, in order to win, the French government was obliged to step in and offer an 'aid for trade' cheap loan arrangement and full technological training by French scientists. A similar situation also appears to be emerging with the Chinese plans to upgrade and expand the TC infrastructure of the industrial Yangtze Delta region.

A third potential benefit from the shift to digital technology relates to the modular nature of exchange systems and the opportunities for entry in smaller scale private and public exchanges. The PABX market has witnessed rapid growth in small private exchanges. In this very dynamic sector of the market the software is much less complex and many new manufacturers have entered from the computer and office equipment markets. In the USA in 1961 there were only 4 PABX manufacturers, by 1980 there were more than 30, and in terms of terminal equipment overall there are now over 1000 approved local manufactures (OECD 1983). Furthermore, the modular nature of digital technology means that it is now possible to gradually develop and acquire capabilities even in public exchanges. Brazil, for example, has developed and manufactured locally small exchanges of roughly 1000 lines for use in rural areas. They are also planning to build on the experience gained in software and hardware technology to gradually move up the scale of technological complexity onto larger public exchanges. The tendency towards greater modularity reflects a higher degree of capital and technological divisibility and this is a direct consequence of microelectronic innovations. (The implications of the shift away from the highly 'verticalised' manufacturing technology towards digital 'horizontalised' technology is discussed below in section 2.2).

To summarise, despite the substantial barriers to entry in exchange systems there may well be 'points of entry' for DCs as a result of the diffusion of digital technology. The exploitation of any potential technological opportunities will depend very much on the size of the domestic market and level of scientific and technological infrastructure, as well as effective domestic government policies towards TCs.

2.1.2 The Transmission Sector

In the transmission sub-sector a similar pattern of increasing competition within the industry has emerged as a result of digital innovation. However, the much lower degree of technological complexity and lower financial barriers to entry have given rise to many new entrants to this sector, principally from the technologically convergent areas of radio and aerospace manufacturing. The traditional dominance of the coaxial cable manufacturers has given way to microwave system producers, and both of these transmission mediums have benefited greatly from digital PCM and TDM techniques. As with exchange systems cost/performance ratios have improved dramatically. Miniturisation with micro technology has made satellite communications economically viable and the use of satellites is growing rapidly in both private and public communication networks. In recent years digital innovation has resulted in falling communication costs in the region of 11% per annum in terrestial systems. With satellite communications cost reductions have averaged roughly 40% per annum per data/speech channel (Muller 1982).

Fibre optic technology also boasts considerable advantages over traditional systems in terms of greater capacity, speed, flexibility, resistance to interference and significantly reduced installation costs. As technical difficulties are being overcome and the technological and economic superiority of fibre optics, over traditional systems, is gradually being accepted, they are forecast to diffuse far more rapidly in the latter half of the '80s and throughout the '90s.

As far as the DCs are concerned the move towards digital technology again holds good prospects both in the use and the production of the equipment locally. By by-passing intermediate technologies the DCs are in a position to avoid more costly and less efficient transmission methods and move directly to digital IT infrastructure. Modern digital systems are not only far less costly but can also simultaneously transmit voice, data, text, TV and various other forms of information using the same hardware.

In terms of entry into production, the relatively low barriers to entry indicate that there may well be opportunities for DCs, especially the larger economies, to locally manufacture and develop systems. Local Brazilian firms for example, are already designing and manufacturing digital PCM and TDM equipment to supply the local market. Brazil has also developed a fibre optic transmission system and will be producing in volume for the local market this year (Hobday 1985). Brazil, of course, is a relatively large economy among the DCs, with a well developed scientific and technological base; however there may well be opportunities for smaller DCs to begin manufacture and gain the 'leading edge' advantages of direct experience in developing the technology.

2.1.3 Peripheral Equipment

Turning to peripheral equipment, market entry opportunities for DCs are probably greatest in this rapidly growing sub-sector. As a consequence of digital diffusion the manufacturing processes and the products themselves have converged with several other industries experiencing microelectronic innovation. The 'merger' of the computer and TCs industries, based on semiconductor technology, has given rise to market entry not only from traditional computer firms, but also the office equipment industry and even some areas of the consumer electronics industry. The economic attraction of digital technology is again, far greater capacity, speed, flexibility, a much wider range of functions and an overall improvement in cost/performance ratios - as compared with electromechanical analogue equipment.

Here again the traditional market boundaries are being radically redefined, competition is increasing, and equipment prices are in general, falling. Digital technology has created a far larger market and in spite of economic recession many new products and applications are recording increasing sales.

It is in the peripheral sub-sector that the barriers to entry are lowest in TCs. Consequently there is a growing range of technological opportunities for entry by DCs in many important areas such as intelligent terminals, modem and codec equipment, key systems, mobile radio, visual display units etc. The very rapidly growing PABX market is also sometimes included in this sector.

2.2 The 'technological divisibility' of digital TCs - new opportunities for Developing Countries.

In order to understand the overall prospects for DCs in view of the rapidly changing technology it is helpful to explain in more depth the nature of digital technology in contrast to electromechanical technology. Hopefully an analysis of how 'digitalisation' has transformed TC products and processes will shed further light on the opportunities facing DCs.

As noted earlier digital technology is intrinsically modular which means that a system is comprised of a range of independent but compatable modules which together form the TC network. Put another way digital systems are 'horizontalized' in the sense that various independent components form the building blocks of an expandable system. So too in the manufacturing process microelectronic components constitute the building blocks of the product and resemble more and more the final good itself. This is in sharp contrast to electromechanical technology. Here, there is a high degree of vertical integration in the production process with a large number of specialised TC component inputs such as relays, screws and connectors. Under the 'verticalized' electromechanical technology most of the component parts are manufactured by the TC manufacturers themselves and the skills and knowhow required in production are very specific to TCs. Indeed a thoroughgoing engineering capacity is required in virually all stages of component production, testing, manufacture, installation and maintenance. The actual manufacture of electromechancial crossbar systems is a far more complex process than with digital technology and large numbers of engineers and technicians are needed especially in fine engineering and electromechanical interfacing.

