An Outline for Policy Analysis

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Editor's Note

With pleasure we present to our readers the special series of UNU/INTECH Discussion Papers: *Information Revolution and Policy Implications for Developing Countries*. Papers of the Series were originally developed for the International Workshop on The Information Revolution and Economic and Social Exclusion in Developing Countries, held in Maastricht on 23-25 October 1996. The Workshop was an important event organized by UNU/INTECH and financed by the Dutch Government. Insights developed from the Workshop have not only been benefiting UNU/INTECH research work, but also contributing to many other initiatives in the area of innovation policy for information technology in developing countries.

There are six papers in the special series. The first five papers have been widely circulated and are provided here in the latest modified versions. These are outcomes from the two major themes set for the Workshop: ‘The Developments of Access and Effective Use of Information Technology and Exclusion’, and ‘The Gender Dimension in Exclusion’. The sixth paper, by Ludovico Alcorta, is a summary of the three country cases on Burkina Faso, South Africa and Tanzania organized for the Workshop.


#2002-2* Constantine Vaitsos, “Policy Agenda for the Information Revolution and Exclusion Phenomena in Developing Countries”


#2002-4* Carlos M. Correa, “Implications of Intellectual Property Rights for the Access to and Use of Information Technologies in Developing Countries

#2002-5* Cecilia Ng Choon Sim, “Making Women’s Voices Heard: Technological Change and Women’s Employment with Special Reference to Malaysia”

#2002-6* Ludovico Alcorta, “The Information Revolution and Economic and Social Exclusion: The Experiences of Burkina Faso, South Africa and Tanzania”

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AN OUTLINE FOR POLICY ANALYSIS

Professor Charles Cooper
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1 In preparing this paper, I have drawn liberally on the ideas developed in the national papers on Burkina Faso, South Africa, and Tanzania presented to the UNU/INTECH Workshop on the Information Revolution and Social and Economic Exclusion. I also benefited from discussion over two days in the University of Cape Town with Dr David Kaplan, Director of the Science and Technology Policy Research Centre, Mr James Hodge of the Centre, Dr Jonathon Miller of the Graduate School of Business at the University of Cape Town, and Dr Haji Semboja of the Economic and Social Research Foundation of Tanzania. I must also acknowledge the invaluable support and inspiration I have drawn from my research colleagues at UNU/INTECH, who share responsibility for any good things in this paper. Professor Swasti Mitter took time from her overcrowded schedule to give detailed and invaluable comments and, as so often before, I am very grateful to her.
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1. INTRODUCTION

The concept of an “information revolution” has been interpreted in various ways. At an early stage it referred pre-eminently to rapid changes and advances in the capacity to process information in a digitised form in both production and service sectors (informatics). More recently, the term has been used somewhat more narrowly to describe the striking technological developments that have emerged from the interaction of information processing capabilities with telecommunications systems (telematics). The emergence of a set of new service functions associated with the Internet is an example. In this paper, it is intended to use the terms information technology and information revolution in a somewhat broad sense, designating the information processing/telecommunications interaction, but also the development and application of information processing systems that may not be seen as part of the development of telematics per se.

As in the case of other major technological changes, it is to be expected that the information revolution will have a basically progressive impact in the world economy, opening the way to increased efficiency in production and improvements in the welfare of populations. These positive effects will flow partly from effects on production methods (e.g., the development of new manufacturing methods and systems such as CAD/CAM); partly from the efficiency effects working through major improvements in service operations linked to production (e.g., improvements in the responsiveness of production systems to consumer needs because of improved access to market information); and partly through direct impacts of the information revolution on many service operations which are directly used by consumers (e.g., banking and finance, household information activities, and the delivery of social services of various kinds, including education). In other words, IT may be expected to increase production capacities, enhance the quality of life, and open new employment opportunities.

At the same time, it is to be expected that the information revolution, like most other technological transformations, will have some consequences which are less obviously desirable. These will be particularly relevant from the point of view of global and national equity.

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2 In some definitions broadcasting, publishing, and other media are included in the convergence.
For example, rapid advances in information technology affect the terms of competitiveness between countries even in sectors such as garments, which a decade or so ago were regarded as relatively stagnant technologically, and therefore well adapted to conditions in countries which had a weak “technology base” and an abundance of unskilled labour. These countries may be excluded from the benefits of information technologies. Rapid technological change internationally may well pose major problems of transition for them especially under modern conditions of liberalisation. The information revolution likewise will have differential impacts on specific groups within countries. Even in a country that is successfully linked to the global informational economy, some groups women assembly workers, for example may be excluded because of their insufficient access to learning processes and thus to new skills. At the same time, the application of information technology will create new opportunities for some: there will in short be inclusions as well as exclusions.

This paper is especially concerned with the possibilities of exclusion and inclusion from applications of information technology for countries and regions and for social groups. It will doubtless be felt that the emphasis in the paper is predominantly on potential and actual exclusions, and that the paper is to that extent unbalanced. That may indeed be the case, but the prospect of exclusion and its economic and social implications are major concerns in a number of poorer countries with limited technological skills many, but not all, in the sub-Saharan region, for example and it is legitimate that these concerns should be specifically addressed. The bias, if there is one, results from this focus, not from a conviction that the impacts of information technology are bound to damage the poor and weak. And the orientation of the paper is toward understanding the mechanisms that might lead to exclusion in order, if possible, to correct them. There is also a certain emphasis in the paper on definitional questions, in the interest of establishing some degree of agreement about categories and concepts.

The discussion will proceed from the near-truism that the conditions of access to information technology will determine whether or not individuals, social groups or whole countries are excluded from its benefits. We will think of restrictions on access as arising in two broadly defined ways. First, access may be restricted if, for one reason or another, those seeking to use the technology simply cannot get hold of it. This might happen, for example, if a potential producer of information technology is excluded from key components because of patent protection (though more commonly patents do not make for absolute exclusions, they simply make access more expensive). Second, access may be restricted because the potential user does not have the capability to choose sensibly what is needed or to use the technology even if it is
easily available. This second dimension will play a major part in the discussion which follows. Access, on this broad definition, determines importantly the welfare effects of information technology, especially through the influence it has on who gains and who loses from an application of such technology, or, in a widely used jargon, on the distributional effects.

The paper will proceed as follows:

- In the second section there is a description of the range of industries and fields of application that are involved in the supply and use of information technology. This is not exhaustive or even particularly informative; its purpose is to give some precision to the field of interest involved in policy research on information technology. It is, therefore, more definitional in purpose than analytic.

- In the third section there is a discussion of the different problems of access to information technology that may arise. This uses the framework set up in the second part. It distinguishes problems of access associated with the “supply side” that is to say, with the industries supplying the different components of information technology, from problems encountered by users of information technology the “user side”.

- The fourth section underlines the importance of learning processes in determining access, especially where users of information technology applications are concerned. It argues that the accumulation of technological capability is a critical requirement for successful access to information technology.
2. INDUSTRIES AND FIELDS OF APPLICATION: SOME DEFINITIONS

The development and application of information technologies involves numerous industries and social institutions. These are well known, but it is nevertheless helpful to give a short description. We will distinguish three main categories:

- the manufacturing and service industries involved in supplying various components of information technology;
- the social and economic infrastructures needed for the effective application of information technology;
- the institutions and social groups involved in applications.

The fact that these different categories are involved in the development and application of information technologies does not really distinguish them from other types of technological innovation. Most innovations pose new requirements for producing industries. Most pose new infrastructural requirements, involving plant and equipment for application of the technology, human skills to exploit it properly, and investments in public utilities of various kinds. And most innovations impose new divisions of labour in society, and so involve a range of institutions and social groups in their application.

Thus we could discuss the development and application of many technological innovations in the same categories as we have proposed for the analysis of information technologies. But development and application of information technologies nevertheless pose new challenges and problems, which may not be different in kind, but certainly seem so in magnitude. For one thing, the speed of innovation both major and incremental seems exceptionally high. And for another, the number of sectors of social and economic activity that may be involved in any single innovation is typically much greater than for other technologies which are more sector-specific.

It is indeed these differences in magnitude of impact which lead to a concern about the implications of information technologies in developing countries. Once again, the impacts of
technological changes in general in developing countries, have long been a matter of interest in policy-oriented research. This is reflected in a large body of empirical research on output and employment effects, on implications for trade and competitiveness, on the changes in international and intranational distribution of welfare which might result from technological changes. All these questions are raised about the impacts of information technologies: but they are raised a fortiori, because of the speed of innovation in information technology and the widespread pattern of impacts of these technologies.

**The Information Industries**

It is helpful to think of the information industries which supply the equipment and systems required for the application of information technology as comprising the following three categories:

- The manufacturing sectors producing computers and ancillary equipment, including network equipment, and the sectors producing telecommunications capital goods.
- The service sectors producing software for IT applications across a wide range of user sectors.
- The service sectors providing supporting services for applications in the form of consultancy and advisory activities.

Since manufacturing and services enterprises may be engaged across several of these activities, this is not a completely satisfactory framework for classifying firms. But it is a reasonable (if simple-minded) way of grouping key activities. The extent to which each of these activities is present in different countries varies considerably even in countries where information technology applications are well advanced. There are countries without any significant hardware manufacturing capability where applications are nevertheless well advanced. In fact, the supply of all the goods and services in the categories set out above is highly internationalised. Even countries which are highly advanced in the manufacture of computer systems or telecommunications equipment rely heavily on licensing and joint venture arrangements for part of their hardware requirements. There are different reasons for this, depending on the goods and services in question. In the computer sector, for example, innovative leads change quite rapidly, and no firm is likely to hold a world market hegemony for long. In a liberalised world market, users in most countries will accordingly switch suppliers quite frequently.
In telecommunications, there are important scale economies in the production of standard equipment, and most countries import their requirements from a relatively small group of firms in a few highly industrialised countries. In software production, more traditional sources of comparative advantage are starting to determine the international location of production, and so induce new patterns of international specialisation: India, for example, has a relative abundance of software programmers at relatively low wage levels, and is a major world exporter. Advisory and consultancy firms are also internationalised, though here there are probably more important locational requirements: to be effective, consultants probably have to be close to the user enterprises.

It is useful to keep in mind that the information industries are capital goods sectors. Many of the questions which were raised in the past about the desirability of developing countries having a capability in the production of capital goods (such as machinery and equipment in general) have been raised in relation to the information industry. The central question, which has precise parallels in older debates about capital goods, is to what extent various parts of the information industries may have to be present in a country to facilitate effective application by users. In practice, the question has been answered differently by policy makers in different countries. In Brazil and some other larger Latin American countries, as well as in India about a decade ago, policy has been importantly based on the idea that nationally based and nationally owned information industries are important for the successful use of information technologies elsewhere in the society. Probably this is a much less widely held view today, partly because liberalisation has largely brushed away the apparatus of trade protection that was central to the pursuit of such policies. However, there is still a good deal of debate about these matters in relation to information technologies, and we will return to them later.

**Social, Economic, and Technological Infrastructures for Effective Applications**

If it makes sense to think of the information industries described in the preceding section as a modern emanation of the capital goods sector, then it is also sensible to think of what has become known as the national infrastructure for application of information technology as essentially composed of key items of capital stock needed to make proper use of information applications. These elements of national infrastructure or national capital stock in information systems are essential for effective use of applications. They fall into four main groups:
• The stock of computers in the country. This includes mainframe and mid-range computers as well as the institutional and household stock of personal computers. The available stock of computers is most likely a function of the level of wealth (and so also of income levels).

• The stock of software in the society. This includes for example, the computer operating systems in use, and software for operating networks.

• The stock of telecommunications equipment. This is a critical part of the infrastructure for information technology. Issues include the effectiveness and reliability of the existing system (which is usually a function of the age of the capital stock comprising it, and of the level of national wealth), the reliability and competence with which it is managed, and its geographic coverage, as well as such matters as bandwidth availability. Given the difficulties which poor countries often experience with telecommunications systems, it is hard to overestimate the importance of their role in information technology applications. In these countries, the question of how far limited network systems might be developed with minimum reliance on national telecommunications may be important, as will the possibility of by-passing archaic national systems, for example by using satellite communications.

• The stock of human skills in the development and use of information technology and information technology applications including all those skills acquired through experience in operating information systems such as local and wide area networks, and including also the skills needed in the management and operation of telecommunications networks.

In line with the idea that it is useful to think of the national infrastructure for information technology as constituted by capital stocks, one can divide the list of elements of infrastructure into items of physical capital e.g., computers, computer networks, software, and telecommunications equipment in operation and items of human capital e.g., the skills needed in running information technology systems and the telecommunications system. The value of thinking about infrastructure in terms of capital stocks is that it provides an ordered approach to analysing the infrastructure, e.g., in terms of such things as the obsolescence or otherwise of equipment, or the knowledge and skills available; it also emphasises the fact that the construction or reconstitution of the infrastructure requires major investment, which will have various gestation periods, and so require careful attention to timing.

However, while it may be useful to look at the question of infrastructures in this broad way, in terms of stocks of capital, it is important not to overlook the institutional structures in which
these capital stocks are so to say embedded. And it is also important to understand the economic and social histories that have made these stocks of physical and human capital what they are, and have distributed them in certain ways within and between national economies. For example, if computer capacity is available only to a small group of high-income people, this may be the result of the dynamics of income distribution in general in the society; or if women are disadvantaged by having lower levels of technological knowledge, this will most likely be the outcome of a gender bias in the education system and in employment patterns.

Access to information technology applications will depend in general on the successful operation of all parts of the national infrastructure as defined here. And differential access to the various components of the infrastructure will be an important factor in the distributional effects of information technology applications in other words, in the inclusions and exclusions which may result from it. We will therefore return to the concept of the national infrastructure as a set of important capital stocks, in the discussion of access in Section III.

Areas of Application of Information Technology

At this point let us note that the range of applications of information technology which are of immediate or potential interest in developing countries is wider than is sometimes recognised. Some tend to discuss the problems of the information revolution in developing countries simply in terms of communications connecting to the Internet and related matters but in fact, as most will agree, there is a much wider range of concerns. A sketch of the main fields of IT application follows.

First, IT investments are found in the provision of a wide range of services which are normally the business of the private service sector. Typical of these are retailing (whether on the Internet or in its more conventional forms), banking, insurance, financial and stock market services, and more general informational activities for the general public. IT is also increasingly used in the provision of public services and in public administration for example, in health services, education, tax collection, or the distribution of public welfare. In some countries it has a considerable field of application in policing. Within the production sectors IT is widely used in ancillary activities such as inventory control (where it has had a critical role in the development of “just in time” manufacturing systems as well as in more run-of-the-mill inventory systems),

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3 Some writers define national infrastructure in more limited ways, including mainly the telecommunications system and closely related components.
or in support of enterprise administration and secretarial functions. IT is also importantly used in the control of production within enterprises for example, in CAD/CAM systems, or in the dedicated computer systems used in process control in sectors like the chemical, oil, and gas industries.

In addition, of course, specific applications in informational activities proper and in networking activities have become very important. Internet applications, e-mail, and related forms of communications have grown extraordinarily rapidly. So have database services. The networking of computer systems has become a key activity, not only in obvious areas like the Internet, but at the level of firms (where it may be used to integrate marketing, design, and production information), in other intra-institutional applications across a very wide range of sectors, in national information systems like the French Minitel, and in similar systems under consideration or in application at the national level in some European and Asian countries.
3. PROBLEMS OF ACCESS AND ITS IMPROVEMENT

We started with the assertion that exclusions and inclusions of the application of information technologies are determined in the first instance by the conditions of access. It is now time to return to that idea, perilously close as it is to tautology, and to indicate how it might be given empirical content.

The description just given in Section II deals with the organisational and institutional forms that mediate and determine the role of the production and application of information technology in societies. We can use this description to show some of the main determinants of access.

These fall under two main headings:

• problems associated with the terms on which information technologies are produced and sold in the world market;

• problems associated with the human and physical capital stocks available to support the application of information technology in other words, with the national infrastructure as defined in Section II.

Access and the Production of Information Technologies

We identified three main agencies involved in the production and application of information technologies: the manufacturing sectors which make telecommunications and information hardware (including, of course, the computer industry); firms involved in the production of software; and the advisory and support services needed to aid applications in society. A first question is: to what extent do these different agents have to be present in a national economy in order to assure effective application of information technologies i.e., to avoid exclusions of the country or of elements of the national society from the application of information technologies?

Behind this, as we have already suggested, there is a rather old-fashioned question, which harks back to venerable debates on the necessity or otherwise of having the production of capital goods in developing countries as a basis for industrialisation. The key argument of those who believed that the physical presence of capital goods production was necessary to national
projects of industrialisation was that the “deep” sectors of the economy were likely to generate important external economies in the form of technological capabilities, which would not be present without them. Let us note in passing that, whatever its ultimate empirical merits, this is an argument more likely to hold in the context of countries living in a high degree of economic isolation, behind trade protective barriers, than in the context of a liberalised world economy. It is not surprising, therefore, that the underlying model was drawn in the first instance from the early development experience of the Soviet Union and in the post-war years from the Indian Second and Third Five Year Plans, inspired by Mahalanobis. It is probably not useful to reiterate the terms of the earlier debates, but it may aid discussion to make three (probably contestable) points, which help to squeeze out some questions which are relevant to the question of information technology in particular. The first is that in actual practice, the capital goods strategy was only really implemented in a very few economies in India and some of the larger Latin American countries. Whatever its merits in generating technological capabilities (and there are certainly people who argue that it did so say in India or Brazil), it also resulted in a supply of high-cost producer goods to local user industries, which caused considerable problems of competitiveness in subsequent shifts to more open economy systems. Precisely similar arguments are made nowadays about attempts to set up nationally-based information technology production in developing countries, notably in Brazil and, to some extent, in India. This is argued by some to have been counter-productive because of the resulting high cost of informatics equipment to local users. Others defend the policy, if only in part, on the grounds that it created technological capabilities which were subsequently very important in the diffusion of information technology applications.

In short, the earlier debate continues, albeit in a somewhat disguised form, and about a very different type of industry from the classical capital goods industries of the Soviet and post-war Indian models. It is, however, much attenuated by the dominant (and indeed, after the Uruguay Round, legal) requirements for more open economic systems.

The second point which may be drawn from the earlier debate is that although a number of countries did eventually establish economically successful production of capital goods, they did so largely to meet international demand, rather than on the lines required by the closed economy model. Some of the Southeast Asian NICs established vigorous export production of mechanical and electrical machinery by interventionist policies often described as technological upgrading. Interestingly, technological upgrading postulates a process which runs in precisely the opposite direction to the idea that capital goods production is needed to generate technological
capabilities that then spread through other sectors. In upgrading, technological capabilities generated in the lighter industries, based on consumer goods production, eventually provided the skill basis for the export-oriented and highly successful machinery industries which followed them temporally. And, as is directly to the point here, the South Korean and Taiwanese information technology industries, now entering chip production in a major way, also followed this line of development: arguably, the skills built up in consumer electronics as well as in large-scale information technology applications created a basis for the subsequent growth of the production sector.

Third, it remains true that the older argument about the role of the capital goods sector in the industrial economy was right in focusing on the importance of technological externalities in the economy: at the most general level, on the fact that production processes themselves are important in creating technological capabilities. Unfortunately, there is still a good deal of vagueness about which processes are needed for any particular set of skills, and also about where the skill returns to production, if one may call them that, are significant. And there is also an unresolved debate, likely to be important in relation to information technology systems, about whether the older “deep sector first” strategies such as followed in the eighties in Brazilian informatics policies are more or less effective in generating the capabilities needed for countries to get access to information technology systems than the more recent “technology upgrading” strategies of the older (and newer) NICs.

However, aside from the question of which of these types of strategy might be more effective in creating information technology skills, it is pretty safe to conclude from the available evidence that effective application of information technology systems does not depend on countries being able to produce hardware. Production of information hardware and telecommunications capital goods is highly concentrated in a very few countries, yet those countries in Europe and Asia which do not produce these goods have been able to achieve very high rates of diffusion of information technology systems in the national economies. Furthermore, if South Korea and Taiwan have made rather successful applications of information technology systems, it is not because they are increasingly good at making computers, but because they have built up a relevant skill base in other ways. The timing of events in these countries bears this out: they were good at using information technology systems before they got good at making silicon chips. The same must by definition be true in countries like Singapore, and others in Southeast Asia, which are not yet engaged in the technologically higher levels of hardware production.
Software production and services to support application which we earlier identified as the other important activities of the information industry may be a somewhat different matter, although it is still not clear that a definitive argument can be made that countries need to produce software in order to use it well. There are, however, some important differences from the arguments about information technology hardware.

First, application support services are needed to support and further virtually all applications, and at early stages these are usually provided by specialised firms and agencies. This is nowadays true even of applications specifically designed to be user friendly to non-technical people, such as word processors; it is even more true of custom-made industrial applications or systems to deliver consumer services through networks. To an important extent, these support services need to be immediately and quickly available, and therefore to be locally present. This does not preclude that at the higher levels of technological complexity there may be trade in user services; it is simply that there are day-to-day service needs (which anyone who has tried to get a network to function will appreciate) that probably have to be available in immediate proximity. So the presence of application support services is very likely essential if countries and populations within them are to have effective access to information technologies. Those who struggle with e-mail access in out-of-the-way places (in industrialised Europe just as much as in the so-called Southern countries) will attest to this, and also to the cost of breakdowns.

Second, the boundary between application support services and software development skills is not very clearly defined. Some support operations require the service provider to programme and develop customised solutions, even in simple applications and once programming capabilities are mobilised, the development of software for new applications is never far away. There are probably important externalities here, through learning by doing in application support activities, though there seems to have been little research on the matter. The implication is that where the support for applications is present and operating successfully, software development is quite likely to follow, at least for local adaptations.