In constrast, the modular 'horizontalized' nature of digital technology requires far less engineering in manufacturing,which resembles a simpler assembly process. A large proportion of the microelectronic components are bought in from semiconductor manufacturers outside the TC industry itself. (Material input costs, now primarily semiconductors, have risen to an estimated 70% of total direct costs in 1978, from only 20% in 1965, OECD 1983 p57). The horizontal nature of digital technology implies a far higher degree of capital and technological divisibility. Capital divisibility implies more opportunities for smaller scale investments in specialised product areas - this is the case even in the highly complex exchange systems. The concept of 'technological divisibility'is also extremely useful in this context. The technological divisibility of digital TCs means that it is possible to select a specific product area and master the design and production process. In this manner skills can be gradually learned and accumulated as firms move upwards towards more complex products and systems.

Although it is not possible here to discuss these technological issues in detail it is plain to see how digital technology has both radically transformed the international market structure in TCs, and provided opportunities for DCs to enter the previously guarded market. Digital diffusion has acted to break down the electromechanical oligopoly which characterised the industry for many years. The oligopoly of the TC suppliers was closely associated with the vertically integrated production process, in-house component suppliers, and TC specific engineering skills. As the diffusion of digital technology occurred the products not only became far cheaper and generally superior, but also many new competitors were capable of entering the industry. The technological convergence of a 'cluster' of industries based on digital information technology allowed entry from the computer, aerospace, office equipment and other, traditionally seperate, industies. Although the traditional manufacturers still dominate the large-scale public exchange market, this represents a declining share of the total TC industry and in PABXs, transmission and peripheral technologies new competitors are seriously challenging the traditional suppliers.

Indeed this process of 'technological convergence' around semiconductor digital technology is one of the striking features of the information technology industry. Conceptually this can be viewed as an acceleration of the process of technological convergence during the 19th and 20th centuries described by Rosenberg (1976, pp 156-157) where many previously unrelated products in terms of nature and use became closely related on a manufacturing technology basis. This process of technological convergence not only applies to IT finished products and their manufacturing processes, but also to the production of the microelectronic building blocks of the IT industry. It is remarkable that semiconductor components covering such widely diverse applications as consumer, computer and military industries, are all manufactured in basically the same way.

As far as the DCs are concerned this process of digitalisation presents several important opportunities for market entry. Under electromechanical technology a thoroughgoing engineering capacity was required throughout the development, manufacture and even operation and maintenance of the networks. This both supported the stability of the industry and prevented entry by DC as well as IAC firms. With digital technology far fewer engineering skills are required. A small range of high level information-based design skills, coupled with a much wider range of simple assembly and testing skills are needed. This process of skill polarisation is a common feature of the IT industry.

Given a supply of these information-based design skills DCs are in a good position to enter the manufacture of several important areas of the TC industry and IT in general. Following design and development the manufacturing process itself is a relatively simple, assembly type operation requiring far fewer engineering and technical expertise. In operation and maintenance there is also a dramatic reduction in the numbers of engineers and technicians needed. Rather than being an obstacle to DC entry, skill polarisation under digital

IT may assist in overcoming existing skill bottlenecks especially in fine engineering and electromechanical interfacing. The move to digital technology could potentially allow the application of existing research and university resources more directly to the design and development of local products in telecommunications. In fact the convergence around semiconductor technology cuts both ways not only allowing other industries to enter TC production, but also TC producers to enter other areas of IT. In the following an effort will be made to identify possible TC led strategies to exploit these potential technological opportunities.

PART 3 TELECOMMUNICATIONS IN LATIN AMERICA - CURRENT DEMAND AND IMPORT SUBSTITUTION POSSIBILITIES.

The previous sections attempted to show that, potentially at least, there are very real possibilities for entry or import-substitution in TCs as a result of the shift to digital technology. The aim of this section is to examine the dimensions and growth of the Latin American TC market. An attempt is made to illustrate: first, the large overall size of the TC market; second, the general trend towards fully digital TCs and third, the centralisation of TC planning and purchasing under government administrations. Overall there appears to be considerable potential for Latin American countries to both 'leap-frog' older forms of communications infrastructure, and to use TCs as a leading edge in developing an IT industrial base for the region. In successfully exploiting any technological opportunities much will depend on coordinated and deliberate government policy both at the national and regional level. Part 4 looks in more detail at some of the individual countries of the region to identify possible TC led strategies of IT development.

Table 2 overleaf presents selected telecommunications and economic data for the major countries of the region, and as can be seen,country variations in terms of population and economic size are reflected in existing infrastructure. Although these data are now somewhat out of date they clearly illustrate the wide variations in installed infrastructure accross countries. Brazil, Mexico and Argentina are at the top end of the scale with several millions of telephone lines and countries such as Bolivia and Ecuador are at the lower end with installations in the hundreds of thousands.

GNP per capita broadly corresponds to telephone density reflecting the well established correlation between TCs and economic development indicators (Saunders et al. 1983 Chapter 4). Countries with relatively high per capita incomes such as Venezuela, Argentina and Costa Rica also register high telephone densities. Conversely, poorer countries such as

Table 2 Selected Telecommunications and Economic Indicators - Latin America circa 1980.

Country	Total Telephone Lines '000s	Total Telex Subscribers	Telephone Density Per 100 population	Total Population Millions	GNP per capita Income ($1979)
Argentina	1850	5000	10.3	27.0	2210
Bolivia	127	330	2.6	5.0	550
Brazil	4000	28000	6.3	115.0	1770
Chile	380	2000	5.0	11.0	1890
Colombia	1250	3400	6.0	30.0	1060
Costa Rica	112	800	10.4	2.3	1630
Dominican Rpblc.	110	900	n/a	6.0	n/a
Ecuador	220	1500	3.2	8.3	1110
Mexico	2520	8700	7.5	70.0	1880
Peru	232	2000	2.8	17.7	850
Venezuela	750	8000	8.6	14.1	3440
Sub Totals	11550	60600			
Other (17 Countries)	1280	8200			
Totals	12830	68800			

Sources: A.D.Little, Saunders et al (1983)

Bolivia, Peru and Euador register both low incomes per capita and low telephone densities.

As a result of the poor overall condition of much of the existing infrastructure in many of the countries of Latin America, systems are often subject to overloading at peak periods, and there is a general problem of unreliability and technical incompatability across countries. Furthermore in most countries there are large unmet demands for telephones, both registered and unregistered. These problems have led most Latin American countries to establish overall government owned or controlled operating service companies. By centralising TCs under one government entity it is possible to plan the expansion of existing networks and to introduce new technology systematically.

To understand the scope for import substitution and local production overall it is helpful to examine the current and forecasted equipment markets by value across countries. As table 3 below demonstrates, total TC demand for the region is estimated to have grown from $1.2 billion in 1980 to $1.8 billion in 1985, and then forecast to reach $2.4 billion in 1990. (All data unless otherwise stated are from A.D. Little Inc.) This represents a doubling of the market over the 1980s.

Overall the current market size represents appx. 3% of the total world market and while this appears very small, it can be misleading as Latin America represents an extremely important segment of the world market. Although the market represents only 3% of total world sales, in terms of digital public switching Latin America accounts for 16.3% of sales which compares with say 27.3% for Europe and 28% for the USA. As noted earlier sales to uncommitted third world markets are extremely important to the major multinational suppliers and Latin America represents a major and growing share of these sales. Equipment sales for the region are over 3 times the total for Africa, one and a half times Oceana, and far larger than less developed Asia. Regional plans for installing digital technology increases the importance of the Latin American market

Table 3 Telecommunications Equipment Markets in the Latin American Region. (Millions of dollars)[1]

A) Total Market	1980	1985	1990	Annual Average Growth % 1980-85	1986-90
Argentina	116.0	162.3	226.1	6.9	7.0
Bolivia	11.0	15.5	22.2	7.7	7.0
Brazil	474.6	713.3	868.3	8.5	4.0
Chile	25.9	42.1	61.4	10.2	8.0
Colombia	68.4	105.2	147.5	9.0	7.0
Costa Rica	18.2	24.1	29.4	5.8	4.0
Dominican Rpblc.	6.5	9.3	13.7	7.4	8.0
Ecuador	11.2	17.4	24.5	9.2	7.0
Mexico	175.6	285.5	430.9	10.2	9.0
Peru	21.5	41.0	81.5	13.8	15.0
Venezuela	97.1	188.1	248.3	14.1	6.0
Other Countries	146.7	200.5	236.9	6.5	3.0
Grand Total	1172.7	1804.3	2390.7	9.0	6.0

B) System Market	1980	1985	1990	1980-85	1986-90
Telephone	978.0	1524.1	2010.4	9.3	6.0
Telex, Telegraph and data	104.9	144.3	186.4	6.6	5.0
Satellite Comms.	14.2	14.6	34.0	0.6	18.0
Mobile Radio	70.4	111.9	145.3	9.7	5.0
Radio Paging	3.5	6.8	10.6	14.2	9.0
Cable TV	1.7	2.6	4.0	8.9	9.0
Grand Total	1172.7	1804.3	2390.7	9.0	6.0

1 Constant 1979 dollars

Source A.D. Little Inc.

and MNC competition within the region is expected to be very intense throughout the '80s.

Growth rates are expected to fall from an annual average of 9.0% over the 1980-85 period to around 6% p.a. over 1986-90. The estimated fall off in growth is partly due to assumptions regarding the Brazilian market which represents around 40% of the overall total, and also due to the fact that the starting base in 1985 is that much higher. The five largest markets, Brazil, Mexico, Argentina, Colombia and Venezuela represent around 80% of the Latin American market. The top 11 countries listed above constitute about 90% of the total equipment market and account for roughly 90% of all installed infrastructure in the region.

Part B of table 3 gives a breakdown of equipment sales within the TC sector. As in other regions the telephone market overwhelmingly dominates, accounting for roughly 83% of total demand. Within the telephone market the shares as between switching, transmission and peripheral equipment are not significantly different from international shares as discussed in part 2.1 above. In keeping with international trends the PABX market is expected to continue to grow rapidly. The balance of the market is largely accounted for by telegraph, telex, data transmission, mobile radio and radio telephone equipment.

Turning to technological trends within the region, while the pace of technological change is very uneven as between countries there is a general shift towards fully digital stored programme controlled (SPC) public switching. Recognition of the clear superiority of fully digital over previous systems has led most countries to establish plans to expand networks using digital technology. Brazil, Mexico, Argentina, Chile, Colombia and Peru have all begun the process of planning and contracting for SPC equipment. Some of the smaller countries of the region (in terms of TC market size) such as Ecuador and Bolivia are proceeding much more slowly towards fully electronic technology.

As far as transmission equipment is concered there are general plans for the upgrading of old paper insulated underground cables, and the diffusion of digital PCM and TDM systems is expected to continue rapidly. In terms of microwave transmission there is a slow move towards digitally modulated systems, and more digital satellite transmission will be adopted throughout the '80s and the '90s. In the PABX and peripheral market new demand is generally for digital equipment due to its economic and technical superiority, and there is a growing demand for equipment such as mobile radio and key systems, modems etc. Most of the larger economies are also expanding digital data transmission and telex facilities.

An important area of concern which should be mentioned here is the overwhelming focus of most planning for urban TC expansion and the danger that the rural areas will lag seriously behind. The greater demand for urban TCs and the higher levels of profitability in comparison with the rural sector has led to the concentration of investment in the major industrial centres. Despite some projects for rural expansion in several Latin American countries such as Costa Rica and Brazil and a number of rural TC cooperatives, rural TC expansion remains very much a second priority. This partly reflects the deeper poverty in the rural areas and the generally superior infrastructural developments in the urban sectors. Nevertheless without sufficient attention to rural telecommunications planning, there remains a very real long-term threat to agricultural efficiency, regional integration, and further urban/rural inequality.

Returning to the issue of market trends most of the Latin American market is supplied by the major international corporations or their subsidiaries located in the various countries. Table 4 provides details of the major suppliers, by country, in rough order of importance for the switching equipment market. With the shift to digital technology Japanese firms such as NEC, Oki and Hitachi are challenging the traditionally dominant European and US firms. The traditional suppliers, ITT, Ericsson and Siemens are also being challenged by Japanese

Table 4 Leading Suppliers of Telephone Exchange Equipment in Latin America.

Country	Principal Suppliers in Approximate Order of Importance.
Brazil	Ericsson, ITT, NEC, Siemens
Mexico	ITT, Ericsson
Argentina	ITT, Siemens, Ericsson, NEC.
Colombia	Ericsson, ITT, Siemens
Venezuela	Ericsson, ITT, Hitachi
Chile	ITT, NEC
Peru	ITT, Philips
Ecuador	Ericsson
Bolivia	Oki, Ericcson
Costa Rica	Ericsson, ITT, GTE
Dominican Rpblc.	GTE

Source: A.D. Little Inc.

firms in the transmission and peripheral equipment markets.