Third, there is clear evidence that some developing countries have shown comparative advantages in software production, because it is an activity intensive in the use of human skills and capabilities, which they have available, yet not too intensive in the need for investments and advanced manufacturing capabilities, which are less abundant. India, which has become a major world exporter of software and programming services, is a case in point. Fragmentary evidence from India, suggests in addition that initially export-oriented software and programming
activities have also had an influence on new applications (and software markets) in India itself, and that there may be important learning externalities because of the presence of the software industry itself.

There is not much doubt that the software end of the information industry is, in principle, more appropriate to conditions in developing countries than the hardware side, but the extent to which software capabilities are necessary to successful applications of information technology systems is not clear.

There is a more convincing and obvious argument that various other support services must indeed be present, and, as we have suggested, these may naturally develop in the direction of software production under ordinary market pressures. But, from a policy point of view, that is a somewhat different matter.

So far we have dealt with the information industry itself in terms of whether countries need to establish production of information technology outputs hardware, software, and supporting services in order to facilitate successful applications in other words, in order to avoid being “excluded”. The underlying, and arguably defensible, assumption is that, for most developing countries, the first requirement to avoid exclusion is to be sure of the capacity to use information technology applications. It is, however, legitimate to raise a further question, relevant especially to those countries which are developing some parts of the information industry itself: whether there are dangers of these countries being excluded from entering production of hardware and software. It is essentially about the impact of intellectual property protection, in the form of patents and copyrights, on information technology production in developing countries. It is, of course, an important part of the framework for policy analysis in many countries in the first instance those which are able to establish software industries. It is, however, too large a question in its own right to be tackled in this paper.

Access and the Social, Economic, and Technological Infrastructure

The social, economic, and technological infrastructure for information technology was defined in Section II as consisting of a number of important capital stocks, viz., the stock of telecommunications equipment, the stock of computers and ancillary software (operating systems and applications), and the stock of human skills in the development and use of information technology applications. It is natural for economists to think of these as a set of
capital stocks which reflect the initial conditions for application of information technologies. But the infrastructure cannot be described adequately in a purely quantitative way, and the institutional environment in which the capital stocks are set is also important.

As explained in Section II, access to information technology depends upon these capital stocks: telecommunications is essential for a wide range of applications; access to computer capacities is also essential; and the stock of human skills similarly so. Evidently then, increasing the availabilities of these capital stocks, improving the efficiency with which they are used, and making them available to parts of the population which are presently deprived of them, are all likely to be important objectives of a national policy designed to diminish exclusion from information technology. However, these purposes are not always as easy to achieve as may appear. The problem is that the present state and dispositions of the stocks are path-dependent, to use a currently fashionable term: they are the outcome of past social and economic histories. And the social and economic forces that were at work in forming those histories have to be understood in order to devise policies to improve the situation (assuming that such policies actually exist). A few hypothetical but recognisable examples illustrate the problems.

Take the case of the telecommunications infrastructure: a common problem in poor countries is that this is technologically out of date and under capacity. It may also be run down through lack of repair and maintenance, and it may cover a quite small part of the geographic area of the country. In many countries for example, in the sub-Saharan region the telecommunications infrastructure has deteriorated markedly in recent years, largely because of a failure of state investment. This is a deep problem which is unlikely to be solved by exhortation. Underinvestment by the state in most of the poorer sub-Saharan countries is a result of macroeconomic policies designed to achieve fiscal balance. State capital budgets are always easier to cut for clear political reasons than current budgets. Maintenance of the telecommunications system may have much less immediate appeal than, say, a set of subsidies for current consumption. This type of underlying conflict is part of the context in which information technology policies must operate. In many African countries even relatively rich ones like South Africa the only solution for the creation of a modernised telecommunications structure is seen to be privatisation of the telecommunications network, along with the setting of rates more in line with commercial exigencies, though even this option usually depends on attracting foreign investment into the local telecommunications sector. This is one example of the difficulties that may flow from patterns of path-dependency.
Similarly, the size and distribution of the computer stock and the stock of software are the outcome of prior economic histories. This is most clearly seen, perhaps, in the case of private ownership of computers, which is nearly always closely related to the distribution of wealth and income in the population at large. Policies to redistribute access to computer capacity, which are likely to figure in most information policies in poor countries, will have to address this underlying problem. It is a severe one; the social and economic forces determining the distribution of income and wealth are strong, and they are customarily held together by equally strong political forces. While income levels remain generally low and income growth limited, policy makers will need to find ways of extending access to computer capacity to the population at large, that are not dependent on individual incomes and wealth. Education may have a direct role to play in this process. Again, the issue of path dependence is present: the social and economic structures which have produced the present state of affairs are in most countries still in the ascendant. And they have to be addressed, and perhaps by-passed, if the situation is to be changed.

Finally, and perhaps most difficult of all, there is the supply of human skills needed in the development and use of information technology. One difficulty here is a technical one: we are simply to a degree ignorant of where these skills come from. In part, of course, the formal education system is a source for some particular technical skills programming skills or system maintenance skills but even here it seems that in technologically fast-moving fields a good number of skills are acquired by various types of individualised learning process on-the-job learning of one form or another. The situation is even less clear in relation to user skills. The processes by which new users of information technology applications for example, computer banking services either come to terms with them and learn to use them effectively or fail to do so are hardly understood, and we do not really know whether formal education plays a part in people having the ability to acquire them (though we do know that at present many probably most user skills are acquired outside the formal education system).

To the extent that formal education plays a role in providing the skills needed to use information technology applications, it will inevitably impart to the acquisition of those skills the biases that may already be built into it. For example, the massive racial biases built into the South African education system by the apartheid regime will continue for a long time to prejudice educationally disadvantaged groups in their ability to come to terms with the skills needed to use applications. In this they are reinforced by the biases which income disparities and consequent lack of access to computer capacities have already created. And there are other
important sources of bias in most educational systems certainly not just Third World ones. There are, for example, some well-known self-reinforcing biases against the poor in most education systems. In the case of education related to the application of information technologies, these are likely to be strengthened by the fact that most poor people in developing countries leave formal education at the primary level, whereas the skills needed to cope with applications of the new technologies are probably not really accessible until the secondary level.

And there are other examples. The widespread bias against women in technical education is still a major problem in European countries, and it appears to be entrenched in the sub-Saharan. It is an outcome of strongly held prejudices about women’s role in society and in the household. It does not bode well for women’s participation in the benefits of the information society. In the next section, the issue of learning and skill acquisition is discussed in further detail.

This discussion of the role of social and economic infrastructures in the applications of information technology has emphasised their importance in determining who is likely to be included and who excluded from such benefits as the applications of information technologies are likely to generate. It has also hopefully opened the way for another conclusion, which though it may seem obvious, is so important that it needs to be drawn out of the analysis. Aside from the major macroeconomic issues which arise in regard to the development of the telecommunications sector, the other infrastructural factors give rise to the possibilities of exclusion from information technology benefits because of the operation of the same social forces which have always underlain distributional inequalities in developing countries. These are maldistributions of income and wealth, on the one hand, and (often closely related) inequities arising from the way the education system works, on the other. The risk is therefore quite clear: if the introduction of information technology in fact leads to important economic and social advantages if information technologies are in that sense a “good thing” they may nevertheless reinforce an already existing system of inequalities. Indeed, if they are applied without attention to the potential exclusions which existing income distribution and educational bias may introduce, we could face an outcome where the more successfully the new technologies can contribute to human welfare at the individual level, the more decisive they may be in deteriorating the distribution of welfare and generating socially damaging exclusions. The only recourse in this case is to policies which tackle the tendencies to exclusion directly if not at root (which in the case of income and educational biases is very difficult) then at least through the pursuit of ways round the structural difficulties.
There are some possible outcomes which are a bit brighter than these rather sombre reflections. For example, it may be that information technologies will change employment patterns for women in ways which are advantageous, as well as in some of the less happy ways which we have anticipated here.

But we cannot rely on the overwhelming force of such positive developments to offset the problems we have discussed here. Markets have never been good at solving distributional problems, and we would be ill-advised to suppose that they might do so in the case of applications of information technology.
4. NOTES ON TECHNOLOGICAL CHANGE, INFORMATION TECHNOLOGIES, AND LEARNING PROCESS

To complete the discussion, we will include a set of observations on the implications of information technologies for learning processes. This is a central matter: it is at least a necessary condition for avoiding exclusion from the new technologies that people are able to acquire the skills needed to produce with them and to use them as consumers. Indeed, some find this also a sufficient condition, since it can be argued that, provided society is able to ensure that people can participate in such learning processes, market forces are likely to provide an adequate basis for ensuring inclusion. The following are notes on the kind of learning process that is needed; “notes” because this seems a properly modest title for what are unavoidably speculations at this stage. The speculations are presented in five steps.

First, it is easy to see that technological changes quite generally result in changes in the organisation of social and economic activities and in the skills required to carry them out. This has been recognised for a long time, certainly since Adam Smith, and probably before. Information technology is no exception to this, though it has the characteristic, already noted, of influencing many sectors and therefore imposing changes in the skills needed in production in many parts of the economy simultaneously.

An aspect of changing skill requirements imposed by information technologies is the fact that consumers of new technology products, such as personal computers, or household devices like audio and television systems, or automated banking and social welfare services, need new skills in order to make effective use of them. As electronic communication systems become more and more prevalently used for shopping, or for personal banking, or for entering bets on horses, or for having one’s horoscope read, the range of skills which customers will need will probably increase. Against this, it is obviously in the interests of the producers of such things to keep the need for customer skills to a minimum and to contribute to the education of customers; hence the hunt for user-friendliness. Where customer skills are concerned, the market may therefore work rather well.
To sum up: technological changes are associated with transitions, and a socially important dimension of these transitions is the change in the skills needed to participate in production, or to provide services, or to access newly automated services, or generally to use new technology.

The second point follows directly: it is that exclusion/inclusion in such transition is importantly influenced by the success of societies and individuals in responding to the changes in skills required. That there are very considerable differences in response is, I think, clear from casual observation. An important part of the discussion in this paper has dealt with the various reasons for these differences.

It is because the issue of skills and the readiness with which individuals can acquire them the human capital question is apparently so dominant in relation to information technologies that we choose to focus specially on it in this last section.

The third point is that, with the advent of information technology systems, we seem to have entered a distinctive period in which technological change is not only accelerating but is also much more continuous in its social impact than with other technologies. In turn, the problem of exclusion/inclusion needs to be seen increasingly as a continuous dynamic problem. The problem arises at all levels: even as I struggle to master the range of things a new 486 computer can do, others are investing in Pentiums which have a whole range of software possibilities which are beyond my present capacities and would involve difficult investments of my time in skill acquisition. I am thus excluded from the newest technology, albeit in a relatively modest and socially non-crucial way. Indeed, if we think about the matter in fully dynamic terms, most of us are nearly always excluded in these relatively benign ways from the newest things.

With the fourth point we come to the heart of the matter: what mechanisms exist to meet the need for changes in skills, capabilities, and organisation which the processes of technological change generate? The effectiveness of these mechanisms, and biases in the ways they operate, will affect who gets included and who excluded from the social activities or advantages associated with new technologies. And here “who” refers to “which societies” and “which social groups” as well as “which individuals”. It is immediately obvious that in reasonably differentiated social systems

4 There are those who would argue that the rate and continuity of innovation in information technologies is in this respect an outcome of an advanced form of Schumpeterian competition—competition based on innovative advantage between the innovator firms, rather than on the classical price competition of economic textbooks.
there is usually a range of ways in which changing skill requirements are met, ranging from the educational institutions at all levels to a whole variety of less formalised learning processes. The latter may include, for example, the individual sitting in front of her computer and learning from a succession of mistakes.

How do we tackle this wide range of mechanisms in an analytically sensible way? If their effectiveness is as important to the exclusion/inclusion question as I have tried to suggest, we need some way of discussing them which is more useful analytically (and less boring) than a long list of institutional descriptions. One rather obvious approach is to distinguish between the formally constituted elements of educational systems—schools, universities, vocational training organisations, specialised diploma systems to acquire knowledge of new software systems, and the like, on the one hand; and, on the other, all those less formal methods of acquiring skills in the use and application of new technologies, such as learning by doing in production or in services, or the kind of learning which consumers of such things as PCs have to go through to become proficient in their use. It is clear that this distinction needs to be sharpened. Very likely one requires more than a two-way categorisation. But as a first approximation we might distinguish these two broad classes as formal and informal learning processes. And we note that a feature of some informal systems, though not all, is that they are intra-firm or internal to the institutions in which the new technologies are being used which might of course be households.

A plausible hypothesis is that the higher the rate of technological change, the greater will be the role of informal learning processes in the acquisition of the relevant skills. The reasoning is simple perhaps simple-minded. In the first place, formal systems of education and training are usually quite slow to adapt to changing demands, and so are bound to be out of date if the technology is changing fast. Second, formal systems as they exist at present are best at providing codifiable and more general skills, whereas the skills needed to encompass rapidly changing new technologies are usually hard to codify for example, to set down in training manuals and are usually rather specific. The underlying assumption here is that the proportion of knowledge about the use of a technology which is likely to remain “tacit” is probably higher when the rate of technological change is higher. Tacitness, in short, is a characteristic of a technology which, in part at least, is a consequence of rapid technological change. When a technology has been in use long enough, most of the skills needed to use it effectively become codified, and in this area at least, tacitness may reduce. If we look at matters in this way, the “tacitness” of technological knowledge, which has come to be an important preoccupation among economists dealing with the transfer of technology
between firms, appears less a property inherent in a technology and more a contingent outcome of the fact that the skills needed to use it are not yet fully analysed and codified.

Fifth and finally, it follows that exclusion is more likely to happen when informal systems of learning, “learning by doing”, for example are predominant because of a high rate of technological change. These are also situations in which tacitness is likely to be higher. The reason is simply that in this case the possibilities of getting access to the knowledge needed to use the technology are limited because the formal training system cannot supply it and acquisition depends more heavily on being incorporated in the production or service systems in which the technology is being applied.

An important characteristic of the rapidly changing new information technology in a great many of its applications is that the skills required to master its use are unlikely to be obtainable directly from the formal education and training systems. Learning to use these technologies, which is an essential element in participating in whatever advantages they confer, is likely then to depend on access to the production and service activities in which these technologies are applied. The possibilities of exclusion are thereby increased. It is harder for people to access tacit knowledge, especially if its acquisition depends on learning by doing. This is a specially important reason why we should expect particular problems of exclusion with new information technologies.

But where does this set of assertions lead? At one level it might be seen as rather gloomy: populations of producers and users will be excluded from the benefits which technological changes may offer because society cannot offer ways of helping them deal with the tacit and codified and very rapidly changing knowledge they need to do so. But there is another important argument to be made here. It runs as follows: As the rate of obsolescence of any given set of skills increases, so does the relative importance of people’s capacity to learn new techniques. The technology diminishes the usefulness of already acquired skills in comparison to the usefulness of having a capacity for ongoing learning. But the response to this is not to take the formal systems of education and training as they are, but to raise new questions about them. The systems we have may not be adapted to teaching tacit skills; indeed, nor formal system, by definition, is ever likely to be.
But this doesn’t mean that formal systems of education and training thereby become irrelevant. The problem is to redesign them so that they are better adapted than at present to producing people who are more easily able to learn in the course of their working lives.

It is not clear that education systems anywhere are yet able to address this issue. For example, we do not seem to understand why some people coming out of formal education have a strong inclination to continue learning, while others hope to rely on what they have already acquired in the education they have experienced, and seem to have little incentive to increase their knowledge. Are these differences in attitude a consequence of pedagogy? If they are, there are some grounds for optimism. It may well be that the most important requirement to avoid people being excluded from the gains of the new technologies lies in an education system less concerned with producing people of specific skills though that must obviously remain an important part of education and more focused on inculcating the assumption that learning is of necessity a continuing process in an economy and society where the basis of production and consumption is in continuous change. How to do this is a hard question for education policy makers.
5. FINAL POINTS

It is not appropriate to draw conclusions from the discussion in this paper, since it is in the nature of a proposal for policy analysis. This form seemed appropriate as a device for introducing the Workshop on Information Revolution and Economic and Social Exclusion in Developing Countries. It is hopefully useful too as a basis for further analysis and research. For the present it should provide a setting for the material presented in Theme I of the Workshop Access and Exclusion.
Policy Agenda for the Information Revolution and Exclusion Phenomena in Developing Countries

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Editor's Note

With pleasure we present to our readers the special series of UNU/INTECH Discussion Papers: *Information Revolution and Policy Implications for Developing Countries*. Papers of the Series were originally developed for the International Workshop on The Information Revolution and Economic and Social Exclusion in Developing Countries, held in Maastricht on 23 -25 October 1996. The Workshop was an important event organized by UNU/INTECH and financed by the Dutch Government. Insights developed from the Workshop have not only been benefiting UNU/INTECH research work, but also contributing to many other initiatives in the area of innovation policy for information technology in developing countries.

There are six papers in the special series. The first five papers have been widely circulated and are provided here in the latest modified versions. These are outcomes from the two major themes set for the Workshop: ‘The Developments of Access and Effective Use of Information Technology and Exclusion’, and ‘The Gender Dimension in Exclusion’. The sixth paper, by Ludovico Alcorta, is a summary of the three country cases on Burkina Faso, South Africa and Tanzania organized for the Workshop.


#2002-2* Constantine Vaitsos, “Policy Agenda for the Information Revolution and Exclusion Phenomena in Developing Countries”


#2002-4* Carlos M. Correa, “Implications of Intellectual Property Rights for the Access to and Use of Information Technologies in Developing Countries

#2002-5* Cecilia Ng Choon Sim, “Making Women’s Voices Heard: Technological Change and Women’s Employment with Special Reference to Malaysia”

#2002-6* Ludovico Alcorta, “The Information Revolution and Economic and Social Exclusion: The Experiences of Burkina Faso, South Africa and Tanzania”

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POLICY AGENDA FOR THE INFORMATION REVOLUTION AND EXCLUSION PHENOMENA IN DEVELOPING COUNTRIES

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INTRODUCTION

An attempt to synthesise the main findings of the three-day UNU/INTECH workshop on the social and economic exclusion implications of information and communications technology (ICT) in developing countries constitutes a rather formidable task. During the conference, distinct views were expressed by specialists from a variety of social science, natural science, and engineering disciplines. A number of country experiences were analysed, each with distinct developmental specificities and characteristics of socio-economic inclusion/exclusion. It turns out that each country is being affected significantly but differently by the radical technological changes transforming the world’s economic and social structures, and so are various groups and individuals within each society.  

For these reasons, a unifying overall target was selected in attempting to present a synopsis of the relevant themes and issues of the workshop. This target has to do with the policy context, relevant for developing economies, emerging from the ICT revolution. This synopsis will thus come close to what Prof. Waardenburg underlined during the opening session of the workshop as being a main concern of Minister Jan Pronk in sponsoring this conference.

The present synopsis consists of five main sections. Section 1 sets the stage by focusing on broad expressions of policy concerns about the impact of ICT in transforming the overall economic base of the world production and exchange systems. Section 2 defines the economic and institutional space of the ICT applications, while Section 3 deals with the uniqueness of the ICT revolution in comparison to other radical technological changes. Section 4 presents some of the main concerns about the impact of ICT on socioeconomic cohesion and exclusion. Finally, Section 5 contrasts alternative approaches to development policy and their relevance in view of the challenges of ICT.

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1 Being a synopsis of the workshop proceedings, the pages which follow do not attempt to present direct quotations and references from the written contributions and discussions of the conference. References are given, though, with respect to other relevant publications.
1. SETTING THE STAGE

There exists widespread agreement that ICT constitutes an exceptionally important cluster of innovations. In describing these innovations and their related fundamental social implications, some authors have used the expression “change of techno-economic paradigm”, while others prefer Schumpeter’s terminology of “successive industrial revolution”.² ICT’s radical changes have brought about far-reaching structural and economic transformations, which are evident in emerging major secular trends in output levels, and even more so in the context of output and employment, in competitiveness and efficiency considerations, and in business strategies and corporate organisation.

Similarly, key institutional changes induced by the ICT revolution are affecting the very core of the economic governance of world business and international economic affairs.

Furthermore, and as a direct result of such ICT changes, the world economy is experiencing a well noted, even if poorly measured, alteration in the very structure and capacity for its reproduction, namely in the composition and content of aggregate investments. This change involves three main expressions:³

- First, a marked shift is observed toward greater reliance on intangible assets. These involve investment activities which develop the knowledge and competence base to introduce entirely new products and processes. They also require investments in human resources, organisation and information structures, software, and in the abilities to respond to and reach markets.

- Second, important and growing complementarities exist between physical and intangible assets as well as an increased content of high technology in both of them.

- Finally, investment and production activities are noted for their growing reliance on an elusive synthetic capability which some authors call “knowledge/competence”.⁴ This

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implies that changes in the technological infrastructure of an economy do not simply result through the replacement of existing hardware by capital goods embodying new-vintage know-how. Instead, the whole process is conditioned by the generation, organisation, and use of “knowledge/competence”.

These changes are also transforming the nature and degree of competition as well as its space and time horizons. Technology-driven competition and, to use the Schumpeterian term, the “creative waves of destruction”, imply a new market context, which involves fierce competition on a world scale prompted by shorter technology and product cycles. The competitive arena is extended geographically through selective globalisation processes in markets and production systems. It is also expressed by strategic alliances among big firms so as to cope with the size, risks, and new patterns of investment requirements in knowledge creation and its applications. Finally, the new market context has produced increased market concentration in key economic areas and novel exclusion mechanisms. Several of these exclusion mechanisms stem from the practices of the main corporate ICT suppliers and the strategic alliances between them. The resulting and active pursuit of restrictive business practices is taking place at a time when governments are reducing barriers to trade and investment while they are also diminishing their own direct participation in productive activities through diverse forms of privatisation initiatives.