Additional pressures towards increasing competition are arising from the trend towards centralisation of TC organisation and planning under government administration. This has enabled the larger DCs notably Brazil, Mexico and Argentina, to insist that manufacturing and in some cases technological facilities are located within national boundaries. In effect the governments monopsony purchasing power is being used as a strategic means of aquiring local production facilities and increasing the competition among the suppliers who are obliged to comply to gain orders and remain in the market. This is a position very peculiar to TCs and does not apply to other areas of IT, for example in computer and office equipment sales, where purchasing is distributed across government, industry, and mass market sectors. This again strengthens the argument for using the TC sector as a major leading edge in the accumulation of digital technology for the DCs.

In summary the above analysis indicates that there exists a real potential for Latin America to employ TCs as a leading edge in the aquisition of a base in digital technology, and indeed to gain the advantages of leapfrogging earlier forms of infrastructure. Latin America represents a large and rapidly growing market experiencing a general shift towards digital technology. The centralisation of TC purchasing in government hands allows the possibility of import-substitution by local firms, and local government to insist that a greater level of manufacturing by the MNCs is actually located within national boundaries. However for the individual countries of the region much will depend on local market size and possibilities of regional collaboration. In addition coordinated national and regional policies will also be a determining factor in establishing a manufacturing and technological base in IT. The following attempts to highlight the considerable variations accross individual countries and attempts to identify possibilities for market entry.

PART 4 A PRELIMINARY SURVEY OF LOCAL TC DEVELOPMENTS AND PROSPECTS FOR REGIONAL COLLABORATION.

The aim of this section is to provide a brief survey of the major countries of the region and to point to areas of possible international collaboration, especially among smaller countries. A great deal of further research is needed in this area and here it is only possible to selectively discuss the general status of local manufacturing and technological achievements for the larger markets of the region. Several of the economies of Latin America already possess a surprisingly strong capacity in telecommunications technology and an effort is made to identify possible strategies of TC-led information technology development. Recent experiences of international cooperation within for example, the Andean and Central American sub regions suggest that although there is a strong impetus to coordinate TC planning internationally, there exists far greater scope for these kinds of efforts especially in the area of technological collaboration.

In terms of telecommunications demand the four largest countries of the region, Brazil, Mexico, Argentina and Venezuela represent around 75% of total TC sales. It is useful therefore to briefly discuss each of these countries in turn.

4.1 Brazil

Within Latin America Brazil stands out as an example of how, through coordinated government policy initiatives, rapid infrastructural developments can be achieved in conjunction with domestic industrial and technological progress. A detailed analysis of Brazil's remarkable achievements in this area is presented elsewhere (Hobday 1985). Here it is helpful to briefly outline: a) Brazil's strategy of technological accumulation in digital TCs, and b) the developing linkages between TCs and broader IT. These two facets of the Brazilian TC industry hold valuable insights for other Latin American countries wishing to follow a similar path in establishing a national base in digital technology.

In the early '70s Brazil set itself two main objectives - to build a modern, efficient TC infrastructure and to establish a thoroughgoing industrial base in TC technology (the decision to acquire fully digital technology took place as early as 1976). To achieve these complementary aims the ministry of communications set up an R&D centre in TCs (CPqD) under the overall operating company Telebras. The centre was responsible for mastering all main areas of digital technology in TCs. At the same time all regional purchasing was centralised under Telebras and this substantial monopsony power was to be used to insist that the MNC subsidiaries located more manufacturing and technological facilities within the national boundaries, and where possible to foster the development of new Brazilian firms. CPqD also played a major role in this respect. The gradual accumulation of knowhow and technical expertise gave Brazil an improved bargaining position in relation to the MNCs and ensured a greater degree of technological integration of the subsidiaries. In addition the centre was responsible for assessing local firms' capabilities and choosing which firms would participate in the joint development and eventually production of equipment for the local market.

This pragmatic approach towards TC development succeeded in achieving a rapid expansion and general upgrading of the TC network. The numbers of telephones and telexes increased dramatically, while the extended and improved transmission infrastructure ensured that almost all of Brazil's regions became integrated within the national communications network. It is the view of the orchestrators of this strategy that the infrastructural improvements could not have been achieved without a corresponding upgrading of the nation's industrial and technological capacity in TCs. At the level of R&D and national and MNC industry, a substantial base in digital technology was created in almost all important areas of peripheral and transmission technology. Even in the highly complex area of public switching the government R&D centre has produced small exchanges suitable for rural TCs, and feels confident that it can move upwards to medium and large scale public exchanges. The close relationship between the operating companies and the equipment suppliers meant that the upgrading of technological capacity at the industrial level was crucial in supporting the rapidly expanding network.

In terms of establishing a broader base in IT, and in effect using TCs as a cutting edge in digital technology, there are various important achievements and limitations,of direct interest to other DCs. At the level of IT infrastructure there can be little doubt that the upgraded network is well equipped to meet the growing national and international demands for informatics and telematics services. Indeed much of the installed equipment is of later vintage technology than that of developed Europe. Most new exchanges being installed currently employ the latest digital TDS switching, and in this sense Brazil is effectively leap-frogging earlier technology. At the industrial level several of the larger domestic TC firms are currently developing and producing other related IT products such as microcomputers and data transmission equipment, as well as fibre optic systems. The convergence discussed earlier of several information based industries around digital technology has allowed greater scope for diversification by TC firms in Brazil (as elsewhere), and the application of accumulated engineering and management skills to other areas of IT.

Finally at the level of R&D, the government TC development centre has already set up a wide range of digital TC programmes which, potentially, have wider IT application. Substantial experience has been gained in setting up electronic capital equipment and designing various digital products. For instance the first Brazilian integrated circuit suitable for mass production was produced by the centre and a further 4 chips have been successfully developed. These and other achievements such as the development of distributed TDS exchange technology demanded a great deal of expertise in software, CAD, mask production, testing, quality control and in the overall management of information technology. Potentially this substantial base of skills (appx. 800 engineers are employed) could be used for engineering training in various aspects of IT design, prototype development, management etc. Indeed the centre is already responsible for training of industrial engineers in domestic TC firms, and is participating in the establishment of the new informatics technology centre (CTI). The TC centre is also providing a source of highly trained engineers and specialists for the informatics centre.

Given the tendency towards technological convergence an overall IT or telematics planning administration would probably assist a great deal in exploiting any potential leading edge linkages between TCs and other areas of IT. Most other Latin American countries do not have such institutions or ministries, and TCs are usually organised seperately from other areas of IT especially in R&D and industrial policy.