Moreover, the leaders in the new “techno-economic paradigm”, especially the transnational corporations, regard their global strategies as a form of strategic “arms race” in which they are all attempting to accumulate new resources faster than their rivals.

Similarly, governments use their power to impose new international institutional norms so as to support their national champions and achieve an extension of their national economic space in third-country markets and resources. This is largely achieved through integrated production systems operating across national boundaries. Such systems are supported by transnationally extended related party transactions which displace the market mechanism through the internalisation of the corresponding trade relations. These internalised exchanges presently account for significantly more than one-third of world trade in goods. Even more, they are becoming dominant in a number of important services. For example, in technology licensing

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contracts, related party transactions presently account for 95% of the fees involved in total sales to developing countries of such disembodied know-how from Germany, the U.K. and the U.S.  

Undoubtedly, the market mechanism constitutes a fundamental social institution which contributes significantly to the advancement and application of creative initiatives and to the promotion of rational decisions in resource allocation. Yet, given the pervasiveness of the ICT revolution, the successful diffusion and application of the corresponding constellation of innovations are not simply or even mainly the outcome of corrections in market failures or of creating competitive markets. Instead, they require a number of organisational and institutional changes. Such changes involve the spheres of public policies and management practices, the nature of industrial relations, the quality of the factors of production, and the competence of corporate organisation. Equally critical are the structure of industrial communications, the quality and efficiency of information flows, and the longer-term creation of skills and knowledge in societies. All of these involve novel forms of complementary actions between public policies, institution-building efforts, and private sector initiatives. However, the exclusion of countries and population groups which are less knowledgeable, weaker, and poorer in assets and/or income, constitutes the other side of the same technological, economic, organisational, and institutional evolutions.

Furthermore, since markets are themselves social institutions, their functioning depends on a series of prior decisions and rules which govern economic relations and business initiatives. These involve regulatory provisions, the definition and means of protection of property rights on both tangible and intangible assets, new norms and standards, etc. Consequently, given the importance of ICT in all branches of the economy, the corresponding functioning of markets requires important political decisions and initiatives as well as institutional arrangements. These in turn express key interests and power relations, both nationally and internationally. Such interests and power relations tend to shape the future of every economy in crucial areas through the redefinition of the rule of the law (“état de droit”) applicable in each society. In other words, these issues are not market driven but market determining and depend on public policy considerations and initiatives.

Finally, it is well recognised that markets and their signals (i.e., prices and volumes) do not respond to or reflect the full range of important social costs and benefits of technology. On

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these matters expert opinions differ and, in the last analysis, their positions often reflect value judgements expressing ideological, political, and ethical considerations.

Similar concerns arise in other areas, as in the case of environmental protection, calling for more comprehensive analytical and policy approaches. Markets cannot be expected to anticipate future social costs and benefits resulting from technological change. Consequently, public awareness, political debate, and corresponding decision making are not only unavoidable but absolutely essential. This is especially so in cases like ICT, which involve radical and pervasive technological breakthroughs.

The new growth opportunities and economies of scale which have emerged from the application of ICT provide important new options and generate additional resources for improving social conditions. At the same time, though, there are also regressive structural implications. These arise from the same cluster of innovations and their economic applications, but lead to countervailing effects which, as discussed below, have disintegrating ramifications on socio-economic cohesion through increased inequities, marginalisation, and exclusion, all part of the ICT revolution and its applications.
2. THE ECONOMIC/INSTITUTIONAL SPACE OF ICT APPLICATIONS

A very large number of diverse “end users” of ICT services and products exist among businesses and institutions, households, the public sector, etc.. In addition, in each economy the relevant economic/institutional space involves two broad categories, namely, the suppliers of ICT and of its applications and the supporting infrastructure.

For the suppliers of the new technologies, the dynamics from the immense drive for growth are such that expanding activities has become an imperative. Standing still is not feasible in view of grave risks of being displaced by the competition. Moreover, the quality of the needed growth has become such that fewer and fewer industries can remain both profitable and efficient on a purely domestic basis. Growth becomes synonymous with internationalisation, with corresponding inclusion/exclusion effects.

The wave of technical change has produced six different categories of very significant suppliers of ICT goods and services:7

1. A continuous and rapid pace of dramatic improvements is taking place in large-scale integration of electronic circuits (VLSI). This enables both the reduction of costs and the improvement of quality. It also results in an immense enhancement of capacity and of speed in data processing in the products embodying such circuits.

2. As a consequence, successive generations of new computer hardware are being generated, incorporating dramatic improvements in storing, processing, and communicating vast quantities of information. These evolutions have implied the availability of cheaper, faster, more powerful, and more reliable microprocessors, and of small and super-computers. The new applications of computers prompt, in turn, the development of new generations of software and related service activities.

The utilisation of the new hardware and software in electronic computing facilities has facilitated the design and production of new generations of diverse capital and consumer goods (e.g., word processors, electronic instruments, VCRS, robots, machine tools).

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Together with the continuous development of new-generation computers, these electronic goods and their components represent the most dynamically growing sector in the world economy, surpassing the corresponding performances of more “traditional” industries such as the automobile sector, petrochemicals, metal products, etc.8

3. The new capital goods together with developments in communications technology affect every function within each industry and firm as well as their interactions (e.g., the integration of R&D, design, production, administration, and marketing). This has greatly strengthened the introduction of various activities involving new Management Information Systems, Computer-Aided Design, Flexible Manufacturing Systems, new systems of production planning and inventory control, procedures of total quality control, etc.

4. The concomitant development of optical fibres, and the convergence of informatics/computers with telecommunications technology through telematics, have brought new activities to the forefront. These involve the whole sector of telecommunications and its hardware together with a novel set of products and services related to computer-based networks, data banks, information services, etc. Their combined presence opens up new venues of co-operation among users in different locations, and in ways, speeds, and functions previously unthinkable.

5. Finally, the combination of technical and organisational changes have introduced important economies of scale, which have emerged from:

(i) expanding the innovation frontier, its dimensions and their combinations;
(ii) introducing rapid changes in the applications of these innovations; and
(iii) providing a more varied mix for the resulting products and services.

Such economies of scope create a series of new economic activities, which can be grouped into three categories:

- company-based R&D and co-operative research efforts, which include not only new arrangements and alliances between firms, but also joint research efforts between governments and enterprises together with banks, universities, and other institutions;

- new services and skills (in-house or through consultancy) in design, software engineering, and development; and

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- networking among and between knowledge creators, producers, and users of goods and services.

Given these six groupings of suppliers, the corresponding infrastructure for the use of ICT in each country involves the following four main areas:

1. The “soft” infrastructure refers to the regulatory conditions and norms, both national and at regional or international levels, which enable and/or restrict access to and use of distinct applications of ICT. The institutional requirements of this “soft” infrastructure are considerable.

2. They often involve highly specialised and interdisciplinary knowledge which the rest of the institutional and political system might be lacking. Furthermore, they tend to express strong pressures from businesses and governments with vested interests on the suppliers side. Finally, they might be the outcome of company practices which explicitly or implicitly (e.g., compatibility requirements) define the size, structure, and prospects of markets and of productive activities.

3. The “hardware” infrastructure involves the stock of tangible investments and equipment in computers, telecommunications, and other capital goods which embody the new ICT.

4. The educational, knowledge, and competence base of a society undoubtedly constitutes the most strategic infrastructural component in this rapidly changing technological area. The development of these elements and their organisational inputs require sizeable and continuous investment commitments and institutional support.

5. Finally, the customisation of capabilities, through organisational development, productive restructuring, and learning processes, is facilitating access to ICT and its applications. Such initiatives constitute a key infrastructural element as far as inclusion/exclusion phenomena are concerned. This customisation of capabilities translates the availability of knowledge, resources, and institutional potentials into societal conditions which enable the matching of effective demand with the opportunities offered by the ICT revolution.
3. THE UNIQUE CHARACTERISTICS OF ICT

During the last two centuries, industrial revolutions have brought about fundamental changes in the economic and social structures of societies as well as drastic changes in their institutional and political environments. Thus, it is valid to ask what makes the ICT revolution unique in comparison to other radical technological changes. Four main reasons will be presented here. Of these, the first constitutes the most fundamental one, influencing all the rest.

3.1 ICT’s Pervasiveness

Despite the far-reaching socio-economic effects of previous radical technological changes (in energy use, in transportation and metal mechanic products, in the chemical treatment and use of natural resources), they did not match the pervasive nature of ICT in world economic activities and social relations. The crucial difference of ICT is that it transcends and penetrates all aspects of contemporary economic and social affairs. This pervasiveness gives a generic character to ICT which enters into the “production function” of all human endeavours.

Three overall implications originate from this generic nature of ICT:

- As far as output composition and growth patterns are concerned, important and sharp differences obviously continue to distinguish the various parts of the world economy. Yet all major economies, which are also the main suppliers of ICT goods and services, as well as the few developing countries which participate actively in related activities, have registered their fastest growth in broadly the same sectors. All of them show an intensity in ICT applications even if they are expressed in distinct families of products. Differences in national innovation systems and in systemic efficiency capabilities explain differences not simply in transition phases toward the new techno-economic paradigm; more importantly, they express variations in longer-term performances and competitive strengths across a large number of sectors. Furthermore, trade relations are increasingly taking place not between sectors, as in the nineteenth century, but within them, thus instancing major intra-industry specialisations. Such specialisations are now being intensified by moving even more at the intra-firm level through transnationally integrated production systems and related party transactions.
Nevertheless, a key question still calls for an answer. Despite the dynamism propelled by the new technologies, overall national productivity and income growth rates have declined in relation to the late 1950s and 1960s. This is particularly so among industrialised economies which lack the suppressed demand of the developing countries and the potential for even fuller use of their already installed production base.

This productivity paradox is not simply a lag phenomenon. Instead, the potentially very important benefits to be derived from the new technologies and their applications are not inevitable and automatic. It turns out that their realisation depends on organisational restructuring and superior organisation in research, design, development, production, and marketing at the level of the firm. It is also dependent on the quality of organisation in the support infrastructure, and in public policies.

Still, organisational patterns and attitudes are notoriously hard to change, despite the recognised need to do so. They certainly have a pace of evolution much slower than that of technological change. Also, transformations in organisational and institutional matters do not constitute a unilateral initiative, but have to take place systemically. They involve, in an integrated manner, public policies, the strategies and organisational structures of firms, educational institutions, labour practices, financial and communications infrastructures, etc.⁹

- Not only production levels per se but also the quality of economic activities and of the content of output have been greatly affected by the ICT revolution. This applies to both private goods and to social services. Such qualitative changes have altered and redefined fundamental economic expressions. One of them concerns the very essence of international competitiveness.

In the past, at both the micro and macro levels, competitiveness had basically to do with issues of relative costs and relative prices. Thus, in the context of production and market realities originating from previous industrial revolutions, comparative advantages at the level of firms and of national economies counted on comparisons in relative quantitative use and the pricing of scarce resources.

With the advent of the ICT revolution and its applications, competitiveness is becoming more a matter of capabilities and of flexibility to adapt and take advantage of a fast-changing techno-economic environment.

Instead of relative costs, the competitive edge reflects abilities in productive delivery with respect to quality, timing, and quickness in responding to market changes. Mass production gives way to mass customisation and product differentiation, just-in-time production, quality standards, and flexibility in specialisation.

- Knowledge and technological change are not socially neutral. Fundamental changes in production processes, in the scope of economic activities, and in the content of output imply crucial changes in social relations. Consequently, given the pervasiveness of the ICT revolution, key implications are also generated in terms of the organisation of societies. Power relations do not simply shift from one socio-economic group to another; they are transformed. Discriminatory practices, inequities, and market segmentations are all affected, thus leading to novel conditions characterising social cohesion. Furthermore, the reproduction of societies and of their economies is altered. Among other key reasons, this change takes place in view of the power, income, and wealth redistributive effects of ICT both between and within (national) economic systems. Also, since opportunities for productive employment are so seriously affected by the ICT revolution, so are the conditions of human development and of the ability to lead fulfilling lives. Finally, social and cultural patterns are also affected by evolutions in the knowledge base of societies. Section 4 below will discuss the social cohesion implications of ICT.

3.2 ICT: Continuity of Change

It is generally acknowledged that a key characteristic of the ICT revolution is the speed of the innovation, diffusion, and application processes of new productive know-how. This high rate of change has radically shortened, as noted above, technological and product cycles. More than that, though, what is perhaps more central is the continuity of change: competition is driven by innovation. As a consequence, economies do not simply move from one equilibrium position to another, as happened during previous industrial revolutions. Instead, they find themselves, at least in the foreseeable future, in a continuous and dynamic disequilibrium.
Such a radical change poses special life-long demands on the learning processes of societies and of their populations. Learning to learn, learning to cope with change and to organise for it in view of its continuity, and learning to invest and produce, emerge as strategic resources. In the final analysis, capabilities turn out to be the distinguishing advantage, in production and in economic survival, within the context of such a dynamic disequilibrium.10

At the enterprise level, continuous asset accumulation is not simply a goal in itself complementary to or antagonistic to profit maximisation; it can turn out to be a critical medium to cover the resource demands for continuous capabilities development, and risk coverage. The limits posed in this accumulation of assets by individual firms pushes them to strategic alliances with others. At the national level, investments in education, in science and technology systems, and in supportive infrastructure services assume a commanding importance. Finally, flexibility in public policy decisions, as well as in corporate ones, becomes a key factor in improving micro/macro interdependencies and in expanding the scope of policy implications.

Previous industrial revolutions were noted for one critically important impact: the significance of scale economies in plant production. Such economies of scale reduced unit costs, thus improving the then-prevailing conditions of competitiveness. In view of the considerations noted above, ICT is characterised by two other types of economies:

- First, **dynamic economies of scale** that is, benefits arising from the size of activities over time and not simply in individual production periods become strategic. This is due to the importance of learning and the needs of knowledge accumulation. In turn, such intertemporal benefits place particular emphasis both on access to the opportunities which arise world-wide and on endogenous growth patterns. This duality raises more complex questions about the nature of protectionist policies and the pursuit of liberalisation practices. The required pragmatism in structuring appropriate policies extends beyond the boundaries set on decision making by simplistic distinctions of previous decades between import substitution versus export promotion strategies.

- Second, **enterprise scale economies**, instead of plant sizes, turn out to be strategic. The former become more relevant in view of the need to accumulate resources to cover increasing demands in research, design, development, and world-wide marketing

10 See Charles Cooper’s contribution in the introduction of this volume.
networks. Thus, corporate power, together with capabilities, turn out to be of paramount importance. Plant sizes, on the other hand, can move in the opposite direction. They may be reduced to enable more vocational and production flexibility, facilitated by the new technologies.

3.3 ICT and the Knowledge Revolution

Just prior to the take-off of the ICT revolution, a seminal article by K. Arrow interpreted some of the fundamental properties of knowledge in economic analysis\textsuperscript{11}. At that time, knowledge was viewed as a close equivalent to information. The latter is analysed as having the properties of a durable public good. This means that, once produced, know-how can be reproduced and used, by its creator and/or by others, without additional cost and independently of the scale and frequency of activities. On the basis of this, important differences exist between the private and social effects of the innovation process. Furthermore, market outcomes depend on the expected profitability of the innovating firm and of its imitators on the basis of the market structure and the volumes of operations relative to the costs of creating and/or procuring knowledge.

This emphasis on competence and on learning requirements, instead of on the informational character of knowledge, leads to different conclusions and policy implications. Knowledge, in this case, is perceived as being idiosyncratic to specific individuals, organisations, and applications, while others might be excluded. Furthermore, the transfer of learning is not a costless procedure, as the transfer of information could be, nor can it be repeated independently of the scale and frequency of the corresponding activities. These tacit elements of knowledge imply that the latter cannot be simply codified and easily reproduced or transferred. Furthermore, technology draws from the development of diverse knowledge sources and depends on the capability to synthesise them\textsuperscript{12}.

Even imitation, undertaken through reverse engineering, calls for important prior cognitive elements and capabilities on the part of those who undertake it.

As a consequence, the process of innovation has its own internal logic and is not simply the automatic and “linear” outcome of cost/benefit comparisons defined by markets. Even more,


market structures turn out to be expressions of knowledge generation. All these properties and conditions are particularly present in, and reflect the specificities of, the ICT revolution. Its policy implications will be examined in the concluding section below.

3.4 ICT and the Internationalisation of Business Operations

The last particularity of ICT to be underlined here concerns the intensity by which it has prompted the internationalisation of business operations. This has, in turn, modified and blurred the definition of national economic spaces in view of the emergence of complex integrated production systems operated by transnational corporations across national boundaries. This intensified search for internationalisation, greater that in any previous period in history, turns out to be the direct result of ICT, which provides the enabling conditions for expanding geographically and, at the same time, for integrating and more tightly controlling corporate spaces. And internationalisation becomes a critical factor in resource accumulation, since the boundaries of national markets turn out to be limited and restrictive. The available evidence indicates that in the two decades 1974-1993, the standardised value of world production increased by slightly more than 75%, while the equivalent for world merchandise exports increased by about 150%. In comparison, the correspondingly standardised foreign direct investment flows surpassed all other aggregate world indices, with the exception of finance capital involved in international investments. Foreign direct investments went up by significantly more than 500% during this period. The resulting internationalisation process, moulded within the structures of integrated and tightly controlled production systems, creates its own patterns of inclusion/exclusion and of concentration on a global scale.

4. SOCIAL COHESION AND EXCLUSION/INCLUSION PHENOMENA OF ICT

- the degree or lack of access to opportunities and resources;
- the nature and extent of control over decisions and productive assets; and
- the dynamics and structural characteristics of development trajectories which create and/or reproduce socio-economic conditions for more or less equitable participation in the fruits of progress, or for marginalisation and exclusion from them.

One of the central issues which transcends diverse social cohesion concerns has to do with the determination of employment opportunities offered in a society, the conditions of the labour markets, and the content of work. Poverty and equity outcomes are largely determined by the employment evolution.

From the available evidence, it is well recognised that ICT reshapes work in fundamental ways, involving the total volume of employment as well as the distribution of workers across occupations and firms. ICT also reshapes work by changing the very nature of the skills required and the interrelationships among jobs and functions within a firm and sectorially.

As far as the volume of employment is concerned, important differences exist between the effects of ICT at the levels of the firm, the industry, and the nation as a whole\(^\text{14}\). Employment creation and displacement phenomena are likely to occur simultaneously and in different intensities. The end result will depend on:

- whether an economy participates in the generation and supply of ICT and of its applications or is only a user;
- whether firms are led to downsize their employment practices to meet competitive pressures or introduce new human resource management practices related to the novel opportunities offered by ICT, together with the reorganisation of their activities;

whether sectorial restructuring takes place so that the redistribution of employment opportunities between sectors can serve to offset labour displacement effects in some ICT uses by enhancement in others; and

whether aggregate demand management and the macroeconomic environment favours sustainable growth and employment creation.

From the beginning of the ’70s, trends in the OECD labour markets indicate important ABN-AMRO structural changes in employment patterns and in the content of work opportunities. Major factors in these longer-term trends are associated with the productive restructuring taking place in view of the ICT revolution.

To start with, serious changes are noted in the employment share of distinct sectors, and in magnitudes which far exceed corresponding variations in output shares. As a result strong differentials emerge in relative productivities, leading to a widening gap in wage and salary differentials, particularly in the context of weakening trade unions. The latter are significantly affected by major shifts in policies on the welfare state. Consequently, multiple forces strain simultaneously the conditions of social cohesion prevalent in an economy and bring about corresponding conflicts, which elevate confrontations between workers and governments.

Second, in a number of countries, net job creation is strongly related to the knowledge-intensive parts of the economy, while shrinkages of work opportunities are evident in more traditional activities. Such activities tend to be affected by liberalisation policies, thus reinforcing protectionist pressures during sectoral adjustment periods. Other countries, though, especially the developing ones, confront new realities in their external sector with trade liberalisation taking place in their imports without corresponding opportunities in export promotion. Exceptions exist for a few developing countries, mainly in Southeast Asia, in ICT-related export activities.

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15 For example in the European market economies, the share of manufacturing value added was 30.6% of the total GDP in 1973, 28.2% in 1985, and was projected to be 28.8% in 2000. In contrast, the employment share dropped consistently from 29% in 1973, to 26.3% in 1985, and is expected to reach 22.1% by 2000. This was the largest relative drop in employment. It was compensated by increases in collective services (the highest increase) followed by trade and finance. Data from the Economic Commission for Europe cited in Sanders, C., Matthews, M., and Patel, P. (1991) “Structural change and patterns of production and trade”; in Freeman, C. et al. (1991) Technology and the Future of Europe, 18-36.

Third, one of the most worrisome findings of the recent OECD Jobs Study is the strong tendency in the ’80s toward polarisation in the labour markets. This phenomenon is mainly expressed on two fronts. In certain countries, e.g., the U.S. and the U.K., relative wages for less skilled workers have dropped dramatically. As a result, not insignificant parts of the labour force have become working poor, while, at the same time, unemployment rates are not easy to combat. In other countries, especially continental Western European economies, polarisation in terms of relative wages was not as dramatic as it was in terms of unemployment, which was especially high among unskilled workers and new entrants in the labour force. Thus, knowledge, learning, and unequal access conditions are key factors in contemporary labour market segmentation.