Also it must be remembered that Brazil is very much a special case in Latin America with an internal TC market greater than two and a half times the size of its nearest rival (Mexico), and many times larger than most of the other nations of the region. Furthermore Brazil has a very well developed university and technological infrastructure to provide the skills and expertise for local industry and research. In discussing other Latin American countries it is therefore imperative to look towards areas of potential regional collaboration, joint development, and specialisation in the development of TC and information technology.

4.2 Mexico

As noted above Mexico is the second largest TC market in Latin America with an estimated equipment sales of $286m in 1985. (Unless otherwise stated sales data are from A.D.Little in constant 1979 prices). The overall operating company, Telemex, has like Brazil taken steps to raise the level of economic and technological integration of the MNC subsidiaries within the country, in order to help establish a greater indigenous capacity in TCs. Recent government policy has been directed towards assuring Mexican capital participation in the subsidiaries and efforts to increase the nationalisation indices of inputs. The government has also established the long term objective of encouraging greater participation of local industy not only in TCs but in informatics too.

In terms of R&D capacity Mexico has 7 main electronics R&D centres of which the TC centre, Indetelec, is the largest. Together these institutes are involved in several important areas of IT development, including semiconductor design and diffusion, digital TC development and network planning, micro-computer development, computer software, and electronic instrumentation (Galli 1982).

Indetelec was established in 1981 and is a joint venture between Indetel (a former ITT subsidiary, now jointly owned), and Mexican government and private capital. The centre has appx. 275 employees of which 200 are engineers. Technological activities are shared between adaptation of ITTs digital exchange to suit Mexican TC conditions, and increasingly the development of digital transmission and peripheral equipment. Already Indetelec has developed fairly sophisticated software expertise for the exchange system. In addition Indetel overall has achieved high levels of nationalisation of inputs in all but main exchange technology, and subcontracts to around 250 Mexican suppliers.

The second largest MNC supplier, Ericsson, has far less local technological capacity especially in the area of fully digital technology. There is no local technological input to the AXE digital exchange and none planned. All system design and adaptation is carried out almost exclusively in the parent company in Sweden, and local engineering capacity is confined to very low level digital products, and electromechanical crossbar technology.

The different levels of technological integration of the MNCs may reflect the global profit strategies of the two corporations. Unlike Ericsson, ITT has a strictly decentralised profit cost centre (PCC) strategy which means that each plant must be independently profitable. All inputs including technology, have to be paid for by local subsidiaries and this has led to the building up of local technological capacity in Mexico, as in Brazil. Indeed ITTs Mexican subsidiary does not duplicate technological efforts conducted in other ITT plants abroad and technological developments in Mexico can be exported to other ITT subsidiaries. However, as the Brazilian case illustrated, Ericsson is also willing to transfer greater levels of technology if the necessity arises. There is therefore probably scope for additional local technological activity by Ericsson, if government policy encourages this.

Mexico is also embarking on R&D through a new centre, the National Institute of Communications, under the operating company Telmex. Already Telmex is engaged in the joint manufacture of PABXs with a Canadian firm, and has developed programmes to support the planned network expansion encouraging local firms to paricipate through the use of its purchasing power.

In terms of IT, as Tigre (1983) argues, there is real potential for linking TC activities to the closely related area of telematics. With a coordinated state purchasing policy, and long-term technology strategy, there is scope for entry into IT in such areas as microcomputers, distributed data processing systems, data terminals for videotext, automated office equipment etc. By reserving selected markets for local manufacturers wherever possible and providing support to local industry, Mexico could well enter these areas of IT.

To successfully exploit the existing technological base closer links would also be required between the activities of the research institutes and local industrial requirements. Opportunities in this area will depend very much on Mexico's long-term commitment to local technology.

4.3 Argentina

Like Mexico, Argentina also has a fairly well established university and scientific infrastructure and a large demand for TC equipment, in the region of $162m this year. Argentina's existing electronics industry and internal demand for TCs again offers potential for the broader development of IT. By 1978 Argentina had already established considerable experience in the general field of electronics. At this time the electronics industrial base amounted to over 300 firms employing over 27,000 people, and producing an annual output of over $460 millions (Maxwell 1983). Mucn of this output is not in digital but analogue technology and includes a substantial proportion of consumer electronics. However, in terms of a technological resource base the electronics sector as a whole employed around 1800 engineers. In addition the Secretariat of Communications coordinates various projects directly concerned with digital technology.

In 1976 the three existing research institutes were amalgamated under an organistation called CENICE, responsible for several development projects in solid state technology (Galli 1983). These projects include the development of hybrid circuits for local TC industrial production, and the design of a limited range of integrated circuits and transistors. The TC sector in Argentina acts then as a source of organisation and financefor digital technological development. Furthermore the rapid forecast growth in TC demand in the region of 7% p.a. over the period 1986 to 1990 means that potentially at least TCs could be a leading source of demand for IT production and development locally.

If we turn to local TC infrastructural organisation the overall operating company Entel is also a source of engineering capacity. Entel employees a total of 45,000 people responsible for the planning, operation and maintenance of roughly 90% of Argentina's telephone network. There now exists a very substantial unmet demand for TC services and the upgrading of several transmisson network systems needs attending to. Entel has therefore planned major improvements and expansion of the system and digital equipment is expected to be adopted rapidly.

There are three major MNC equipment suppliers, manufacturing and assembling equipment within the country with ITT responsible for 60% of installed facilities, Siemens with 30% and Ericsson with about 10%. Japanese suppliers such as Hitachi are also keen to participate in the market and generally the open market policy has led to increasing competition among the corporations.

Further investigation is required to establish the exact level of technological capacity of the subsidiaries. The ITT subsidiary, CSEA, partly owned by an Argentinian conglomerate, employed a workforce of about 3200 in 1980 and manufactured SXS electromechanical exchanges, PBXs, and a range of other equipment. Siemens assemble exchange equipment mainly from imported components. It appears that little desigr and development capacity is concentrated in the subsidiaries and additional research is recommended here especially in view of the government's plans for TC expansion and upgrading.

Existing demand from the public TC sector certainly could be employed as a lead in encouraging local industry, and in negotiating for higher levels of technology transfer on the part of the MNCs. Given Argentina's relatively small market, any IT strategy would need to be both selective and probably require government technological and financial support. Maxwell (1983) suggests two possible strategies: first, the support of low volume, small scale, non standardised products engineered for the local market (eg. microcomputers); second, the strategic choice of a small range of high volume, standardised products or components with a view on export markets. These strategies need not be mutually exclusive but both would require consistency in terms of government support.