In such a context, exclusion phenomena become endemic, even among industrially more advanced countries. These phenomena tend to be highly correlated with the manner by which “learning economies” adjust to the new techno-economic paradigm.

In the case of developing countries, the contrasts in the conditions of exclusion in labour markets tend to be even more pronounced. A few countries, especially in Southeast Asia, have been able to assume an active role in the ICT revolution. They represent the counter example, with inclusion phenomena both internationally and domestically. Conditions for such a “special” performance among emerging economies as world players in the ICT era rested on the prior existence of longer-term policies on education, income, and wealth redistribution, hence improving access opportunities for the majority of their populations. Furthermore, they were based on stable macro-environments, supported by high domestic savings rates. They also involved outward-oriented economic policies founded on active and non-neutral trade and investment policies. Such policies placed a high priority on the support and protection of endogenous growth poles and of domestic productive actors. Finally, they included proactive and selective public sector policies at the sectorial and institutional levels. Key among such policies are diverse interventions on technology and human resource development.


But for the majority of developing countries in Latin America, Africa, and parts of Asia, the experience has been quite different. Summarising the experience of several economies studied by the International Labour Office, and with special references made to Latin America, the following main conclusions were reached on the realities of the labour market:

- **First**, during periods of aggregate macroeconomic and structural adjustment, employment performance was seriously and negatively affected while poverty and inequity increased. Production rationalisation, improved competitiveness, and technology introduction led to employment downsizing.

- **Second**, growth is a necessary condition for reducing unemployment, yet the rhythm and sustainability of growth are also critical. Even more, employment generation during recovery periods concentrated mainly in the informal sector, thus leading to low and slow growth in productivity. Technology-driven activities remained at the margin of labour absorption. In fact, during the last 15 years, eight out of ten new jobs created in the whole region of Latin America were in the informal sector.

- **As a consequence,** the quality of the new jobs generated is quite different from the corresponding ones in economies which actively participate in the generation of ICT and in the supply of the corresponding goods and services.

- **Third**, real wages were determined more by the degree of success in controlling inflation than by evolutions in the labour market. Macroeconomic and structural conditions turned out to be far more important in determining real earnings as compared to the effects of technological change on productivity and wages.

- **Finally,** although strong recovery is associated with poverty reduction, it does not follow that equity is improved. Quite often income differentials continue to increase even further, as also happened in a number of industrially advanced economies.

The lessons to be drawn from these broad conclusions on the labour market and the state of employment opportunities stress the contingent nature of technological change and of its

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20 For example, Singapore doubled in 1996 the public commitments for subsidising R&D activities by both national and foreign-owned subsidiaries operating in the country. It also more than tripled the corresponding public resources to help the development and introduction of new products by private firms. See Financial Times, 31 January 1977.


22 Between 1980 and 1990, on average, wages in the manufacturing sector of Latin America dropped by 13% in real terms and the minimum ones by 31%. The corresponding drops between 1980 and 1995 are reported to be 8% and 27%, respectively.
impacts. The immense opportunities offered by the ICT revolution are potentially realisable for those individuals, firms, and economies who have or can develop capabilities, organisation, resources, and/or power to be included. For most of the others, though, such opportunities are not automatic, nor can the required techno-economic changes simply be transplanted independently of the socio-economic context. Even more, the dynamics of exclusion can accentuate existing inequities, discrimination, and marginalisation. As a consequence, structural constraints are reproduced and reinforced, placing severe limits on efforts to attain acceptable levels of social cohesion in a country.

In this respect, there exist a number of interrelated areas of policy issues which bear on the phenomena of exclusion as far as the ICT is concerned. First, the potential for introducing ICT in the fight against poverty might prove in practice severely limited if access to elementary technical provisions cannot be satisfied resource-wise. For example, the cost of installing even a simple telephone line in an already existing telecommunications system can prove to be higher than the level of annual per capita income in some countries. It can also exceed the corresponding per capita income of significant sections of the population in many developing countries, namely the lower half of their income brackets.

Thus, the level of privately available resources can prove such as to exclude a large number of people from participating in the fruits of technical progress. On the other hand, the use of ICT applications can contribute to overcoming other resource shortages, e.g., the use of telematics to confront problems about the availability of qualified primary education teachers needed to cover widespread rural areas. In these cases, public resources have to be committed in an appropriately focalised and localised manner so as to develop socially viable solutions in which technology can open up previously unavailable options. Again, the use of technology is not automatic. It requires public policy commitments, as well as different priorities in resource distribution and usage in a country, all of which are issues of an eminently political nature. It also calls for the development of particular organisational capabilities and for changes in human resource management.

Second, it has already been noted that the ICT revolution has redefined educational needs. This is highly relevant for the introduction of economic activities which depend upon ICT applications, not to speak of the more demanding requirements for specialised knowledge and human capital in sourcing, operating, and innovating technology itself.
The use of ICT in productive activities as well as the demands posed for life-long learning capabilities have brought into the forefront the critical importance of appropriate secondary education, available to a wide spectrum of a country’s population. Previous industrial revolutions, with their emphasis on standardised mass production and on knowledge embodied in physical assets, had placed corresponding demands on literacy levels and primary education. The two areas continue nowadays to be among the more strategic development challenges for a number of countries. This is true not only among the least developed economies in Africa or elsewhere, but also in major developing countries, such as Brazil. Yet, in the context of the ICT revolution, primary education is not enough to match the new work requirements. The quality upgrading and the quantitative requirements need to be extended to cover, at least, the level of secondary education.

On the other hand, educational reforms and human resource improvements require longer-term societal investments, both public and private, with sustained policy commitments. Meanwhile, the less fortunate in a country’s population can remain largely excluded from access to educational upgrading. This situation leads to their corresponding exclusion from the major opportunities offered by the ICT revolution. As a consequence, socio-economic inequities and marginalisation conditions are not only reproduced but could be accentuated by the educationally induced unequal access to ICT and its applications.

Third, the overall context of social cohesion is greatly influenced by what roles are set and what power relations are imposed in a society. Such roles and power relations affect the participation of distinct groups of the population in the fruits of progress. In this respect, gender-related considerations turn out to be seriously affected.

The gender bias of radical changes in ICT has to do with the following structural issues in role definition and power relations:

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23 In 1960 only 2% of the Brazilian population had attained secondary education. In the early 1980s the corresponding figure had increased to only 7%. In contrast, the Republic of Korea, in the immediate post World War II years, reported only 13% of its population having had any type of formal education. Yet, after four decades of continuous commitments on human resource development, in the early 1980s the Republic of Korea reported that more than 55% of its population had attained secondary education. For the case of Brazil, see Barros, Mendouca, and Santos (1992), “Consequencias do Desequilido a seus Mecanismos de Auto-Reproduzidas”, in En Perspectivas da Economia Brasileira—1992, IPEA, Rio de Janeiro. For the case of the Republic of Korea, see Lee, J.-W. (1995) “Economic Growth and Human Development in the Republic of Korea, 1945-1992”, paper prepared for UN DP (1996) Human Development Report, New York.
Child bearing and raising as well as household responsibilities increase the probability that the access of females to the labour market will tend, throughout their economically active lives, to take place more via the informal sector. This is particularly confirmed by evidence drawn from developing countries and from societies in which informality in work opportunities is closely linked to efforts for overcoming poverty and destitution. For example, single working mothers often tend to be the poorer and less privileged among the poor in developing countries.  

At the same time, the informal sector displays structural characteristics which, on the whole, make it less susceptible to the applications of ICT. Thus, the productivity potentials of the use of new technologies will tend to bypass several informal sector activities and, consequently, the workers in such activities. In disproportionately large numbers such workers are females who will find themselves excluded from the benefits of the new technological breakthroughs. This indirect gender bias of the new technologies is obviously not uniform. In other cases, qualified females can be facilitated by ICT to undertake more effectively and with more flexibility their multiple roles in external, remunerated work as well as within their families. The heterogeneity of implications of the new technologies is, again, related to capabilities, human resource advancement, and access characteristics.

Furthermore, biases in the definition of skills and discrimination at the workplace can further be accentuated through the use of the new technologies. For example, greater dexterity has been shown by females in assembling integrated circuits and other (micro) electronic products in “free industrial zones”. This has led to their massive and highly competitive hiring in such work stations, often under very poor work and environmental conditions. Yet, females are excluded from higher-paying and potentially more rewarding jobs in the same economic activities.

Moving at a more aggregate level, the economic geography portrayed by a country implies differentiated access to and impacts from the new technologies. Thus, in view of infrastructural requirements and diverse economies of agglomeration, differential accesses exist in the use of ICT between the urban centres and dispersed rural areas. If additional discriminatory factors are also taken into account (e.g., lower educational levels in rural areas, higher incidence of poverty and lower resource availabilities, gender and racial biases, etc.), then further serious inequities arise through the differences in the opportunities offered by ICT applications. To overcome such an intensification in unequal socio-economic development within a country, explicit rural
support programs need to be introduced, with special focus on the more vulnerable groups of the population.

Finally, at the international level major inequities result from the concentration of production of ICT goods and services in specific industrially advanced economies. With a few notable exceptions, mostly in Southeast Asia, such ICT-related productive activities turn out, at least for the time being, to be out of reach of most developing countries or, at best, with the latter having only a marginal role. For example, in 1991, the U.S., the European Union, and Japan accounted for 98.8% of world production and 97.7% of world exports of packaged software. All other countries represented 7.7% of world consumption and 17.7% of corresponding imports.25

In the areas where some penetration by newcomers could take place, important barriers to entry have been erected. A major such institutional barrier involves the newly imposed norms on intellectual property rights (IPRs). More changes have taken place on this front during the last 15 years than in the previous 150. Such changes were sanctioned by the World Trade Organisation after the last round of GATT negotiations. The corresponding “TRIPs Agreement” represented a major achievement of U.S. industrial groups, and a “conceptual leap”, linking IPRs to trade issues, backed by multilateral trade retaliation for noncompliance.26 Furthermore, bilateral pressures have been exerted by governments against a number of developing countries so as to extend protection even beyond the “minimum” WTO norms. Such has been the case of the procedures initiated under Section 301 of the U.S. Trade Act against Brazil, Thailand, and, more recently, China. The overall intention is two-fold: to restrict the access of the newly emerging economies in productive activities and to increase payments from users in the rest of the world.

The primary concern of the new approach to IPR is not to protect creativity and ingenuity but to reward investors. This creates new exclusion mechanisms beyond the range of innovation or of market concentrations established on the basis of knowledge and scale requirements. Instead,  


the combination of technical and legal developments could create access barriers to potentially all types of information, as epitomised by institutional trends in databases and in information in “cyberspace”. Some have argued that evolutions in these fields could “distort the public service mission [even] of libraries”. 27

The evolving institutional framework and the combined industry-government initiatives from major supplying countries aim at solidifying differences in access and rewards between producers and users of ICT goods and services. International inequities are, thus, further accentuated through institutionally imposed restrictive business practices.

5. CONCLUDING REMARKS: ALTERNATIVE POLICY APPROACHES IN VIEW OF THE ICT CHALLENGES

Within the context of the market system and the central role that markets have assumed in contemporary development, contrasting policy approaches have emerged. Their recommendations can be grouped into three alternative schools of thought, and their key policy components need to be explicitly reckoned with in formulating appropriate policy initiatives which address the implications of radical ICT changes. These three alternative approaches refer to:

- minimalist state interventions and “free” functioning of markets, as proposed by the neoliberal tradition;
- market-friendly and market-supporting functional interventions, as proposed by the revised World Bank position on structural adjustment programs; and
- the evolutionary school of eclectically combined functional and selective interventions suitable to the market and institutional realities and needs of each economy, with primary examples being those of the Southeast Asian countries.

The first approach, founded half a century ago on the theses of the Austrian school of political economy, has been extended in recent years by neoliberal positions based on two fundamental premises: First, the working of the market system is too complex to be grasped or manipulated, and, consequently, it is not possible to intervene adequately; and, second, the expansion of capitalism constitutes an organic dynamic process hindered by any attempt to intervene in the “free” functioning of its markets. The market’s distortions and failures are mainly the result of government interventions and of excesses in public sector participation in the functioning of economies. Policy guidelines emanating from the above lead to the following conclusions:

- Appropriate signals relevant to business decisions need to be dictated by international market forces. Their appropriateness is accepted regardless of their origin and/or the institutional context from which such signals emerge and are applied. The prevalence of international market forces has been translated into the quick and non-discriminatory liberalisation of external trade, direct foreign investments, technology and financial

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market regimes. This is the policy essence of the neoliberal prescription emanating from the Washington Consensus reached a few years ago between heads of governments of the Western Hemisphere economies.\(^{29}\)

- For policy makers, this approach often involves a misrepresentation of the Southeast Asian experience. The latter’s export orientation was misinterpreted to imply neutrality in trade policies, which was, instead, presumed to mean openness and free trade. In turn, this led to a preference for “government-free” and non-interventionist economic environments, thus proposing minimalist government policies and very limited public sector roles. As a consequence of this approach, the most active industrial and overall development policy would be one which is limited in assuring a stable macroeconomic environment and some basic infrastructure. On that basis, market forces will be free to lead business enterprises to undertake the most appropriate investment and operational decisions.

A second broad approach has resulted from the redrawing of the acceptable policy lines as introduced by the World Bank in its structural adjustment programs of the 1990s. According to this approach, public policy interventions are considered appropriate as long as they offset generic market failures. These market-friendly or functional interventions are, consequently, acceptable and come to complement other efforts which reduce government interference in the functioning of an economy. These latter interventions are characterised by the World Bank as being market-distorting and hence market non-friendly due to their selective nature. Compared to its own policy prescriptions of the 1980s, the change in the Bank’s position originated from the need to give a convincing answer to the pervasiveness of selective and proactive interventions in most high-performing Asian economies. Their successful performance took place not only along with multiple interventionist government policies but also, it is being claimed, precisely because of them.

- At the technical level, the distinction between market-friendly (functional) and non-friendly (selective) interventions although spurious, since any intervention which corrects for market failures is “friendly”—addressed the following four major areas of generic market failures:

  - factor market failures, especially in education and information gaps, thus accepting public support for human capital formation and for institutional development to enhance informed decisions;

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• **scale economies**, thus calling for the regulation of inevitable (and/or “desirable”) dominant market positions by large firms in certain activities in which lumpiness of investments is required;

• **non-appropriability of know-how** by firms, thus justifying public support for national innovation systems and intellectual property protection regimes; and

• **interdependence of certain investment decisions**, thus requiring measures which promote infrastructural investments and interrelated fixed capital formations.

In addition, the World Bank correctly stressed the crucial importance of certain “fundamentals” in the policy context of an economy. Such “fundamentals” concern the presence of sound macro policies, the discipline provided by an export orientation, and the pivotal role of a well-educated and adequately trained workforce. Thus, together with these key macro considerations and aggregate resource conditions, the Bank’s revised position accepted three types of government measures to improve restructuring decisions:

• removal of policy distortions;

• interventions to offset generic market failures; and

• market-supporting and market-creating institutions.

Such measures are discipline-strengthening (by increasing competition), mobility-enhancing (through liberalisation policies) and, at least in the short run, resource-augmenting (by the inflows of capital, technology, and information).

A third policy approach recognises that the core of the development process centres on the complex requirements for advancing diverse capabilities in an economy.\(^{30}\) In the current historical context, the long-term success of productive systems depends on their ability to harness new technologies. Such harnessing does not restrict public and private sector policy initiatives only to the requirements of the new technologies. Instead, it also calls for the development of new management and organisational skills, the presence of a multiskilled and adequately trained workforce, collaborative linkages between enterprises, and access

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opportunities in third markets. It also involves effective relations of enterprises with capital markets, technology generators, and information flows.

In these circumstances, the development of productive and competitive capabilities in an economy calls for the adequacy of policy initiatives with respect to three essential properties of the development process:

- Technology, and productive know-how more generally, are not codified to be simply picked up from some shelf of the international market and transferred the way physical goods are exchanged. Instead, the tacitness of knowledge implies considerable enterprise-specificity. In turn, this calls for the need to develop diverse capabilities of learning-to-learn and of learning from investment and production activities.

Consequently, the accumulation process in the knowledge base of an economy calls for specific policy instruments which support the longer-term and efficient presence of productive enterprises and of institutions in a country. Otherwise, the unwarranted disappearance of firms and/or of certain activities means the destruction of accumulated capabilities. Their replacement is not likely to be satisfied simply through corresponding market penetration by imports sold at world competitive prices.

- Innovation and learning endeavours are costly, risky, and largely unpredictable processes. This calls for adequately designed protection mechanisms to promote the critically important resource commitments which advance technological and organisational innovation in a society. Yet such protection generates costs for other economic actors in that country. Also, if not properly handled, it could distort longer-term resource allocation in an economy. The resolution of these trade-offs represents a key policy challenge which goes beyond the confines of market failure questions raised by the World Bank. It concerns the priorities and requirements in following a trajectory of dynamic economies of scale and in seeking non-static advantages in resource allocations. Both acknowledge the importance of externalities in the development process.

- As noted in the first point above, knowledge applied in economic activities is not an exogenous factor but, instead, is endogenously mastered by and advanced from enterprise, sector, and country specific resource commitments and initiatives. Furthermore, technological and productive deepening does not simply result from the mere multiplication of inputs. Rather it calls for more complex and activity/sector-specific interventions and competencies. As a consequence, there is a definite need to
design distinct combinations of functional and selective interventions and this because sector conditions and technological requirements differ among them and over time.

- The different policy framework implied by the capabilities development approach, as contrasted to the other two noted above, was clearly present in the industrial policy strategies of the high-performing Asian economies. This is also true for a number of successful OECD experiences. Such an approach eclectically combined functional and selective interventions. The exact nature of these interventions needs to be country- and sector-specific. Knowledge and comprehension lend themselves to abstraction and generalisation processes. On the other hand, in order to be effective, policies require their own knowledge elements as well as specificity and differentiation to account for the socio-economic and institutional context within which they are applied. Part of this context involves the presence of not only market but also of serious government failures, and the need to advance government capabilities so as to promote development through public sector reform.

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Editor's Note

With pleasure we present to our readers the special series of UNU/INTECH Discussion Papers: Information Revolution and Policy Implications for Developing Countries. Papers of the Series were originally developed for the International Workshop on The Information Revolution and Economic and Social Exclusion in Developing Countries, held in Maastricht on 23 -25 October 1996. The Workshop was an important event organized by UNU/INTECH and financed by the Dutch Government. Insights developed from the Workshop have not only been benefiting UNU/INTECH research work, but also contributing to many other initiatives in the area of innovation policy for information technology in developing countries.

There are six papers in the special series. The first five papers have been widely circulated and are provided here in the latest modified versions. These are outcomes from the two major themes set for the Workshop: ‘The Developments of Access and Effective Use of Information Technology and Exclusion’, and ‘The Gender Dimension in Exclusion’. The sixth paper, by Ludovico Alcorta, is a summary of the three country cases on Burkina Faso, South Africa and Tanzania organized for the Workshop.


#2002-2* Constantine Vaitsos, “Policy Agenda for the Information Revolution and Exclusion Phenomena in Developing Countries”


#2002-4* Carlos M. Correa, “Implications of Intellectual Property Rights for the Access to and Use of Information Technologies in Developing Countries

#2002-5* Cecilie Ng Choon Sim, “Making Women’s Voices Heard: Technological Change and Women’s Employment with Special Reference to Malaysia”

#2002-6* Ludovico Alcorta, “The Information Revolution and Economic and Social Exclusion: The Experiences of Burkina Faso, South Africa and Tanzania”

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NATIONAL INNOVATION SYSTEMS AND THE INNOVATIVE RECOMBINATION OF TECHNOLOGICAL CAPABILITY IN ECONOMIC TRANSITION IN CHINA: GETTING ACCESS TO THE INFORMATION REVOLUTION

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1. INTRODUCTION

This paper examines developments over the last 15 years in the Chinese information technology (IT) industry. By identifying the characteristics explaining China’s emerging strength in IT, we hope to provide a reference to other developing countries seeking to participate in this industry.

The idea of the “national innovation system” (NIS) plays a central role in our analysis because it brings together the processes of technological, institutional and policy changes that underlay China’s development in this area. The national innovation systems approach suggests that economic performance will be shaped by a learning process in which knowledge is accumulated and distributed among institutions. Government policy may contribute to this process by guiding or controlling the rate and direction of institutional evolution and by identifying and filling important gaps in the institutional framework in which learning occurs. Where and how to intervene is neither obvious nor straightforward, and government may inadvertently impede rather than promote the learning process. The complexity of the policy problem is particularly dramatic in the case of China due to the major changes brought about by the transition from strategies of military preparedness and self-reliance, which directed learning along one path, to market reform and an opening to international trade, which directed learning along a very different path. Transition involves redeploying accumulated technological capabilities and restructuring institutional arrangements, tasks which are a major challenge for government policy managers (Gu 1995).

A key feature in economic transition is the opening of the domestic economy to international trade, bringing about the creation of new incentives and competitive challenges (Steinmueller and Bastos 1995). These changes are particularly important for the information technology industry. IT products now have a long tradition as internationally traded goods. And IT manufacturing operations is one of the few areas where the term “global division of labour” accurately describes the ongoing process of production specialisation.

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1 For an expanded version of this paper see Gu and Steinmueller (1997).

2 See Freeman (1987), Lundvall (1992), Nelson (1993), and papers published in the Cambridge Journal of Economics, 1996, 19. Apart from these specific works, the idea of national innovation system has widely been employed in studies dealing with issues such as national competitiveness or catching up. Similar concerns have been developed under the terminology “social capability” by Abramovitz (1986).
The implications for developing countries of this globalisation process are uncertain. According to some scholars (e.g., Ernst and O’Connor 1989, 1992), the global division of labour is largely asymmetrical, forcing developing countries to compete with one another in offering low-wage assembly while denying them access to design and process know-how. This means that the “export-led growth” strategy in the IT industry that contributed to the recent success of the Korean and some Southeast Asian economies, is unlikely to be reproducible in other countries such as Thailand, Malaysia, Indonesia, or the Philippines. Adopting this strategy is now seriously constrained by the rigours of the end product markets in industrial economies, and by heightened barriers to gaining access to key technologies. An entirely different conclusion is reached by Soete (1985). Soete assumes a rapid rate of international technological diffusion that would provide the opportunity for NIEs to achieve “world class” products more rapidly than was the case with earlier successful NIEs. According to Soete, the convergence in technological capabilities among industrialised countries makes them competitors in the sale of capital goods and know-how to new entrants, rather than the effective controllers of the oligopolistic market that Ernst and O’Connor describe.

When this debate first appeared in the literature, there was little evidence available to test or go beyond the two alternative arguments. Was technological know-how to be oligopolistically constrained, or was it to be openly available, dispersed from competing suppliers? Steinmueller (1995) has developed a third hypothesis, suggesting that the dissemination of knowledge in the electronics industry is particularly difficult to control and that the main barriers to competitive entry can be overcome through a combination of participation in using and producing IT products.3 This argument is, however, as speculative as the earlier ones, and silent on the issue of how a developing economy can combine participation in using and producing IT products and achieve successful entry.

IT and electronic industry developments in China have now generated substantial evidence about entry possibilities. We will examine the process by which China has managed to acquire or develop the specialised know-how, new firm organisations, and domestic markets that are

---

3 Steinmueller’s argument begins with the presumption that market restrictions will be ineffective in agreement with Soete, but he finds it unnecessary to presume the necessity of vigorous competition among industrialised countries in order for new entrants to gain access to capital goods and know-how sold at the market place. Instead, he places greater weight on the “internal” processes of capability development in the production of IT, such as the development of a technologically skilled labour force, experience gained from direct participation in the production or use of the IT, and the development of a domestic demand for IT products. Steinmueller’s view of catch-up prospects is therefore even more optimistic in situations where these conditions are favourable.
necessary to have a strong domestic IT and electronics industry. Our examination of this process indicates that the entry process has been more complex than the explanations offered by earlier authors. It incorporates elements of each of these simpler explanations, as well as a relatively neglected process that we call “innovative recombination of technological capabilities”, in which continuing institutional restructuring has released accumulated capabilities that were then recombined and further improved to meet market opportunities, both domestically and internationally. The significance of learning in this process highlights the value of a national systems of innovation approach for analysing the potential for entry and relevant policies to promote entry. The foundations for an IT industry have been built during the economic transition through the processes of domestic capability development, expanding international participation, the articulation of domestic market demand, the process of institutional restructuring, and the strengthening of supporting industries. However, it still remains uncertain if this industry in China will become a “brand” exporter in the international market. For the Chinese economy as a whole, it also remains uncertain how and where the benefits from widespread and sophisticated IT applications will promote productivity and welfare.

1.1 Attributes of a national innovation system

The national innovation systems approach emphasises the endogenous character of knowledge generation and use in the creation of distinctive patterns of industrial specialisation and capability. It opens the possibility for a richer and more complex treatment of public and private institutions and recognises a wider scope for historical contingencies and differences in comparative industrial performance than conventional economic approaches.

But since this approach has encountered some methodological complications⁴, it is important to develop a framework which assists the comparative analysis of institutional performance, market development, and strategic choices. One such framework is that of Porter (1990), in which the traditional economic factors like market structure and relative endowment have been partly re-integrated with more institutional parameters. Porter brings together four “attributes” of national competitive advantages:

a) Demand conditions—the size, structure, and sophistication of demand for goods and services by domestic consumers;

---

⁴ See OECD document DSTI/STP (96) 11: National Innovation Systems: Proposals for Phase II.
b) Related and supporting industries—the “upstream” industries that provide critical intermediate input and support to the process of innovation and upgrading, such as the machinery industry, and the “complementary” industries that share activities in a value chain;

c) Factor conditions—the level and composition of factors of production, that embrace not only naturally endowed factors but also “created” human resources and the “higher-order” knowledge resources that are critical for the efficiency of learning of an economy; and

d) Firm strategy, structure, and rivalry.

Porter arrays these four attributes in the form of a “diamond” to convey their interactive and interdependent character. He argues that the attributes of the diamond may evolve either in mutually reinforcing or destructive patterns over an extended period of time, and that this evolution may be shaped by both internal attributes under the co-ordination of government policy, and by external factors, such as the influence of international markets.

The working hypothesis suggested by Porter is that effective and sustained development requires significant change in several of the “diamond” attributes which can be greatly influenced by participation in international trade—in transferring know-how, developing organisations, creating new market opportunities, strengthening competition, establishing new upstream and downstream linkages, and re-orienting the acquisition and development of skills. The specific channels of international participation by which these attributes have been influenced in China’s IT industry include: (1) OEM assembly, (2) imports of technological know-how and the procurement of production equipment, (3) buying components and parts as intermediate input in domestic production, (4) direct foreign investment, and (5) purchasing engineering service in the international market. Each of these will be considered in our analysis.

1.2 Alternative models for IT development in developing countries

The developing world has achieved some successes in the creation of viable IT industries in South Korea and other “first-tier” NIEs. Their successful developments are explained beginning with original equipment manufacture (OEM) of foreign designs (Ernst and O’Connor 1989, 1992; Hobday 1995a, 1995b; Simon 1993). There are two key features of this model of
development. The first is that manufacturing competencies rather than applications have been the major areas of the developments. Skilled and disciplined low-wage labour forces played a central part in the successful experience with labour-intensive manufacturing. The second feature is that the manufacturing of IT products has been very heavily export-oriented.

What has been less appreciated is the effect of timing on the success of this particular path of development. Manufacturing-focused and export-oriented approaches resulted, in part, from the multinational companies’ overseas sourcing aimed at finding sites for low-cost production in the 1960s to 1970s. Leading-edge companies in both the U.S. and Japan, and to a lesser extent, Europe, followed the strategy of outsourcing low cost production which was often OEM-based. The recipients of OEM production were able to begin the accumulation of the national innovation systems’ “attributes”, building on a relatively weak base in firm organisation, supporting industries, demand conditions, and higher-order factor creation ability. Indeed, much of the success of the “first-tier” NIEs resulted from their speed and flexibility in seizing the opportunities presented by “changes in international production” (Dunning 1993: 51-77). Relying upon the rapidly expanded international IT product markets and the rapid growth of international OEM contracting, the NIEs have largely overcome their weaknesses in domestic market demand and in foreign distribution channels. Is this experience relevant for explaining the IT development in China?

Our contention is that China’s recent development in the IT area differs substantially from the experiences of South Korea, Singapore, Taiwan, and Hong Kong. The key differentiating features of China’s development are: (1) a simultaneous development in both IT production and IT applications (consumption); (2) the active involvement of a sizeable domestic market in the development of IT production and IT applications that accompanied a move into export markets; and (3) the incorporation of a wider range of engineering services with greater sophistication than that of the earlier entrants, in supporting IT production and IT applications.

The domestic market has been of basic importance in promoting the IT industry in China. Many products and services provided by the IT industry during the period examined were linked to domestic market transformations, and often resulted in some exports under export promotion. The domestic market therefore served as the major driving force by which production and applications of IT were more closely linked to each other. The incorporation of a wide range of engineering services has been necessary for the simultaneous development of production and applications of IT, and the emerging engineering services reflect a wider range of accumulations
of technological capability, embracing not only production engineering but also systems design and user programming. In short, the recent experience of the IT industry in China represents a model, characterized by close interaction between manufacturing and application activities. Application engineering and production engineering were relatively intensively incorporated.

Domestic and international markets were both targeted. The characteristics of the development of the IT industry in China is the subject to be examined in the paper. A learning process associated with the development will be summarized as well.

For the purpose of comparison, it is useful to cite the existing literature which highlights the experience in the “first tier” NIEs where there was the absence of a strong interaction between production and application. The learning process of the “first-tier” NIEs was centred exclusively in the development of manufacturing capabilities. Hobday (Hobday 1995a, 1995b), for example, has identified the learning ladder as starting with OEM assembly skills, focused on fulfilling criteria on quality, cost, and delivery time set by foreign contractors. At later stages, process engineering and product design capabilities were acquired. Hobday maintains that progress involved moving from being “pulled” by OEM contractors towards more active sales and up to the highest stage of the ladder, that of “own-brand” marketing. But, as he noted, not all the export-oriented developers have successfully climbed to the later stages. A simplified version of Hobday’s learning ladder is depicted in Table 1 to provide a reference point for our comparison.
Table 1: Stages of marketing and technology learning for IT manufacturing in the “first-tier” NIEs

<table>
<thead>
<tr>
<th>Marketing Stages</th>
<th>Technology Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, passive importer-pull</td>
<td>assembly skills</td>
</tr>
<tr>
<td>2, active sales of capacity</td>
<td>incremental process changes</td>
</tr>
<tr>
<td></td>
<td>reverse engineering of product</td>
</tr>
<tr>
<td>3, advanced production sales</td>
<td>full production skills</td>
</tr>
<tr>
<td></td>
<td>product design</td>
</tr>
<tr>
<td>4, product marketing push</td>
<td>begins R&amp;D</td>
</tr>
<tr>
<td></td>
<td>product innovation</td>
</tr>
<tr>
<td>5, own-brand push</td>
<td>competitive R&amp;D</td>
</tr>
<tr>
<td></td>
<td>advanced product and process innovation</td>
</tr>
</tbody>
</table>

Source: reproduced from Hobday (1995b:40)

The scope of this paper is roughly that of the electronics industry, though its central theme is information technology. Consumer electronics is included because there are numerous spillovers across various branches of the electronics industry in technology and managerial skills, spillovers which are essential particularly if the catch-up process requires transiting various accumulations in order to reach the state of the art. Section 2 briefly summarises the structural characteristics of the Chinese electronics industry before and during the current reform. The characteristics developed under central planning established the initial conditions for the current market-oriented economic reform. Section 3 examines specific cases drawn from the consumer electronics, personal computer, informatics, and telecommunications sectors of the industry for evidence about how the national innovation systems approach offers a perspective to explore the development experiences in China during the 1980s and early 1990s. Section 4 attempts to generalise some of the lessons from the Chinese approach, which we refer to as “innovative recombination”, for other developing nations seeking to participate in the electronics industry and the information and communications technology revolution.
2. THE CHINESE ELECTRONICS INDUSTRY: BEFORE AND DURING THE ECONOMIC REFORM

2.1 Early Development (1950s-1970s)

The development of China’s electronics industry following 1949 was shaped by the objectives of industrial self-reliance and military preparedness. As in other socialist countries, the strategy of industrial self-reliance emphasised the significance of vertical chains of production proceeding from heavy industry to avoid dependence on imported capital goods. Agrarian reform, which promoted the development of agricultural mechanisation, the construction of a transport and storage infrastructure to achieve a better integration of the economy, and the general development of the machinery industries and steel production were associated with the strategy. Developments in military preparedness were also strongly oriented toward the heavy industries, with a particular emphasis on mechanising and armouring ground forces while creating credible air and sea forces.

Communication needs for self-reliance and military preparedness were a significant impetus to the electronics industry development, but these needs required only a modest development of mass production at either the equipment or components level, indicated by the fact that the 1980 share of electronics industry output in manufacturing was about 2.0 per cent (Table 3). Although low compared to the levels achieved in later years, this share was not dramatically lower than some of the OECD economies during that period.

Despite the modest share of the electronics industry, its absolute size was big enough to support a large number of firms and R&D institutes, partially indicated in the available 1985 statistics. In that year the industry was comprised of 2,779 enterprises, 178 of which were centrally affiliated (i.e., managed directly by the central Ministry of Electronics Industry) (Liu Ying et al. 1987: 692). It employed 1.45 million people among whom 133,500 were technical staff. In addition, there were 50 national-level R&D institutes in 1985 with total staffing of 59,800 (ibid.: 320), while another 93 R&D institutes existed at the local level (ibid.: 9).

These statistics indicate the starting point from which the present capabilities and institutional structure of China’s electronics industry have evolved through a process of growth and
economic reform. To understand how these institutions evolved, we summarise the “initial conditions” in China’s national innovation system for the electronics industry in four areas: 1, sector structure; 2, firm structure and geographical distribution; 3, R&D and educational institutions; and finally, 4, the accumulation of technological capabilities and the general level of technological basis of the industry.

2.1.1 Sector Structure
A peculiar sector structure evolved from the self-reliance and military preparedness strategy in which the component sector was relatively large while the consumer electronics sector was quite weak as measured by the traditional Chinese categorisation of these activities (see Table 7). The size of the component sector as a share of total electronic industry output was 61 per cent in 1980, remarkably high given that China was then a minor exporter of components (see Table 4). The size of the component sector was the result of very high production costs that inflated the stated value of these products despite their poor quality in terms of reliability, uniformity, and stability. Consumer electronics output accounted for only one-fifth of total output in 1980 (Table 7) and suffered from the same problems of high cost and low quality. On the other hand, although their share of electronics output was not very high, military electronics such as radar and communication equipment (included in Table 7 under the category of “investment electronics”) were central to national strategy, and drew significant investment and the best engineering talent. Some military electronics, for instance in the computer area, did make a contribution to the commercial development of related products, but spillovers of this kind were generally weak, contributing to the backwardness in areas such as industrial control equipment and telecommunications equipment.

2.1.2 Firm Structure and Geographical Distribution
Among the total 2,779 electronic enterprises in 1985, the majority, apart from the 178 centrally affiliated, were “local” enterprises. A division of labour existed between the central and local enterprises, with the central enterprises focusing on military electronics. The local enterprises specialised in devices and parts, and on consumer products such as radios, calculators, and televisions. The production organisation of enterprises was mostly based on producing single products in small batches (Liu Ying et al. 1987: 7).

Geographically, the electronics industry was rather widely dispersed. By 1985, four electronic bases were in place: (1) East China, located in Shanghai city and Jiangsu province; (2) North China, in Beijing and Tianjing cities, and Liaoning province; (3) Inland West China, in Sichuan,
Shanxi, Guizhou, and Gangsu provinces, developed during the 1966-1976 inland diffusion; and (4) South China, in Guangdong and Fujian provinces, emerging during the 1980s.

2.1.3 R&D and Educational Institutions
Institutions for R&D and education expanded enormously throughout the 1950s to 1970s, under the policy of planning co-ordination. 1985 statistics reveal that 50 centrally affiliated R&D institutes had been established specialising in electronics technology with staff at the level of 59,800. Interrelations among research, development, design, and manufacturing in the electronic industry were closer than in civilian sectors such as the machinery industry. In addition, there were 93 local R&D institutes established by 1985 (Liu Ying et al. 1987: 9). Approximately 65 universities, colleges and training schools with a focus on electronics were established and offered courses and degrees in the relevant engineering disciplines (ibid.: 9).

2.1.4 Accumulation of Technological Capability
In pursuing self-reliance, experience and capability were accumulated in two areas. In the area of design and testing (which were major activities in R&D institutes), intensive efforts were devoted in developing products and components. Capabilities in design and testing were accumulated due to the frequent need for technologies that were mostly not at the frontier of technological sophistication and that were generally available in the capitalist economies, but, under self-reliance were developed domestically. Underlying these developments, information searching was a well organised process. In the area of the integration of mechanical and electronic technology, a moderate degree of capacity was developed due to the substantial injection of technologies into industrial production. Moreover in general, the wide dissemination of mechanical technology in the country during the same period offered an important basis for the integration between electronic and mechanical engineering.

The technological base of the electronics industry was, however, obsolescent. During the 1950s to 1970s, semiconductor technology replaced the electron valve (vacuum tube) as the result of domestic technology developments involving intensive co-operation over product design and process technology development (Liu Ying et al. 1987: 273-84, 322-23). By the end of 1960s, component output of the Chinese electronics industry was principally based upon semiconductor technology. Thereafter the industry failed to develop technically stable and reliably IC technology, although prototype development in scientific laboratories did not lag
very far behind Western levels (*ibid.*: 280-81, 324-25). Table 2 shows the replacement of vacuum tube production by semiconductors in the second half of the 1960s and the marginal position of IC technology from the second half of the 1960s until the early 1980s.

### Table 2: Composition of Chinese electronic components production, 1953-1985

<table>
<thead>
<tr>
<th>Year</th>
<th>Vacuum Tube</th>
<th>Semiconductor</th>
<th>Integrated Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1953-1957</td>
<td>units, M</td>
<td>8.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(% of total)</td>
<td>(100)</td>
<td></td>
</tr>
<tr>
<td>1958-1962</td>
<td>units, M</td>
<td>112.7</td>
<td>6.98</td>
</tr>
<tr>
<td></td>
<td>(% of total)</td>
<td>(94.2)</td>
<td>(5.8)</td>
</tr>
<tr>
<td>1963-1965</td>
<td>units, M</td>
<td>17.8</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td>(% of total)</td>
<td>(51.2)</td>
<td>(48.8)</td>
</tr>
<tr>
<td>1966-1970</td>
<td>units, M</td>
<td>44.6</td>
<td>314.0</td>
</tr>
<tr>
<td></td>
<td>(% of total)</td>
<td>(12.2)</td>
<td>(86.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1.4)</td>
</tr>
<tr>
<td>1971-1975</td>
<td>units, M</td>
<td>73.9</td>
<td>1093.5</td>
</tr>
<tr>
<td></td>
<td>(% of total)</td>
<td>(6.2)</td>
<td>(92.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1.5)</td>
</tr>
<tr>
<td>1976-1980</td>
<td>units, M</td>
<td>110.5</td>
<td>2233.3</td>
</tr>
<tr>
<td></td>
<td>(% of total)</td>
<td>(4.5)</td>
<td>(90.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(5.0)</td>
</tr>
<tr>
<td>1981-1985</td>
<td>units, M</td>
<td>103.7</td>
<td>4653.0</td>
</tr>
<tr>
<td></td>
<td>(% of total)</td>
<td>(2.1)</td>
<td>(95.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2.9)</td>
</tr>
</tbody>
</table>


To sum up the initial conditions, the electronics industry in China was shaped by a military preparedness and self-reliance strategy, and by isolation from international exchange and competition. The output mix of the industry was highly skewed toward electronic components and to military-related products which were, in general, deficient in quality and costly. The technological basis of the industry was outstripped by the pace of advance achieved in the western economies. Firms were extensively built up whose structure was biased toward keeping the industry running “independently” of international specialisation. Nonetheless, as a result of its early development, China had acquired a relatively advanced level of capability in R&D and design and in production and application engineering. This pre-existing capacity made it possible for the industry to transit from older technologies into semiconductors during the 1960s and the first half of the 1970s. Together with production enterprises, R&D and design institutes as well as educational and training agencies provided the basis for capability accumulation. In short, all the “attributes” of a national system were being developed, but with a structure cast in the circumstances of that time, and which was “distorted” in terms of efficiency. This situation is very different from the starting point of the first-tier NIEs in the early 1960s, where firms were internationally specialised from the outset. In these economies, R&D and design engineering were underdeveloped and required substantial investment later during the 1970s.
The features of the Chinese electronics industry were, however, similar to some extent to those in the larger developing economies that had adopted self-reliance policies. For instance, Frischtak (1993) observed that the Brazilian electronics industry was characterised by less specialisation in which “too little of too many things” were produced. The consequence in Brazil was an inadequate level of competitiveness; but, as in China, there was an accumulation in some design and engineering-intensive areas.

2.2 Changes in the Current Reform (since 1978)

The current economic reform begun around 1980 and has dramatically changed the electronics industry in China. It has involved the introduction of competition through a gradual and substantial withdrawal of direct planning for production and distribution, and an intensification of international participation through a significant expansion of international trade and non-trade relationships. Using aggregate data, this section briefly outlines the process of reform in the industry itself and the changes in international relations during the 1980s through the first half of the 1990s. The variables considered are growth rate, imports and exports, direct foreign investment, and the transformation of product mix in the industry. The purpose of this outline is to examine whether the industry as a whole has expanded or shrunk, whether its innovative capability has been enhanced or weakened, and whether its international competitiveness improved or declined during the reform. This provides an approximate test of arguments about possibilities for entry into the electronics industry by developing economies in the post “Asian Miracle” time. An additional purpose is to delineate at an aggregate level the developments and structural changes of the industry for the following section which will concentrate on micro-level evidence to assess the mechanisms of these developments.

2.2.1 Rate and Sustainability of Growth

Since economic reform, China’s electronics industry has enjoyed a dramatically higher growth rate as shown in Table 3. By 1995, electronics constituted 6.1 per cent in entire gross industrial output, a tripling of 1980’s 2.0 per cent share.

Fluctuations in economic growth in the 1980s slowed electronics development in 1986 and in 1989-90, as indicated by the output indices. In the first years of the 1990s, the growth of the electronics industry was more steady.
The record of 1980s growth is remarkable despite fluctuations, as it was achieved during a period involving problems of institutional restructuring, the underdevelopment of the domestic market, continuing restrictions on international trade, and difficulties in technological catch-up.