A further stategy open to Argentina lies in greater regional cooperation and technology exchange. The country has certainly shown willingness to extend cooperation in TC technology. In 1980 for example, a presidential agreement was signed between the Secretary of State for Communications in Argentina, and the Ministry of Communications in Brazil, covering cooperation in technological and scientific research in TCs. On the broader IT front, Argenina's relatively sophisicated base in numerically controlled machine tools for example (Jacobsson 1983) indicates the possibility not only for exporting to Brazil but also for technology exchange. Conversely Brazil's greater technological capacity in digital TCs provides scope for technology exports and cooperation. Argentina's participation in the 1981 Peruvian scientific and technological cooperation agreement on exchanging expertise and technology, both with Brazil and other Latin American countries, also illustrates the awareness of the benefits to be gained from these types of collaboration.

Ultimately much will depend on any new plans for the expansion and updating of Argentina's TC network by the administration, but potential does exist for TCs to play a leading role as a source of demand, technological expertise, and regional exchanges in technology.

4.4 Venezuela

Although Venezuela boasts one of the highest telephone densities and equipment market sizes in Latin America, the electronics base of the economy is less developed in relation to Brazil, Mexico and Argentina. Venezuela has the highest per capita income in Latin America yet the economic prosperity of the country remains very much based on natural resources and extractive industries, rather than manufacturing production. Although industries such as aluminium, iron and steel, and refined petroleum have been growing rapidly, natural resource industries such as natural gas, petroleum, hydroelectric power, gold and other minerals are still central to economic output and exports. Manufacturing output however grew very rapidly during the '70s at an average rate of 12% per annum, and by 1980 accounted for roughly 25% of GNP and 20% of the labour force.

Available data for the Venezuelan electronics industry are very sparse and research needs to be carried out to gain a proper appreciation of TC and IT development prospects. However, a recent report concerning the professional electronics industry (Chacon 1984) argues that there are very good prospects in the medium term given appropriate government support. As noted Venezuela is one of the wealthiest Latin American countries. Demand for IT products is high, and in addition, much of the extractive industries are state owned and the government uses revenues to support overall economic development. These factors would suggest that the government could play a dual role in terms of: a) providing a source of demand for output, and b) providing investment and technological support to local industry.

Indeed, as Chacon shows, government demand is already playing an important role in the development of the electronics industry. From a very low base the industry has grown extremely rapidly during the late '70s and early '80s averaging some 45% per annum in terms of sales. Government purchasing played a crucial role in the development of the new firms accounting for between 50% to 100% of demand in the early stages.

At present the microelectronics industrial base is very small with local manufacturers in TCs concentrating largely on electromechanical products and very low level digital equipment. TC output is largely in transmission equipment, voltage regulators and other electromechanical devices. In fully electronic technology production is carried out in modems, PABXs, and telex-computer interfacing devices. Interestingly, in the new professional electronics firms overall

42% of those employed are in professional and technologically related areas, of which one third is in R&D. A gradual learning process is occurring in the industry with 30 or so high technology product innovations in production so far.

In the TC sector government demand is often 100% of local firm's total output. Firms are a mixture of local private capital, wholly owned MNC subsidiaries, and joint government/private ventures. In the transmission area output is concentrated in TC cables, in peripheral equipment ouput is largely in PBX (20-200 extensions), together with telephone handsets and teletype terminals. Most public exchange, and digital transmission and telex equipment is imported from the major corporations. The level of locally based technology within the subsidiaries is not clear, neither are government plans towards domestic technology development.

In terms of infrastructure the govenment does plan to introduce digital switching technology, and to install fibre optic PCM transmission. In this manner the new systems will by-pass intermediate technologies and move directly to solid state technology. In view of the large equipment demand by the operating company CANTV, and plans for network expansion there is probably scope for some manufacturing and technological facilities to be located within national boundaries. A detailed assessment would be necessary to evaluate any possibility of linking TC activities to other areas of IT development. Government commitment to long-term technology development would be crucial to any success in the field.

Overall, there does appear to be considerable scope for the larger countries of the region to enter the manufacture and development of IT products. Potentially TCs, as stressed, could play a leading role not only in terms of technological development, but also as a centralised source of demand. When discussing the poorer, and smaller countries of the region it is necessary to look towards possible areas of mutual collaboration to help overcome problems of insufficient scale, poorly developed R&D infrastructure, and the lack of investment resources.

4.5 Other countries of Latin America and possibilities of regional cooperation.

Detailed information on TC and IT developments is extremely limited for the majority of Latin American countries, particularly the smaller economies. There is however evidence that some countries are already entering the manufacture of IT and that TC expansion, as with the larger economies, could play an important role in galvanising local technology and providing a leading source of demand for local production.

Excluding the 4 largest markets, the remaining countries together account for appx. 25% of total Latin American TC sales, around $455 millions in 1985. This constitutes a substantial demand overall and there are also plans in many of the countries to install digital technology. It is important to emphasise that these countries are in no sense an homogenous group, economically, geographically or in terms of telecommunication needs. Equipment demand ranges from Colombia, in the region of $105 millions in 1985 to Bolivia with $15.5m, the Dominican Republic with $9.3m, and other even smaller markets.

Colombia's relatively large TC market and rapid annual growth suggests there is some scope for the manufacture of some TC equipment and possibly some technological development too. Currently most TC equipment is imported from the major European and increasingly, Japanese suppliers. A shift to fully electronic technology is planned over the '80s and the overall TC authority could use its purchasing powers to stimulate local TC and IT production. Indeed there are joint ventures involving government and MNC enterprise in this area and further investigation is recommended to clarify existing plans, and the current level of technological infrastructure. The planned TC expansion in the Amazon region could also be an opportunity for collaboration with Brazilian Ministry of Communications who are also engaged in investments in the Amazon.

Some of the smaller countries already have a surprising level of engineering and technological capacity in electronic technology. Uruguay for instance, has developed

SPC automatic telegraph exchanges and at least three small exchanges (over 100 lines) have been in operation for four years (Telebrasil 1983 Nov/Dec.) These were developed by a local firm in conjuction with the Uruguayan Institute for Electronic Engineering. Another local firm has developed a series of digital products including microcomputers. The quality of these products and prices are internationally competitive and some goods have been exported to Argentina. The relatively low cost of local engineers has proved an advantage. However the very small size of the local market means that specialisation is essential and entry into larger volume production could only be justified on the basis of exports.