Table 3: Share of the electronics industry in total Chinese industry, 1980-1995

<table>
<thead>
<tr>
<th>Year</th>
<th>Output of electronics industry (billion yuan)</th>
<th>Total Industrial Output (billion yuan)</th>
<th>Share of electronics (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>1983</td>
<td>14.3</td>
<td>616</td>
<td>2.3</td>
</tr>
<tr>
<td>1984</td>
<td>21.5</td>
<td>703</td>
<td>3.1</td>
</tr>
<tr>
<td>1985</td>
<td>28.6</td>
<td>829</td>
<td>3.5</td>
</tr>
<tr>
<td>1986</td>
<td>30.0</td>
<td>898</td>
<td>3.3</td>
</tr>
<tr>
<td>1987</td>
<td>42.1</td>
<td>1,021</td>
<td>4.1</td>
</tr>
<tr>
<td>1988</td>
<td>59.8</td>
<td>1,322</td>
<td>4.5</td>
</tr>
<tr>
<td>1989</td>
<td>66.4</td>
<td>1,576</td>
<td>4.2</td>
</tr>
<tr>
<td>1990</td>
<td>69.4</td>
<td>1,672</td>
<td>4.2</td>
</tr>
<tr>
<td>1991</td>
<td>90.2</td>
<td>1,976</td>
<td>4.6</td>
</tr>
<tr>
<td>1992</td>
<td>111.2</td>
<td>2,493</td>
<td>4.5</td>
</tr>
<tr>
<td>1993</td>
<td>166.5</td>
<td>3,557</td>
<td>4.7</td>
</tr>
<tr>
<td>1994</td>
<td>242.4</td>
<td>4,580</td>
<td>5.3</td>
</tr>
<tr>
<td>1995</td>
<td>295.6</td>
<td>4,870</td>
<td>6.1</td>
</tr>
</tbody>
</table>

Note:

Sources:
1. Liu Ying et al. 1987: 679 (for 1980 data);
2. Sun Shangqing 1989: 61 (for 1983-1986);

2.2.2 Imports, Exports, and International Competitiveness

In 1995, China’s electronics exports were US$17.0 billion, accounting for 11.4 per cent of total exports, and representing a fivefold increase in share and an explosive growth in absolute value from the US$650 million and 2.1 per cent of 1986 exports (Table 4). Electronics imports were US$16 billion, and constituted 12 per cent of total imports, in 1995, also a rapid increase compared with $5.17 billion and 8.7 per cent in 1989 (Table 4). Combining the data in Table 4

---

5 Electronics imports have been considerably higher than exports until recently. The significance of the data in Table 4 is in the parallel growth of imports and exports. In terms of global trade balance in the electronics industry, China’s expanding imports are roughly matched by its expanding import market, a fact to be kept in mind when reflecting on trade frictions.
with that in Table 3, it may be estimated that by 1995 and at the current exchange rate, China exported one half of its electronics production, while one half of its domestic consumption was from imports. As a result of expanded international trade, the electronics industry in China is now able to benefit from global production specialisation.

Table 4: China’s electronics imports and exports, 1986-1995 (current US$ billions)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total export</th>
<th>Electronics export (as % of total exports)</th>
<th>Total imports</th>
<th>Electronics imports (as % of total imports)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>9.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1979</td>
<td>13.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>18.1</td>
<td></td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>1981</td>
<td>22.0</td>
<td></td>
<td>22.0</td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>22.3</td>
<td></td>
<td>19.3</td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td>22.2</td>
<td></td>
<td>21.4</td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>26.1</td>
<td></td>
<td>27.4</td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>27.4</td>
<td></td>
<td>42.3</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>30.9</td>
<td>0.65 (2.09%)</td>
<td>42.9</td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>39.4</td>
<td>1.21 (3.07%)</td>
<td>43.2</td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td>47.5</td>
<td>1.92 (4.03%)</td>
<td>55.3</td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>52.5</td>
<td>2.66 (5.06%)</td>
<td>59.1</td>
<td>5.17 (8.7%)</td>
</tr>
<tr>
<td>1990</td>
<td>62.1</td>
<td>3.79 (6.11%)</td>
<td>53.4</td>
<td>5.15 (9.7%)</td>
</tr>
<tr>
<td>1991</td>
<td>71.9</td>
<td>4.90 (6.81%)</td>
<td>63.8</td>
<td>6.01 (9.4%)</td>
</tr>
<tr>
<td>1992</td>
<td>84.9</td>
<td>6.87 (8.09%)</td>
<td>80.6</td>
<td>7.99 (9.9%)</td>
</tr>
<tr>
<td>1993</td>
<td>91.8</td>
<td>8.08 (8.80%)</td>
<td>103.9</td>
<td>10.66 (10.3%)</td>
</tr>
<tr>
<td>1994</td>
<td>121.0</td>
<td>12.3 (10.2%)</td>
<td>115.7</td>
<td>n.a.</td>
</tr>
<tr>
<td>1995</td>
<td>148.8</td>
<td>17.0 (11.4%)</td>
<td>132.1</td>
<td>16 (12%)</td>
</tr>
</tbody>
</table>

Sources:

This record appears to provide a positive response to the pro-open market position in debates over whether developing nations may expand their economies by developing domestic production and withstanding the challenges from import competition. It is nonetheless worth examining the mix of imports and exports to show the competitive position of China in international trade. Table 5, showing electronics products of China with significant exports and imports, indicates that China’s international competitiveness is based on labour-intensive products with lower technological sophistication. But additional factors are at work. One such factor seems to relate to the previous development experience. The current competitiveness in electronic calculators, which has become a significant export subsector, underscores a
“spillover” effect from previous computer development. In comparison, electronic cash registers were a major import item during 1991-1992, though now they appear likely to be replaced by domestic production (see Section 3.3). The significance of learning is apparent when one notes that these two product subsectors are not markedly different in technological sophistication. In addition, underlining these domestic developments is the fact that demand is often and immediately influenced by local economic and societal requirements. Consumer electronics achieved significant exports in 1991-1992, largely enabled by the very rapid growth of domestic demand that appeared in the late 1970s and early 1980s. By comparison, telecommunications switching equipment was still dominated by imports in 1991-1992, when demand in this subsector was high. Investments in upgrading domestic production of telecommunications equipment came much later than that for consumer electronics. Both the exports of consumer electronics and the imports of electronic switches are depicted in Table 5, and more details of the development of the two subsectors are presented in the next section.

<table>
<thead>
<tr>
<th>Export</th>
<th>Import</th>
</tr>
</thead>
<tbody>
<tr>
<td>computer peripherals</td>
<td>computers and computer systems</td>
</tr>
<tr>
<td>electronic calculators</td>
<td>electronic cash registers</td>
</tr>
<tr>
<td>telephone sets</td>
<td>switching equipment</td>
</tr>
<tr>
<td>colour and monochrome TVs</td>
<td>control instrumentation</td>
</tr>
<tr>
<td>radios and radio recorders</td>
<td>medical equipment</td>
</tr>
<tr>
<td>tape recorders</td>
<td>ICs</td>
</tr>
<tr>
<td>electronic watches and clocks</td>
<td>TV picture tubes</td>
</tr>
<tr>
<td>unrecorded media</td>
<td>accessories and parts for consumer</td>
</tr>
<tr>
<td></td>
<td>equipment</td>
</tr>
</tbody>
</table>

Sources:
1. *Yearbook of World Electronics Data*, various years.
2. scattered data in various issues of *China Electronics Industry Yearbook*.

2.2.3 DFI and the Acquisition of Foreign Technology

The aggregate inflow of foreign capital in all industries of China may be divided into two periods—see Table 6. Throughout the 1980s, foreign loans from foreign national governments and international financial institutions were the major sources of capital inflow. However, since 1992, direct foreign investment (DFI) has been the major source of foreign investment funds. The radical increase in DFI has meant that investments from multinational companies are now outweighing those of overseas Chinese investors, previously the major players in DFI (Chen, Chang, and Zhang: 1995). Scattered data suggest that the electronics industry was experiencing
a similar change. By 1995, US$4.2 billion had been invested in electronics enterprises, of which $3 billion came after 1991. Of 8,000 electronic enterprises in which foreign-capital was involved in 1995, 6,400 acquired the investment after 1991. Domestic recipients of DFI from big international companies are mainly the technologically competent Chinese electronics companies.

Table 6: Utilisation of foreign capital by China, 1979-1994 (current US$ billions)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Amount</th>
<th>Foreign Loans Amount</th>
<th>DFI Amount</th>
<th>Others Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1979</td>
<td>2.74</td>
<td>2.51</td>
<td>0.11</td>
<td>0.12</td>
</tr>
<tr>
<td>1980</td>
<td>3.83</td>
<td>2.89</td>
<td>0.19</td>
<td>0.29</td>
</tr>
<tr>
<td>1981</td>
<td>4.22</td>
<td>3.72</td>
<td>0.37</td>
<td>0.12</td>
</tr>
<tr>
<td>1982</td>
<td>2.30</td>
<td>1.74</td>
<td>0.44</td>
<td>0.11</td>
</tr>
<tr>
<td>1983</td>
<td>1.99</td>
<td>1.07</td>
<td>1.80</td>
<td>0.88</td>
</tr>
<tr>
<td>1984</td>
<td>2.71</td>
<td>1.29</td>
<td>1.26</td>
<td>0.16</td>
</tr>
<tr>
<td>1985</td>
<td>4.65</td>
<td>2.69</td>
<td>1.66</td>
<td>0.30</td>
</tr>
<tr>
<td>1986</td>
<td>7.26</td>
<td>5.01</td>
<td>1.87</td>
<td>0.37</td>
</tr>
<tr>
<td>1987</td>
<td>8.45</td>
<td>5.81</td>
<td>2.31</td>
<td>0.33</td>
</tr>
<tr>
<td>1988</td>
<td>10.23</td>
<td>6.49</td>
<td>3.19</td>
<td>0.55</td>
</tr>
<tr>
<td>1989</td>
<td>10.06</td>
<td>6.29</td>
<td>3.39</td>
<td>0.38</td>
</tr>
<tr>
<td>1990</td>
<td>10.29</td>
<td>6.53</td>
<td>3.49</td>
<td>0.27</td>
</tr>
<tr>
<td>1991</td>
<td>11.55</td>
<td>6.89</td>
<td>4.37</td>
<td>0.30</td>
</tr>
<tr>
<td>1992</td>
<td>19.20</td>
<td>7.91</td>
<td>11.01</td>
<td>0.28</td>
</tr>
<tr>
<td>1993</td>
<td>38.96</td>
<td>11.19</td>
<td>27.52</td>
<td>0.26</td>
</tr>
<tr>
<td>1994</td>
<td>43.21</td>
<td>9.27</td>
<td>33.77</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Sources:
1, China Statistical Yearbook 1995: 554 (for 1984-1994);

DFI appears to play a major role in the rise in Chinese electronics exports. In 1994, DFI involved electronics enterprises contributed 56.5 per cent to the total electronics exports of US$6.9 billion. However it is important to gauge the size of DFI against other channels of technology acquisition, especially that of technology transfer licensing. Between 1979 to 1990, a total of 787 technology transfer contracts with fees of US$1.64 billion had been signed. These covered “electronics and communication equipment”, “computer”, “consumer electronics”, and “instrumentation”. In the following five years (1991 to 1995), approximately 1,000 more

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6 For instance, Great Wall of China, a major Chinese PC producer received investments from IBM (People’s Daily, Overseas Edition, 29 March 1995); Mitsubishi has invested in Stone of China, a major IC producer (People’s Daily, Overseas Edition, 22 May 1996); and Sony has invested in telecommunications equipment development with Beijing Research Institute of Post and Telecommunication Technology of China (People’s Daily, Overseas Edition, 14 Nov. 1995).
applications were made for technology import contracts, but unfortunately, no payment data is available. If the value of technology imports in the recent period is similar to that of the earlier period (on a per-contract basis), investments in licensed technology transfer would be quite considerable. Thus, despite a significant contribution of DFI to exports, it appears that China is continuing to make its own effort in electronic industry development, and it would seem incorrect to characterise DFI in China as enhancing “dependency” on foreigners. Instead, China’s domestic consumption and export capability, developed in association with technology transfer during the 1980s, made China more attractive to direct foreign investment, an explanation that also echoes the “locational advantages” effect suggested by Dunning (Dunning 1993: 102-27).

2.2.4 Transformation in the Product Mix of the Industry
The structure of the industry has been undergoing dramatic change due to opening to competition and international participation. As shown in Table 7, the share of the components and parts sector decrease from a 61 per cent level in 1980 to between 30-35 per cent from the mid-1980s and on. Consumer electronics, the major driver for the development of the industry in the 1980s, increased from 21.9 per cent of total output in 1980 to more than 50 per cent during the second half of 1980s. Recently the category “investment electronics” (encompassing industrial electronics, telecommunications, and information technology) is acquiring momentum, and is likely to become a new driving force. Its share of industry outputs increased to 26.7 per cent in 1995, up from 14.9 per cent in 1991. The transformation of product mix of the industry has been supported by institutional restructuring and technological learning in response to changing demands, factors that will be probed more deeply in the next section.

Table 7: Sector structure of the Chinese electronics industry, 1980-1995

<table>
<thead>
<tr>
<th>Year</th>
<th>Investment Electronics (%)</th>
<th>Consumer Electronics (%)</th>
<th>Components and Parts (%)</th>
<th>Total Electronics Output (billion yuan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>17.1</td>
<td>21.9</td>
<td>61.0</td>
<td>28.6</td>
</tr>
<tr>
<td>1985</td>
<td>20.3</td>
<td>46.8</td>
<td>32.9</td>
<td>59.9</td>
</tr>
<tr>
<td>1988</td>
<td>12.8</td>
<td>56.7</td>
<td>31.3</td>
<td>63.4</td>
</tr>
<tr>
<td>1989</td>
<td>15.8</td>
<td>53.3</td>
<td>30.9</td>
<td>67.2</td>
</tr>
<tr>
<td>1990</td>
<td>14.3</td>
<td>52.4</td>
<td>33.3</td>
<td>88.6</td>
</tr>
<tr>
<td>1991</td>
<td>14.9</td>
<td>49.2</td>
<td>35.9</td>
<td>108.7</td>
</tr>
<tr>
<td>1992</td>
<td>19.2</td>
<td>45.8</td>
<td>35.0</td>
<td>139.6</td>
</tr>
<tr>
<td>1993</td>
<td>22.0</td>
<td>43.9</td>
<td>34.1</td>
<td>246</td>
</tr>
<tr>
<td>1994</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>1995</td>
<td>26.7</td>
<td>n.a.</td>
<td>n.a.</td>
<td>246</td>
</tr>
</tbody>
</table>

Note: The total industrial outputs are calculated based on 1980 prices for 1980-1989, and 1990 prices for 1990-1994, but not including 1995 output. It is not clear from the source (no. 3 below) what price basis is employed for 1995 output.

Sources:
1. Liu Ying et al. 1987: 680 (for 1980 data);

In summary, the remarkable record of growth in the Chinese electronics industry confirms the idea that entry barriers have been ineffective in keeping Chinese producers from developing a growing export position, nor has import competition prevented the industry from expanding considerably its domestic production and consumption bases. A number of major weaknesses of the industry inherited from the past were overcome in the course of recent developments.

This outline thus provides evidence for the possibility of a developing economy to have an electronics industry growing in the context of the technological and economical globalisation of the 1990s, without significant increase in the extent of dependence. Moreover, DFI and market liberalisation appear to have strengthened the endogenous “attributes” for China’s national innovation system.

Some may question whether or not China has unique endowments, such as a large domestic market, compared with other developing economies. Market size in China is indeed uniquely large. There are, however, both advantages and disadvantages of size. Change required major restructuring and reform in China, as well as high levels of investment which might well have been achieved at more modest cost in smaller economies. The next section will address the
process by which some of the product groups within the industry have consolidated their position through institutional restructuring and technological learning in the 1980s, and have begun to realise the growth potentials of the 1990s. In relation to the issue of size, many of these developments did not require massive initial scale. Instead, they were built upon distinctive local specialisations in which the size of the domestic market was unimportant in getting started.
We now turn to an examination of key developments in the period of market reform, including: (1) the entry into and upgrading of consumer electronics (since the late 1970s), (2) the entry into the computer software industry (since the mid-1980s), (3) the development of “informatics”, and (4) the expansion of telecommunications networks (since the second half of the 1980s). Our examination is organised chronologically, beginning with the development of consumer electronics, a sector which may appear peripheral to information technology but where the process of restructuring established a model for sustained development toward participation in the information revolution. Much of the impressive record chronicled in the previous section is the consequence of this first step. By keeping in mind the time sequence, we seek to emphasise the learning process by which greater levels of sophistication were cumulatively achieved from earlier, more rudimentary accomplishments.

Institutional restructuring and technological learning are the key themes in our account. They are the basic explanation of how a system that began with major structural distortions has evolved to its current position. These themes are accompanied by a number of complementary sub-themes, including the growing prosperity of the domestic market, the unique response to institutional restructuring of the R&D establishment, the role of international trade, and government policies toward the IT industry. Of these sub-themes, the growing sensitivity of the domestic market not only provides incentive to invest in institutional restructuring and technological learning, but also gives important feedback to learning and restructuring. Market reform has therefore been crucial to achieving major changes in the national innovation system in China, in which the system has been moving toward intense interactions among Porter’s “attributes” since the introduction of competition. Both participation in international trade and government policies have reinforced the development of the industry.

8 The unique qualities of the restructuring of the Chinese R&D establishment is examined in Gu (1994, 1995, and 1996a and 1999). Compared with other socialist economies, China has adopted a more gradualist approach to commercialising its industrial technology R&D system, one which has provided a variety of opportunities to preserve those capabilities developed under central planning that would be relevant under market reform.
3.1 Entering and Upgrading Consumer Electronics

For the Chinese electronics industry, establishing up-to-date and high-quality consumer electronics posed the first challenge at the start of market reform. To respond, OEM assembly became part of the policy thrust not only for consumer electronics, but in general for the electronics industry as a means to escape from the history of substandard product provision (Liu Ying et al. 1987: 93, 174, 195), while avoiding a high trade deficit in the process of trade liberalisation. One statement in support of the focus on OEM assembly was that “beginning with final products will favour the improvement of product standards, enabling the industry to more quickly fill the gaps in domestic demands and achieve export capacity with less investment” (ibid.: 205). This view obviously echoes the experience of China’s successful neighbours, and represents a fundamental shift from the typical self-reliance strategy of doing everything domestically. However it is worthwhile to note that in contrast with the first-tier NIEs, output from OEM assembly went largely to the domestic market, often with the original foreign company’s brand, a pattern that was especially true in the early 1980s. This position became less appropriate as consumer electronics exports expanded from the second half of the 1980s (Tables 8 and 9).

“Special Economic Zones” were set up to absorb DFI into OEM-oriented enterprises, and new firm establishments were created in these Zones to accept foreign investment. Large inland central electronics enterprises which were at the time experiencing serious under-utilisation of capacity were a particular focus of the SEZ policy. These enterprises from inland parts of China responded by setting up their spin-offs in Zones created in the coastal area. During the early 1980s in Shenzhen and Xiamen Zones in particular, capabilities from the Chinese military electronics sector were combined with foreign investment in OEM manufacturing. In addition, “local” small electronics enterprises in the south-east coastal provinces concurrently joined OEM production too, augmenting the basis for a strategic shift beyond “zone” areas, in which DFI was initially less involved. Managerial and technical manpower with experience in organising military-oriented production were transferred to act as important elements in the OEM manufacturing strategy.

OEM production acted as a training school for the transformation of the Chinese electronics industry, setting it on a path of efficiency in production. In addition to the enhancements in technological learning achieved from integrating the accumulated experiences with OEM manufacturing, there have been changes in management routine and work discipline. The involvement of foreign contractors and investors offered the chance for Chinese managers to
intimately observe and practice the managerial styles that are well-adapted to meeting competitive pressure. The sensitivity to, and skills for competitive management, including the management of marketing, were neglected in pre-reform management and were learned and disseminated throughout the industry during the reform period.

Technological development in consumer electronics followed two parallel paths, one based on OEM participation and the other on domestic components production and engineering design. This permitted technological learning and “recombination” of skills gained from each of the paths. OEM participation was chosen as a way to upgrade final products, because it attracted foreign investment and expertise. The strategic characteristic of this choice is indicated by the comment “final product assembling requires less investment and earns return more quickly” (Liu Ying et al. 1987: 81, 205). The upgrading of capabilities in components production and engineering design were more intimately co-ordinated by central policy. An example is the television receivers segment. Even when television sets were assembled upon OEM basis, the equipment used for assembly was improved by equipment developers; the linear ICs used for television sets were produced (based upon a technology import) and improved in IC factories; and R&D activities were carried out on subjects such as IC design, CAD, components technology, remote control technology, digital technology, and testing equipment in a number of R&D performers including both productive enterprises and R&D institutes (ibid.: 198, 305, 448, 451).

The large size of domestic market created a strong and growing motivation for the development of consumer electronics. In quantitative terms, it is reported that in 1994, 86 colour televisions and 62 refrigerators were owned per 100 urban families, and 73 televisions (13 monochrome, and 60 colour) per 100 rural families (People’s Daily, Overseas Edition, 2 Oct. 1995), contributing to the volume of television production depicted in Table 8. Since 1990 China has been the largest television producer in the world, up from the rank of eighth in 1978. These quantitative records suggest the scope in which “learning by doing” has been experienced. Qualitatively, as economic reform brings greater wealth to Chinese families, and as Chinese people take more consumer electronics into their family life, Chinese consumers are becoming more demanding, lending further motivation for consumer electronics producers to advance their technological sophistication.

As the result of the reciprocal enhancement among the attributes of the system—market demands, productive firms, supporting industries, and higher-order factor creation in R&D and
design that continued with intense international participation, notably through OEM production and technology import—the competitiveness of China’s consumer electronics sector improved considerably. This sector had, by the mid-1990s, firmly established its position in the domestic market with its own brand names. Exports grew simultaneously. In 1993, one-fourth of the output of colour TV receivers were exported, an increase from the one-seventh share exported in 1987 (see Tables 8 and 9); but the exports have been based upon foreign design and distributed through international dealers, indicating that the industry still lags in capability, especially in international marketing. As China’s consumer electronics industry enhanced its competitiveness, DFI inflow increased, with a higher proportion from European and North American companies. This trend is comparable to the general trend in DFI into the electronics and information industry in China, noted in the next section. It remains to be seen, however, how the new inflows of DFI will impact this industry in the near future, in the expansion of export with international investors’ brand identification, in a hastening development of the marketing capabilities of domestic firms, or in the growth of innovative capabilities.

The “learning ladder” that the Chinese consumer electronics industry has followed thus far is a combined or parallel one, rather than the strictly linear “learning ladder” for electronics manufacturing introduced by Hobday (Table 1). In the process of learning to mass produce consumer electronics in China, incremental process and product improvement together with design and testing activities came into play sooner than Hobday’s framework would suggest, and thus evolved in parallel since the industry began OEM assembly.

These activities are associated with relatively advanced stages in Hobday’s framework. In terms of marketing capability, however, this Chinese sector reached the “active sales of capacity in international market” stage in the second half of the 1980s but has stayed there since then (see Table 15 in the following section).
Table 8: China’s television production, 1970-1995 (number of sets, thousand)

<table>
<thead>
<tr>
<th>Year</th>
<th>Colour</th>
<th>Monochrome</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>&lt;1</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>1975</td>
<td>3</td>
<td>175</td>
<td>178</td>
</tr>
<tr>
<td>1980</td>
<td>32</td>
<td>2,460</td>
<td>2,492</td>
</tr>
<tr>
<td>1983</td>
<td>531</td>
<td>6,309</td>
<td>6,840</td>
</tr>
<tr>
<td>1985</td>
<td>4,353</td>
<td>12,322</td>
<td>16,675</td>
</tr>
<tr>
<td>1986</td>
<td>4,146</td>
<td>10,444</td>
<td>14,594</td>
</tr>
<tr>
<td>1987</td>
<td>6,727</td>
<td>12,817</td>
<td>19,544</td>
</tr>
<tr>
<td>1988</td>
<td>10,377</td>
<td>14,674</td>
<td>25,051</td>
</tr>
<tr>
<td>1989</td>
<td>9,400</td>
<td>18,263</td>
<td>27,665</td>
</tr>
<tr>
<td>1990</td>
<td>10,330</td>
<td>16,517</td>
<td>26,847</td>
</tr>
<tr>
<td>1991</td>
<td>12,051</td>
<td>13,421</td>
<td>26,914</td>
</tr>
<tr>
<td>1992</td>
<td>13,338</td>
<td>13,168</td>
<td>28,678</td>
</tr>
<tr>
<td>1993</td>
<td>14,358</td>
<td>15,972</td>
<td>30,330</td>
</tr>
<tr>
<td>1994</td>
<td>16,892</td>
<td>15,941</td>
<td>32,833</td>
</tr>
<tr>
<td>1995</td>
<td>19,580</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sources:

Table 9: China’s import and export, colour TV, and consumer electronics, 1987-1993

<table>
<thead>
<tr>
<th>Year</th>
<th>Colour TV</th>
<th>Consumer Electronics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exports</td>
<td>Imports</td>
</tr>
<tr>
<td></td>
<td>set (1,000s)</td>
<td>$ M</td>
</tr>
<tr>
<td>1987</td>
<td>884</td>
<td>129</td>
</tr>
<tr>
<td>1988</td>
<td>1,486</td>
<td>805</td>
</tr>
<tr>
<td>1989</td>
<td>1,735</td>
<td>245</td>
</tr>
<tr>
<td>1990</td>
<td>2,531</td>
<td>396</td>
</tr>
<tr>
<td></td>
<td>(224)</td>
<td>(375)</td>
</tr>
<tr>
<td>1991</td>
<td>2,421</td>
<td>395</td>
</tr>
<tr>
<td>1992</td>
<td>3,559</td>
<td>456</td>
</tr>
<tr>
<td></td>
<td>(441)</td>
<td>(441)</td>
</tr>
<tr>
<td>1993</td>
<td>3,740</td>
<td>478</td>
</tr>
<tr>
<td></td>
<td>(444)</td>
<td>(444)</td>
</tr>
</tbody>
</table>

Note: Data in parentheses are the exports produced based on OEM contract.

3.2 Entering the Computer Software Industry and Other Applications of Computer Technology

Virtually everyone involved in the information industry, from producer to user, writes software. But although China had long been engaged in the development of computer technology, the entry of China into the commercial software industry had to wait for institutional restructuring in the mid-1980s, because at that time electronic producers lagged behind the international level. They concentrated on production rather than application markets, and users of computers were rare and restricted to scientific calculation.

In the mid-1980s, a new kind of enterprise organisation emerged. These were originally initiated by individual scientists and engineers and R&D institutes who actively sought to commercialise their laboratory achievements and to gain advantage from the onset of the PC market boom of that time. These initiatives were endorsed in 1988 by the national reform policy called the Torch Programme for the promotion of this kind of commercial activity. The Torch Programme encouraged new business organisations spun-off from R&D institutes which were termed “New Technology Enterprises” (NTEs). A set of policies was introduced, including the establishment of “Development Zones for New Technology Industries”, which were devised by the Torch Programme to serve as institutional and geographical bases for the development of NTEs.9 Local governments responded enthusiastically in Zone creation, as did the R&D institutes and scientists and engineers who were the major initiators of the NTEs. By 1992, 52 national Zones had been established in important industrial cities such as Beijing, Shanghai, and Shenyang and 5,569 NTEs operated in the Zones as shown in Table 10. By 1995, the NTEs in the 52 Zones increased to 14,000 (People’s Daily, Overseas Edition, 17 February 1996). As many as 100,000 highly educated professionals had moved into the NTEs by the early 1990s, but exact statistics are not available.

The emerging NTEs gave birth to the Chinese software industry. Although the Torch Programme had aimed at promoting a wider range of “new technology” industries, about two-

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9 This is another series of Zones different from the “special Economic Zones” mentioned above, which were for absorbing and managing foreign investment. The Zones initiated by the Torch Programme aimed for the domestic transformation of industrial R&D capability into commercial creativeness, and may be more accurately compared with “technopoles” or “industrial parks”. A similarity between the two zone policies was the attempt to provide institutional support to new industrial activities that had not existed previously. Policies stipulated for the NTEs embraced preferential arrangements in licensing, taxation, international trading, financing and investment, employment, and intellectual property protection, basically equivalent to those for foreign capital-involved ventures adopted in the “Special Economic Zones”.

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thirds of NTEs were working on software development, according to a survey taken for an INTECH project (Gu 1994). By 1991, among the “biggest 20” computer “software and service” companies, 17 could be identified as NTEs. Their software development efforts fell into three categories (Gu 1994):

1) Localisation (“Chinesization”) of computer language. Various Chinese character and text processing technologies were developed and embodied in functional boards and cards, common-use application software, and finished machines.

2) The development of small integrated systems. Through modelling, designing, system development, and engineering services, computer-based automation functions were integrated into various operation and production processes.

3) Software development for final mechanical and communication products in which computer technology is incorporated.

We concentrate here on the first kind of software development, leaving the other two, which are more related to “informatics” applications, for the next section.

Table 10: NTEs in National Zones for New Technology Development, 1990 - 1992

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>1990</th>
<th>1991</th>
<th>1992</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zones units</td>
<td>27</td>
<td>27</td>
<td>52</td>
</tr>
<tr>
<td>NTEs units</td>
<td>1,652</td>
<td>2,587</td>
<td>5,569</td>
</tr>
<tr>
<td>of which those with foreign capital</td>
<td>75</td>
<td>167</td>
<td>564</td>
</tr>
<tr>
<td>involvement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>employment persons</td>
<td>122,889</td>
<td>138,231</td>
<td>340,346</td>
</tr>
<tr>
<td>turnover m. yuan from products %</td>
<td>7,567.1</td>
<td>8,729.5</td>
<td>230,924.9</td>
</tr>
<tr>
<td>% from technological services %</td>
<td>56</td>
<td>51</td>
<td>65</td>
</tr>
<tr>
<td>% from trading</td>
<td>16</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td>%</td>
<td>28</td>
<td>29</td>
<td>23</td>
</tr>
<tr>
<td>annual exports m. yuan</td>
<td>688.7</td>
<td>714.6</td>
<td>16,359.1</td>
</tr>
<tr>
<td>expenditure for technological development m. yuan</td>
<td>418.3</td>
<td>781.3</td>
<td>15,238.1</td>
</tr>
</tbody>
</table>


10 See China Electronics Industry Yearbook 1992: II-47. The largest of the top 20 is Stone Corporation, which we will discuss in the next section.
Re-engineering the English-language basis of the PC to Chinese language constituted a landmark of catch-up by the Chinese computer industry, and a means to overcome a major barrier to widespread application of this revolutionary instrument of computer technology. In the development of Chinese Character Processing technology, the principal requirements were the effectiveness and efficiency of the technology and its compatibility with the ever-improving computer systems. Meeting these requirements involved substantial design innovation and user testing, and was achieved in passing through several distinct steps, as we observed with the history of NTE growth. The first step was selling and servicing imported computers, to which some already-available Chinese Character Processing techniques were added. The second step involved the development of new techniques for typing and for displaying Chinese characters that would be more efficient and would offer higher quality than earlier applications. The third step involved development of Chinese Character Processing Packages (systems) embedded in custom-made ICs that were compatible with state-of-the-art PC architectures.

Getting intimate access to international markets has been essential for keeping pace with the dynamics of mainstream PC technology and for gaining additional value from the development of Chinese Character Processing techniques through incorporation of these techniques into new PC models. International markets have provided a demonstration effect, showing to the Chinese developers the state-of-the-art architecture of commercially competitive PCs, upon which the value of locally developed software is substantiated. This was especially crucial at the initiating stage of NTEs, for many of them learned the technological trajectories embodied in the architecture through selling and servicing imported PCs, a learning process that hastened their engagement in software development. In addition, international markets contributed to software development by supplying key components and providing engineering support for the design and fabrication of customised ICs in which locally developed software is embodied. Interviews with managers in the Chinese computer and machine tool industries (Gu 1994, 1999) indicate that access to component supply and engineering support was available at terms and conditions that they thought were fair. Chinese experts believed that the barriers came mainly from the ignorance and inexperience of local developers with international markets. Successful developers are believed to have
tapped every possible source to reach the international markets, and this experience indicates that investing in learning and searching for international market access is critical. As the latecomer’s capabilities are improved, opportunities for inclusion in international supplier-user networks may follow. The development of particular and specialised competence is likely to be a key for penetrating the competition-cooperation relationship that exists mainly among market leaders.

The positive feedback, mentioned above, from international market access has driven the Chinese computer industry forward in market reform. This positive experience, acquired mainly by leading NTEs, indicates that a strategy of active involvement with existing international suppliers which focuses on developing compatible and specialised innovations is superior to a strategy that follows an “independent” trajectory of development, loosely based on imitation but which attempts to do everything domestically.

The latter approach characterises the pre-market reform pattern of the Chinese computer industry, and persisted through the 1980s among some of the state-owned Chinese PC producers, but has been almost entirely abandoned in favour of the former approach during the 1990s.

Climbing the learning ladder by developing design capabilities complementary to state-of-the-art PCs generated some real competitive advantages for the Chinese computer industry. In international markets, this competitiveness manifested itself in own-designed PC display cards and mother-boards where Chinese producers have captured a small proportion of the market niches. In the domestic market, local producers had strengthened their position in finished PC machines and achieved roughly comparable products with their international counterparts by 1995-1996.\(^{11}\) At present, Legend and Great Wall are the two biggest Chinese PC producers. Legend grew up out of the family

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\(^{11}\) In 1995, among the biggest five PC suppliers in China, two are local producers (Legend and Great Wall). The local producers are now able to quickly develop PCs using the latest CPU technology, such as Pentium Pro-based PC 686 in 1995, while about three years delay was the rule in the late 1980s, as in the development of PC 286, and a one year delay in the early 1990s, as in the development of PC 386 (People’s Daily, Overseas Edition, 13 Nov. 1995; 3 April 1996; 3 June 1996).
of the NTEs, while Great Wall developed from the state-owned enterprises. Competitive advantages have occurred in the areas of Chinese Text Compiling and Printing Systems, led by New Technology of Beijing University (a NTE), and in Chinese Character Typesetting machines, led by Stone Corporation (another NTE). In these segments local producers hold more than 90 per cent of domestic market, and export has begun to Chinese language customers where these technologies are applicable (China Electronics Industry Yearbook 1994: II-36).

Up to the 1990s, the potentials for widespread applications of computer technology were readily prepared in China. The emergence of a software industry introduced an endogenous element of “application capability” into the Chinese economy. In addition, both market operation and government policy were at work during the decade to cultivate market demands and supply capability. Laws and regulations were established for the industry, and institutions for standards and information for software engineering were enhanced or created. Regular yearly software engineer Certificate Examinations started in the mid-1980s and were open to all applicants, with a training course for the examination available via a programme of television instruction. In the early 1990s, a national programme called the “Golden Three” Programme was launched with the aim of accelerating the applications of information technology, especially in service sectors such as macro-economic information, foreign trade management, taxation management, and the banking system. Moreover, as the standard of living of Chinese families goes up, a significant demand for family investment in personal computers has appeared. Reflecting the enhancement in both demand and supply, the consumption of PCs appears to be following a trend of exponential increase. Table 11 summarises PC production and domestic consumption between 1980 and 1995. A significant acceleration in demand emerged from about 1992, with increases in domestic production following thereafter, indicating a promising future for the Chinese PC industry.
Table 11: Personal computer production and consumption in China, 1980-1995

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (thousands of sets)</th>
<th>Consumption (thousands of sets)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>0.059</td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td>15.9</td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>35.7</td>
<td>100(1984)</td>
</tr>
<tr>
<td>1986</td>
<td>39.2</td>
<td>n.a.</td>
</tr>
<tr>
<td>1987</td>
<td>47.5</td>
<td>65#</td>
</tr>
<tr>
<td>1988</td>
<td>53.8</td>
<td>72#</td>
</tr>
<tr>
<td>1989</td>
<td>56.8</td>
<td>68-74#</td>
</tr>
<tr>
<td>1990</td>
<td>78.9</td>
<td>100#</td>
</tr>
<tr>
<td>1991</td>
<td>99.7</td>
<td>122#</td>
</tr>
<tr>
<td>1992</td>
<td>107.8</td>
<td>200</td>
</tr>
<tr>
<td>1993</td>
<td>173.8</td>
<td>450</td>
</tr>
<tr>
<td>1994</td>
<td>220</td>
<td>n.a.</td>
</tr>
<tr>
<td>1995</td>
<td>403</td>
<td>1000</td>
</tr>
<tr>
<td>1996</td>
<td>512***</td>
<td>1500-1700*; 1500**</td>
</tr>
</tbody>
</table>

Sources:

3.3 The Development of Informatics

The “informatics” sector has a vaguer boundary than consumer electronics or personal computers. Informatics includes the applications of information technology in processes and operations of the manufacturing and service sectors. An incorporation of mechanical technology with information technology is often an important feature in informatics development. Software development is one of the major inputs and involves two kinds of activities: integrated systems design and programming services.
Informatics in China is at an early stage of development. Prior to market reform, there was little incentive for widespread applications of information technology, although these were stated goals of the planning administration. We concentrate on two segments of informatics development, manufacturing automation systems and cash registers, based on our own survey, including interviews with leading developers in the two segments. One, the Beijing Automation Research Institute of Machinery Industry, is a centrally affiliated industrial technology research institute, whose automated high-bay warehouses and automatic robot spraying lines are remarkably competitive (Gu 1999). The other is Stone Corporation, an NTE in the Beijing Development Zone of New Technology Industries, whose IC card cash registers dominate the domestic market. The market leaders in these two segments are representative of the origins of the organisations prevalent in informatics developments—NTEs and industrial technology R&D institutes. The other participants are a few of the strongest computer producers, and a number of centres for the applications of information technology that are still organisationally integrated within their user industries.

The informatics sector, like the software/personal computer sector, has developed a distinctive pattern of learning whose innovative practice centres around systems integration and user conditions adaptation. Design and testing capabilities, key factors for software/personal computer development, are certainly helpful and crucial for informatics as well. The focus of design and testing in informatics development, however, is more on solving integration problems in compiling the electronic and mechanical components into a system. The integration also needs to be more responsive to the specific conditions of individual users. Innovativeness in system integration depends on mechanical and electronics components, and the ability to fulfil user requirements therefore often appears to explain the successes in this segment of informatics. To support the innovative development of these characteristics, institutional restructuring in the 1980s has been necessary for generating appropriate developers, i.e., the NTEs and the former R&D institutes (which have been largely transformed into commercialised suppliers of industrial technology since the 1980s). This is illustrated by the two developers examined here, who have succeeded in reorganising their accumulated capabilities in design and testing to achieve a more commercial orientation. Their technological activities are focused on the added value of systems integration, and on responses to user requirements.

The learning ladder in this development may be described as one proceeding toward higher levels of optimisation of systems, and the increasing incorporation of desired additional functions. The learning process is therefore different from that in the consumer electronics
sector. In consumer electronics, learning is focused on manufacturing skills and product and process innovation that relate to mass production. In informatics the issue is one of responding to diverse user needs by using a variety of mechanical components, and of standard electronic components and devices available in international markets. The result is that informatics industry outputs are more differentiated and produced at smaller scale. In attempting to gain competitive advantage in this complex integration process has been that some developers, including the Beijing Automation Research Institute, have moved out of generic research on electronics technology to the specialisation on systems design and specific mechanical apparatus.

In the development of informatics, international markets have been supportive for providing electronic rather than mechanical subsystems. Most of the integrated circuits and electronic control devices needed have been obtained by import. Compared with Chinese Character Processing technology, the development of informatics usually does not employ state-of-the art electronics components and subsystems. This is partly because the Chinese domestic applications of informatics are not yet very sophisticated, and partly, because informatics contains more “local” elements, ones that are affected by the particularities of applications and incorporated in the mechanical subsystems. Very occasionally, developers have sought international support in mechanical engineering, such as complex die technology. According to our interviews with the developer (Stone Corporation) in late 1996 their experience has been that the international mechanical engineering market is accessible when needed.

Altogether, the features of informatics weigh in favour of local developers due to the fact that more indigenous contents have to be incorporated in the products of this sector, basic components and devices are nonetheless increasingly available and acquired in the global market. Supported by trade in basic electronics, local developers are thus more likely to concentrate on the development of locally specialised characteristics. This preserves the competitiveness of local developers who are closer to, and more aware of, local needs, but also requires the prior accumulation of capabilities in electronic systems design, programming services, and mechanical engineering. Informatics development in developing economies may be influenced by the relatively low wages and the availability of abundant semi-skilled labour that deter the societies from moving to higher levels of automation. This issue was debated in China in the early 1980s (Gu 1999), and has been noted in an INTECH study on CNC machine tools in developing countries (for instance, the Indian case (Alan 1997)). While low wages may reduce the incentive to make productivity improvements in machine tools and other producer
goods, another factor is at work as well. The growing incentives for quality and efficiency improvement from severer competition seems to have a positive influence on informatics development. Government policy might play a considerable role in promoting both the demand and supply sides critical to early stages of the development. In particular, the current national “Golden Three” programme in China is inducing domestic demands for informatics products, especially in the service sectors.

3.4 The Expansion of Telecommunications Networks

Whereas “informatics” involves either localisation or customisation to adapt to their application context, telecommunications systems involve greater economies of scale and standardisation (Antonelli 1986, 1991; Saunders, Warford, and Wellenius 1994). In China, a substantial acceleration in telecommunications network expansion began in 1990, leading to a pattern of exponential increase, with higher than 30 per cent annual growth rate during 1991 to 1995, as shown in Table 12.

As a result of this extraordinary expansion, telephone installation increased to 4.66 per 100 persons by the end of 1995, from a very low level of 0.43 in 1980, and 1.11 in 1990, although the latest achievement is still low by either world average or the average of developing countries. The expansion has also been highly uneven, favouring urban areas, particularly larger coastal cities (see Table 12). In the latter, telephone availability was higher than 30 per 100 persons by 1995, comparable to middle income countries. We concentrate on two aspects of the expansion: the mechanisms for investment in telecommunications systems, and the relationship between expanding applications and the domestic production of telecommunications equipment.
Table 12: Expansion of the telecommunications network in China, 1980-1995

<table>
<thead>
<tr>
<th>Year</th>
<th>Telephones per 100 persons, national average</th>
<th>Telephones per 100 persons in provincial capital cities</th>
<th>Telephones installed at residential sites (10,000s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>0.43</td>
<td>2.1</td>
<td>0.1</td>
</tr>
<tr>
<td>1985</td>
<td>0.60</td>
<td>3.2</td>
<td>3.1 (1986)</td>
</tr>
<tr>
<td>1989</td>
<td>0.98</td>
<td>5.5</td>
<td>n.a.</td>
</tr>
<tr>
<td>1990</td>
<td>1.11</td>
<td>5.9</td>
<td>152</td>
</tr>
<tr>
<td>1991</td>
<td>1.29</td>
<td>7.1</td>
<td>288 (89%)*</td>
</tr>
<tr>
<td>1992</td>
<td>1.69</td>
<td>8.9</td>
<td>494 (71%)*</td>
</tr>
<tr>
<td>1993</td>
<td>n.a.</td>
<td>n.a.</td>
<td>939 (90%)*</td>
</tr>
<tr>
<td>1994</td>
<td>3.20</td>
<td>n.a.</td>
<td>1764 (88%)*</td>
</tr>
<tr>
<td>1995</td>
<td>4.66</td>
<td>15 (in bigger coastal cities, 30+)</td>
<td>2797 (58%)*</td>
</tr>
</tbody>
</table>

Note: Data marked with “*” are yearly increase indices of residential telephones. The installations of residential telephones were mainly paid by private users (rather than institutional users).