Paraguay has 2 main electronics institutes associated with the TC sector. The large demand here for small rural exchanges indicates that Paraguay could potentially benefit from technological cooperation with Brazil, who have both developed and manufactured rural exchanges and are willing to engage in technology sharing arrangements. Costa Rica's rural TC plans could also benefit from Brazil's experience in this area. In the late '70s Costa Rica set up impressive plans for rural TC expansion to serve over 500 local communities but it is not clear how far these plans have progressed, nor whether any local technology development was involved. The local PTT however does organise training abroad for local University engineers and has plans to develop enough technology to adapt systems to suit local circumstances. Costa Rica also has a rapidly growing TC demand and is shifting to fully digital technology.

Peru's TC demand is also rapidly growing and the market, currently standing at over $40m,is expected to double by 1990. At present virtually all equipment is imported but there were plans to set up a TC R&D centre and organise training abroad for local engineers. There is a planned shift to SPC technologyand the possibility of local participation in peripheral and perhaps transmission equipment. Currently only cable is being produced locally.

Both the Bolivian and Chilean TC networks have a heavy suppressed demand for services. Both countries have expansion plans for their TC networks and growth over the period 1985-1990 period is expected to be in the region of 8-10% p.a. in both countries. Some exchange assembly occurs in Chile but both countries rely almost completely on imports of equipment.

Any TC led development of IT will depend very much on the possibilities for regional collaboration, especially for the smaller countries. One of the peculiar characteristics of the TC sector is the close cooperation needed between countries to achieve technical compatability in international communications. Previous experiences of collaboration indicate at least a possibility of extending technological cooperation, and perhaps even reaching agreements on cooperative purchasing and manufacturing specialisation between countries. Here it is only possible to illustrate some examples of the different forms regional cooperation has taken in the past.

At the level of network collaboration there are many examples of international cooperation. In the Central American region CONTELCA, an overall planning body, was established in 1967. Member states included Guatemala, El Salvador, Honduras, Nicaragua and Costa Rica. In 1972 these countries formed INCATEL, the Central American Institute of Telecommunications, to provide training and technical assistance for the member states. During the '70s these organisations achieved several joint objectives including setting up a microwave system to link up the capital cities from Mexico in the north down to Panama in the south. The severe political and military conflict in the area militates against extension into joint planning, purchasing and technological collaboration.

Several projects have been attempted in the Andean sub-region where the principal organisations are CITEL, the Inter-American TC Conference and ASETA, the Association of Telephone Companies of the member countries. These organisations set up microwave links joining up Bolivia, Colombia, Ecuador, Peru and Venezuela. ASETA also established plans for wider integration through a major satellite programme but this appears to have been abandoned. While these and other examples of collaboration, such as automatic data communications networks, can be presented it must be acknowledged that so far little progress has been made towards technical standardisation, and joint planning and purchasing.

So too in the area of technological cooperation there is far greater scope for technology sharing, trading agreements and specialisation in manufacturing than has so far been achieved. In 1981 a basic scientific and technological cooperation agreement was reached in Peru involving 10 Latin American countries. Brazil has several times expressed a willingness to engage in inter DC technological collaboration and within this agreement Brazil was to send specialists to Honduras to assist in TC development. In several respects Brazil could play a key role in these types of agreements. Brazil has accumulated a considerable experience in developing digital technology locally and adapting systems to suit DC economic and geographical conditions. Brazil probably has more accumulated experience in this field than any other DC and certainly has a considerable advantage over the MNC suppliers in this respect. Overall though, the Peruvian agreement set the guidelines for the lending of technical services and personnel training rather than establishing plans for detailed technological collaboration.

4.6 Summary

Even the smallest DCs need an adequate level of technological capacity to plan, purchase and install TCs efficiently. Capabilities are also required to maintain and expand networks - over reliance on external sources of expertise runs the danger of sub-optimal operating efficiency, costly mistakes, inappropriate purchases etc. In the smaller countries of Latin America it may be necessary to rely predominately on local PTTs to ensure the aquisition of these capabilities. However, given the rapidly growing TC markets throughout the region, the possibility of international cooperation and specialisation in manufacturing and technological activities should be taken seriously. Any manufacturing investment decision would of course need to take full account of local market size, level of technological infrastructure, optimum production scales of specific product lines etc. (For a full discussion of investment criteria for TCs in DCs see Hobday 1985[A]). There is also the possibility of using TC purchasing demand to stimulate production in other areas of IT, but this would probably require overall IT or Telematics planning at the national level. As yet most countries of the region do not have integrated IT planning bodies and TCs are usually administered seperately.

In the larger countries of the area it may be both feasible and desirable to gain national capacity in TC through more substantial local manufacturing and R&D investment. Indeed this is already occurring in the major countries with PTTs engaging in joint ventures with MNCs, investments in domestic R&D, and the participation of new indigenous firms. One of the key factors in these activities is the centralisation of TC purchasing at the national level. This has enabled the DCs to negotiate more effectively with the MNCs for technology transfer and to foster the development of local industry.

CONCLUSION

Two main conclusions arise from the above discussion: first, that digital technological innovation presents a range of opportunities for market entry in the TC sector; second, there is good reason to believe that Latin America could exploit these opportunites given appropriate government policies. The process of digital technological diffusion has resulted in a dramatic restructuring of the TC industry worldwide. Competition has increased, new competitors have entered and the DCs have become increasingly important as non-committed export markets. At the same time the capital and technological divisibility of digital technology, in contrast to electromechanical, means there is also scope for DCs to enter what was for many years a stable and slow changing oligopoly. Indeed many of the obstacles which prevented DC entry in electromechanical technology are progressively being broken down as the restructuring of the industry proceeds.

Three features of the Latin American market illustrate at least the potential for import substitution in digital TC technology. First, the large and rapidly growing demand throughout the region. Second, the general trend towards the adoption of fully digital equipment. Third, the concentration of TC purchasing power, in most countries, under one central government administration. These features suggest that the possibility exists not only to "leap-frog" older forms of communications infrastructure, but also to exploit the leading edge properties of TCs in gaining a foothold in the broader area of IT in general. In the developed countries this key role of TCs in developing national capabilities is well recognised by governments, some of which are actively supporting their local supply industries in the competition for the rapidly growing IT markets worldwide. In the overall management of the technology gap it is therefore all the more crucial that DCs in Latin America,as elsewhere, respond to these trends and develop policies to prevent exclusion from many information based economic activities.

Telecommunications, of course, are only one of the possible leading edges in the accumulation of microelectronic capacity. Nevertheless TCs are especially important as they represent not only one of the largest sectors in the international economy, but also the very infrastructure for information activities. In fact, as far as infrastructure is concerned, the DCs have an advantage over the developed economies who are generally, heavily committed to less efficient, older vintage technologies. Many of the countries of Latin America are currently building and expanding their basic TC infrastructure, and by directly installing digital systems they are in a position to gain the enormous technological and economic advantages of by-passing earlier forms of infrastructure.

In Part 4 it was suggested that the existing and rapidly growing demand for digital TCs could be used to stimulate local industrial and technological development in many of the countries of Latin America. A surprising level of technology is already embodied in local PTTs, some of which are already engaging in joint manufacturing ventures and R&D investments. However, to exploit the leading edge properties of TCs and establish linkages with other areas of IT production, overall national coordination of IT and telematics activities would probably be necessary. As the technologies in these areas converge, institutional rigidities and divisions may act to prevent possible linkages at the planning, manufacturing and R&D levels. Clearly far more detailed research is required in this area, especially in the assessment of local investment opportunities, but there does appear to be greater scope for Latin American entry into digital TCs. However, as stressed throughout, the exploitation of any opportunities in the area will depend very much on active and well coordinated government policies.

Glossary of technical terms.

ANALOGUE Electro-magnetic wave form used in transmission. Analagous to a continuously variable physical quantity such as temperature. Digital transmission on the other hand is transmitted in discrete, seperate pulses using Pulse Code Modulation(PCM).

COAXIAL A cable used for trunk transmission. The coaxial outer sheath and central coil are both electrical conductors, seperated from each other by an insulating material. Expensive to install in comparison with alternative systems such as microwave relays and fibre optics.

CODEC Coder/decoder. Converts analogue speech into digital form for transmission and back again for reception.

CROSSBAR Near obsolete, electromechanical switching system, used as an intermediate technology between Strowger and fully electronic exchanges.

DIGITAL A discrete or discontinuous signal transmitted in intervals. Most modern TC and computer technology is now based on digital data transmission because of its advantages over analogue, in terms of speed and low cost per bit of information. The terms "digital" and "microelectronic" and sometimes "PCM" are used interchangably to describe modern TC systems.

ELECTROMECHANICAL Semi-electronic, incorporating moving parts unlike solid state microelectronic technology.

HYBRID CIRCUIT A large scale integrated circuit with other miniturised components such as resistors, conductors and capacitors deposited on the same chip.

INFORMATICS Automated digital data processing systems incorporating hardware and software, involving one or more computers. Transmission between computers is normally processed using PCM techniques.

INFORMATION TECHNOLOGY The range of TC, telematics and informatics technologies based upon semiconductor technology, which permit the storage, transmission and manipulation of data in digital form at low cost and great speed. The term is sometimes used to describe all microelectronic applications and processes Here, however, the term does not include industrial applications of micro technology but is confined to the "information-intensive" industries mentioned above.

INTEGRATED CIRCUIT Also known as a "chip", a microelectronic device, and a semiconductor component. IC's represent the building blocks of the entire microelectronics industry. A ciruit is designed using CAD and a miniturised physical pattern or "mask" is produced, which is then "etched" onto silicon wafers using a complex photo/chemical process. The wafers are then divided up into thousands of individual circuits and mounted onto plastic or ceramic packages and tested. The latest VLSI (very large scale integration) technology allows several hundred thousand circuits to be condensed on one tiny chip.

IT (Information Technology)

MICROELECTRONIC (see integrated circuit and digital).

MICROWAVE Very short electromagnetic radio wave, within the overall wavelength spectrum of long, medium, short, infrared, ultraviolet, X-ray and gamma ray.

MODEM Equipment for modulation and de-modulation of TC signals. In other words it takes an analogue electrical signal and converts it into a digital one for rapid, low cost transmission.

OPTICAL FIBRE Used in PCM transmission, made of silica which is much cheaper and more readily avaible than copper which is used in conventional cables. Advantages over coaxial cable are: larger capacity, resistance to corrosion but not to transmission signals (therefore less signal regenerators or "boosters" needed). In addition fibre optics can be installed using existing infrastructure such as coaxial ducts or railway lines.

PABX Private automatic branch exchange. Self-contained, digital telephone exchanges used by private organisations.

PCM (See pulse code modulation).

PULSE CODE MODULATION Digital transmission of information by modulation of a pulse according to a code.

SEMICONDUCTOR (See integrated circuit).

SOLID STATE No moving parts, fully digital or electronic, as opposed to electromechanical.

STROWGER Electromechanical telephone exchange invented in Kansas in 1889, based on banks of rotary switches connected in series - slow, inflexible and costly in comparison with solid-state systems.

TDM (See time division multiplexing).

TDS (See time division switching).

TELECOMMUNICATIONS Refers to the systems required to produce instantaneous, interactive, communication of information (including speech) across distances. Letter post for example is therefore excluded because it is neither instantaneous nor two-way. Similarly TV and other broadcasting is not included because it is not interactive. The telephone industry accounts for appx. 80% of TC services, while telegraph, telex, and data processing form the large proportion of the balance.

TELEMATICS Also known as teleinformatics. Telematics is based on the fusion of computer and TC technologies made possible by digital technology. Data in digital form is stored, manipulated and transmitted betweencomputers using public TC transmission networks. Telematics also employs broadcasting transmisssion facilities - for example TV sets can be used to access various types of information.(see Videotext).

Time Division Multiplexing A digital transmission mechanism by which many conversations and other signals can be simultaneously transmitted by "interweaving" samples of each signal. Many types of signals can be "multiplexed" together without interfering with each other - unlike unalogue systems.(Also see time division switching)

TIME DIVISION SWITCHING TDS is the most recent stored programme controlled exchange technology. Signals are transferred from one point to another by sending samples down different paths, depending on their desired destination. At exactly the right time a particular "gate" opens and allows the signals down a specific path. By changing the times at which the gate opens different signals can be accepted. TDS is more economical than conventional space division switching (SDS) where the physical path is permanently connected.

Videotext TV sets are used as data terminals which are connected to the public Telecomms network to receive various kinds of information services.

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