Sources:
4. People’s Daily, Overseas Edition, 22 September 1995 (for 1995 telephones per 100 city persons);

Investment decision making for the expansion of the telecommunications network has been highly decentralised, reflecting the market reform approach toward delegating managerial autonomy to lower levels of economic agencies to achieve greater flexibility. Cities and towns have been permitted to make their own decisions regarding the acquisition of switching equipment and the expansion of local infrastructure, in co-operation with the Ministry of Posts and Telecommunications. The decentralised investment has led to somewhat circuitous trunk network connection, complicating access to long distance communications. It nonetheless resulted rapid expansion of the network and the use of very modern technologies. By the middle of the 1990s, 84 per cent of this infrastructure was based on digital technology (People’s Daily, Overseas Edition, 20 Jan. 1996).

Within the decentralised framework, private users have in effect co-invested in the network infrastructure growth. The charge for a telephone connection has been as high as 3,000 to 5,000 yuan, roughly equivalent to US$500-800, which is very substantial in terms of Chinese per capita income. Despite this charge, millions of applications for telephone installation were
received during the first half of the 1990s, they contributed considerably to the telecommunications infrastructure construction.\textsuperscript{12} With the recent telecommunications development, whose dominant users being smaller enterprises as well as households, China has departed from the historical pattern of communications, which had favoured “official” and large institutions, at the expense of ordinary users’ access to telecommunication services.

Although telecommunications modernisation in China has involved substantial local inputs in civil engineering, wiring, and premise equipment, much of the switching and transmission equipment required has to be imported. Imports of telephone exchanges varied between US$160 million and $260 million during 1988 to 1991, raising to $480 million in 1992 and $1,026 million in 1993 (Table 13), and was one of the major trade items creating deficits in these years. Most of the newly installed exchanges during 1988 to 1993 were imported (comparing the data in Tables 12 and 13, the population of China is 1.16 billion). On the other hand, these increases in demand have stimulated domestic producers, but at a slower pace than the other cases that we have examined. Since the 1990s, foreign investment has accelerated, largely to meet local market demand, and to expand the base for OEM exports as well. Modest improvements in the sectoral trade balance have appeared since 1993, mainly stemming from OEM production (see Table 13).

Domestic efforts devoted to the development and design of switches were begun on a small and medium scale, undertaken in both incumbent producers and new entrants—the later remarkably came from the New Technology Enterprises (NTEs) born during market reform. Some small switches were developed in response to specific operating environments. One example of such a development is inexpensive private automatic branch exchanges. For larger exchanges, domestic developments have emerged only very recently. One example indicating the spillovers from computer developments seems to have the potential for the development of larger and more sophisticated digital exchanges (Liu Ying et al. 1987: 118).

Thus as a result of intricate interaction over a long period of time between application, production, and R&D and design, a cycle of technological capability development for this sector seems to be coming to fruition. However, despite recent progress in domestic technology

\textsuperscript{12} Total investment in the 1991-1995 period is reported at 241 billion yuan (\textit{People’s Daily, Overseas Edition}, 20 January 1996). This suggests an annual investment at the level of US$8 billion, which in considerable part might have come from private users’ expenditure. Private users accounted for 60 per cent of newly installed telephones in 1995, as indicated in the right column of Table 12.
development, demand for telephone service is still outpacing domestic capacity. A range of equipment imports may be expected to continue for the foreseeable future. On the other hand, China is increasing OEM production and growing exports of telecommunications equipment; it may encounter trade friction in the future with, for instance, European producers, as Europe has recently begun substantial restructuring in this sector. Recent research suggests that European producers are becoming more pessimistic about their export prospects to Asia (Arundel, Steinmueller, and Hawkins 1996). Such friction may indicate that the international markets for telecommunications equipment are inappropriate for export led development strategy by companies in the larger developing countries. As yet, however, uncertainty and instability has not created prohibitive barriers to latecomers for entering production, so long as the entry is chiefly aimed at fulfilling the needs of local development.

From a domestic viewpoint, the rapid expansion of telecommunications in China suggests requirements for future development efforts. A slower pace in benefiting inland areas creates dislocation problems that will have to be addressed in coming years. It is unclear at present what the balance will be between central and local initiatives, and what mix of technologies will be employed in response to the problems—for instance, how mobile telephony might be applied to compensate for insufficiencies in the wired telecommunications network. Mobile phone penetration in China is growing rapidly but still accounts for only a small portion of connections, with about 3.6 million users by the end of 1995 (People’s Daily, Overseas Edition, 20 January 1996). Current developments may have raised the requirements for making advanced uses of telecommunications networks as well, because the systems are, through rapidly expanding, still at the stage of embryonic employment, mainly for voice communications. Advanced uses of the telecommunications network such as data communications may be sought in the future.
Table 13: Production and trade in telephone exchanges in China, 1985-1993

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (1,000)</th>
<th>Imports $ M (US)</th>
<th>Exports $ M (US)</th>
<th>From OEM assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>912</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>1986</td>
<td>507</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>1987</td>
<td>590</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>1988</td>
<td>826</td>
<td>200</td>
<td>0.002</td>
<td>n.a.</td>
</tr>
<tr>
<td>1989</td>
<td>1,043 (10)*</td>
<td>165</td>
<td>0.39</td>
<td>n.a.</td>
</tr>
<tr>
<td>1990</td>
<td>975 (240)*</td>
<td>236</td>
<td>1.97</td>
<td>n.a.</td>
</tr>
<tr>
<td>1991</td>
<td>1,302 (946)*</td>
<td>266</td>
<td>3.24</td>
<td>n.a.</td>
</tr>
<tr>
<td>1992</td>
<td>2,613 (2405)*</td>
<td>487</td>
<td>7.06</td>
<td>5.92</td>
</tr>
<tr>
<td>1993</td>
<td>6,625 (6480)*</td>
<td>1,026</td>
<td>15.13</td>
<td>13.56</td>
</tr>
</tbody>
</table>

Note: Data in parentheses and marked with an “*” refer to the telephone exchanges produced based on digital technology.
4. INNOVATIVE RECOMBINATION AND NATIONAL INNOVATION SYSTEM

This section summarises the mechanisms and characteristics underlining the recent experiences in China in the development of its electronics and information industry, and explores some implications that might be useful for other developing economies.


Although many nations aspire to a strategy for export-led growth, exporting was not the primary force in China’s development of its electronic and information industry. Instead, export orientation was more significant as an impetus to the technological and managerial transformation of Chinese industry. It was combined with domestic market promotion to create incentives and establish dynamics for China’s development of its electronics industry. In our view, China’s experience offers an alternative to the pervasively quoted experience of South Korea and other “first-tier” NIEs, which has been labelled as “export-led” development and seen as the successful approach.

Recent Chinese experience points to a trend in IT development in which the endogenous factors of a national innovation system may play greater roles. This trend suggests that local applications may act more as the driving force for advancing developments, and this may be regarded as an “application-driven approach”. Some distinctive characteristics of an application-driven approach may be identified from the cases examined above. First, domestic market demands establish a basis for rapid growth. In China this came about from the rapid expansion of the markets for consumer goods, computers, and telecommunications facilities, which, after some delay, was accompanied by the enhancement of domestic supply and a move into some segments of the export market. Second, engineering services in design and testing as well as supporting industries such as mechanical manufacturing were intensively and spontaneously developed for IT applications and production. The incorporation of engineering services and supporting manufacturing allowed the Chinese IT industry more independence in responding to domestic demands.
From the point of view of national innovation systems, the application-driven approach of IT
development requires and is reinforced by greater participation and interaction among all the
elements (“attributes”) of a national innovation system—productive firms, supporting sectors, and
the institutions providing higher-order R&D and design and software services. By contrast, in
export-led development, external factors on both the demand and supply sides play the primary role
in establishing and maintaining development. This is particularly true where the attributes of
national innovation systems are underdeveloped, or where the interactions among the attributes are
poorly established and therefore fragile. Indeed, at earlier stages of first-tier NIE development,
OEM assemblers alone were most critical for linking up factors inside and outside, and it was
through OEM manufacturers that skills and dynamism were gradually spread into supporting
sectors (related industries), higher-actor creation activities (R&D and design), and local demands
and applications. We do not regard “application-driven” development as a complete alternative to
the “export-led” mode. External factors are important in both cases. What we emphasise is the role
that external factors play in relation to internal factors, and that internal factors, when accumulated,
amay change the characteristics of development.

In general, the dramatic reduction of prices that is making electronics and IT products more
affordable for individuals and institutions in less wealthy economies like China, and the relative
strengthening of their national innovation systems, allow a development path in which domestic
demand and domestic supply can play a larger or major role. In China, the strengthening of the
national innovation system came from a longer period of accumulation in industrial development,
although with structural distortions that in many cases accompanied the accumulation process in
the developing world. An immediate implication drawn from the impressive achievements
observed in China is a reasonable optimism regarding the prospect of developing countries for
access to the information revolution, since the conditions from which the current Chinese economic
reform began are, to varying extent, commonly found in a number of developing economies as
well. This optimism, however, does not come from a faith that international markets are “open” and
generally welcoming to entrants. International markets do show some limitations that have been
particularly true for the export of mass-produced IT products, illustrated by increasing trade friction
between China and other economies in recent times. These limitations may be much less
prohibitive, or even favourable to local new entrants, when opportunities are created from within
the local economy, namely from an expansion of the existing international market. Chinese
experience suggests that international technology markets do appear rather open for competent
latecomers, but making use of transferred technology entails great efforts by receivers of the
technology.
4.2 Innovative Recombination of Technological Capability through Institutional Restructuring and Technological Learning

If there is a viable strategy for application-driven development of information technology, what are its mechanisms? How can a sustainable process of such development be maintained, expanded, and deepened in circumstances of economic and technological “globalisation”? How may a system, with some accumulated capability but with a distorted institutional structure, adjust itself to cope with the increasing potentials of IT applications?

The mechanism illustrated by the four subsectors examined here may be described as one of innovative recombination, a term to identify the consequences of several parallel processes: (1) the reallocation of previously accumulated capabilities in production, design, R&D, and testing in novel and productive ways to meet the challenges of market reform and trade liberalisation; (2) the stimulation of market reform and trade liberalisation in inducing the reallocation of innovative capabilities and producing new incentives to innovate; (3) the intensive learning devoted to identifying and filling major gaps in the capabilities inherited from the previous system; and (4) the efforts directed at institutional restructuring that support these developments.

The idea of innovative recombination is very close to the term “technological fusion” employed by Kodama (1990) to describe Japan’s success in mechatronics, and the term “technological combination” used by scholars who work on technological innovation. In the case of China, however, we observed that the sources of success have much more to do with institutional innovation than in Kodama’s examination of Japanese mechatronic developments, where technological issues were predominant. Besides, innovative recombination in our sense involves active effort in selectively accessing international sources of technology to fill gaps in previous accumulations, an important part of the development observed, and particularly significant when an economy turns to change its routines in both internal operation and international relations. Trade liberalisation and market reform in China have not only reshaped directions of technological activities in many aspects, but also increased the chances of accessing international sources to fill the gaps. What is commonly appreciated in both the ideas of “fusion” and “recombination” is that accumulations from the past are important, and that present developments involve the incorporation of such accumulations, whether efficiently or inefficiently.
Innovative recombination which involves conspicuous characteristics may be captured through reviewing the learning ladders associated with it. Table 14 contains a learning ladder derived from the development of Chinese Character Processing technology and informatics development incorporating higher-order engineering inputs. It follows a sequence from lower complexity and lower integration of systems to higher levels centred on systems design to fit with local and user specialities—a learning ladder that is different from that for the mass production of IT depicted in Table 1. Accumulations in R&D and design are the critical technological assets for application engineering, and were in the Chinese system embodied in the state-owned “R&D infrastructure”. Necessary institutional restructuring was achieved due to the Scientific and Technological System Reform in China that gave birth to NTEs, the principal developers of application systems. The NTEs had the technological assets upon which learning in the commercial development of IT applications was able to occur. Nonetheless, technological learning has been very intensive, since applications engineering represented an entirely new direction of innovation in which both new and previously existing firms in the field had no experience.

### Table 14: Learning ladder for IT applications in China’s approach to innovative recombination

<table>
<thead>
<tr>
<th>Chinese Character Processing Technology</th>
<th>Informatics Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning ladder</td>
<td></td>
</tr>
<tr>
<td>1, selling and user services of PC</td>
<td>1, preliminary development of informatics systems</td>
</tr>
<tr>
<td>2, separately developed techniques for typing, character processing, and text processing, which are printed circuit board embodied</td>
<td>2, highly integrated systems, additional functions incorporated</td>
</tr>
<tr>
<td>3, systems integration, which is ASIC embodied</td>
<td></td>
</tr>
<tr>
<td>distinctive feature</td>
<td>the need to cope with the trajectory of the latest PC development</td>
</tr>
<tr>
<td>the need to adapt to users operational contexts, and the need to combine systems design with mechanical framework</td>
<td></td>
</tr>
</tbody>
</table>

“Innovative recombination” occurs in IT applications where higher-order activities are combined with the special demands of local users. The informatics case illustrates the important point that capabilities of design and testing need not be possessed and developed directly at the frontier areas of basic electronic components and devices. Innovations in informatics involve the development of a systems design capability which combines basic information technology with mechanical and complementary technologies. The growing tradability of generic electronics technologies makes more feasible IT systems development. A wide variety of
“generic” techniques are available in international markets through components, electronic engineering services, and design tools. These internationally traded technologies provide not only the construction blocks for systems, but also “blueprints” for the general solutions of engineering problems. Alongside of it, a common set of skills and norms for electronics and IT systems is being widely disseminated through academic and commercial associations, and offers a knowledge basis upon which traded generic techniques tend to be easier to absorb. As shown in our examination, restrictions from international markets in the development of application systems are modest. In many cases, the suppliers of generic technology are not direct competitors in most of the applications that may be derived from the use of their products. Local developers may well possess advantages from being close to and familiar with local users. A broad range of opportunities may therefore exist for countries where the original inventions and innovations of information technology were not generated, but where certain engineering capabilities in R&D and design have been accumulated.  

The boundary between production and services is more blurred in the application-driven approach of IT development. Innovations in application engineering often rely on small batch production. In both Chinese language engineering and informatics development, a high level of customisation and a small but viable scale of demand provided an entry point for local production. By exploiting local specificity through learning and by adapting internationally available technology, Chinese computer producers have been able to harness domestic demands to achieve international competitiveness in computer parts and Chinese character processing machines which are now produced on a larger scale. The size of the Chinese domestic market has provided an impetus not only for the scaling-up of production that starts from small-scale entry, but also in the development of selected scale-dependent products such as consumer electronics and, more recently, telecommunications equipment. The entry in scale-dependent production would be more relevant for larger economies, such as India and Brazil. In smaller economies, there seem to be fewer possibilities for successful entry into scale-dependent production driven principally by domestic needs.

13 The experiences of Western European countries support this point. A study reports that Western European companies are (although not strong in “packaged” software, in which American companies take lead in European as well as world markets) dominant in “custom software and computer services”, holding 80 per cent of the local markets in 1992. Furthermore, “interaction with users and customers” is identified “a major competitive factor” for the custom software and computer services that carries “ideas and feedback” of users to be as “the major source that leads to innovations in the European software firms”. Note that “custom software and computer services” is an indicator of application engineering of IT. Supported by the strong capability in application engineering, Western European countries are large and sophisticated consumers of IT. In 1992 Western Europe constituted 36.5 per cent of the world’s IT market; in comparison, the U.S. held 35.3 per cent and Japan 17.4 per cent. See Malerba and Torrisi 1996.
The learning ladder for mass production of IT products relies heavily on incremental process and product improvements. In applying “innovative recombination” to mass production, a key feature is that design and testing engineering may occur earlier, growing in parallel with learning assembly skills as shown in Table 15, as was the case in consumer electronics. In comparison, the first-tier NIEs (see Table 1) followed a learning process that proceeded more linearly, acquiring assembly skills at an early stage and then advancing to stages in which higher-order activities are incorporated. The Chinese industry, on the other hand, while capable of combining design and testing engineering earlier, lacked skills for basic manufacturing that had to be regained from the practice of OEM production. Institutional restructuring for mass electronics production was more concentrated on the continuing establishment of new firms, including joint ventures in the Special Economic Zones, and on reform of existing firms, aimed at freeing firms from the highly vertical ties of planning co-ordination and enabling them to cope with market competition. OEM production was taken as an important policy thrust to reorient productive activities and to inject new technologies and management practices into the industry.

Table 15: Learning ladder for the production of IT products in China’s approach to innovative recombination

<table>
<thead>
<tr>
<th>Marketing Stages</th>
<th>Technological Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980-1985</td>
<td>domestic market sales</td>
</tr>
<tr>
<td>1986-1990</td>
<td>assembly skills</td>
</tr>
<tr>
<td></td>
<td>incremental process and product changes,</td>
</tr>
<tr>
<td>mid-1990s</td>
<td>incorporated with design and testing</td>
</tr>
<tr>
<td></td>
<td>full production skills and product</td>
</tr>
<tr>
<td></td>
<td>incorporated with design and testing</td>
</tr>
</tbody>
</table>

Along with the initiative of OEM production, other channels for international technology inflow, such as licensing technological know-how, the encouragement of DFI, and opening to key product imports, helped the technological learning indispensable to the radical adjustment of industrial structure. Throughout the process, domestic investment in R&D has been maintained to unify the acquisition of technological capability with trade liberalisation. The result of these efforts has been a substantial strengthening of the innovativeness and competitiveness of Chinese national innovation system. Foreign investors have become more enthusiastic about direct investment in the Chinese electronics industry during the 1990s. These investments would not have been possible without the strengthening of technological capability. The growth of DFI in
China in recent years confirms that the sourcing criteria of multinationals for offshore manufacturing have undergone major changes since the 1980s. Abilities in engineering and technical services have become increasingly desired, in addition to the abilities in fulfilling in quality, cost, and delivery time requirements, because engineering cost has increased dramatically in the past twenty years (Kimmel 1993). Offshore manufacturers that are stronger in engineering capabilities and backed by large local markets are likely to become more attractive if other conditions are similar.

4.3 Policy Implications

The recent development of the electronics and information industry in China is a dramatic example of the general process of market readjustment being undertaken by many developing economies that have been adopting more liberal trade and investment policies in recent years. These reforms appear to have worked very well in China, but have not been based on a purely laissez-faire type of organisation. Instead, both national and local authorities have played a decisive role in the introduction of reform programs and in promoting developments on both the supply and demand sides of the market. The two aspects of these policies that we emphasise are institutional restructuring and international participation. We believe that these are policy issues worthy of further examination.

Institutional restructuring is essential for the recombination process since it resolves structural distortions inherited from the past, and creates the proper organisational basis for necessary technological learning. But institutional restructuring is a process for which pure market mechanisms may be inadequate. In China the radical programs for reforming the scientific and technological system had been critical for the emergence of commercial suppliers of IT application engineering. The role of the reform programs was in the introduction and then regulation of market mechanisms for the development of commercialised engineering suppliers. The Chinese policies of encouraging spin-offs from scientific and technological infrastructure have been critical. Similarly, the policies in China for the transformation of firms toward competitive objectives in the market place were of key importance.

To guide institutional restructuring successfully, it is crucial for policy formation to be pragmatic and responsive to the real situation of a particular country (Gu 1995). Because the restructuring process is intimately dependent on local specific conditions, workable policy measures must be sensible to the specific conditions. In the same token the particular policy
procedures adopted in the reforms in China may be inappropriate for other developing economies though they might have likewise accumulated manufacturing and R&D capabilities. Moreover, for the least developed economies, where there is little accumulation of engineering capability and where a major problem is the development of a minimum level of physical and technological infrastructure, the topic of institutional restructuring is likely less relevant than the topic of institutional construction.

International participation involves a broad range of possibilities in which external sources may be drawn upon to initiate and sustain the innovative recombination approach. Several aspects of the experiences in China are especially useful in connection with this process. The role of OEM production in engaging the downstream part of the value chain may be strongly linked to domestic development in the upstream and complementary sectors. Domestic development requires finding innovative and creative means to draw upon international sources such as foreign technology licensing, equipment and components procurement, and OEM production to fill gaps in the prior accumulation of technological capability. DFI played an important role in the development of China’s export capabilities, as well as the improvement of capabilities to meet with internal demands. At the same time, DFI involving joint ventures had been adopted in China to demonstrate “best practice” for firm management, so as to inspire the transformation of productive firms. More broadly, international commodity and engineering service markets have been taken as signals of the direction in structural adjustment for the industry, and for the development of applications engineering. All of these aspects suggest a strategy for international trade policy, that of inviting “spill-in” benefits from the international participation, a policy that functions if efforts are made to strengthen endogenous capability. This international trade policy seems consistent with the first-tier NIEs, especially South Korea and Taiwan. What differentiates China is a greater width and depth in which learning processes can take place as the result of spill-in effects, given that broader accumulations had already occurred in China.

The innovative recombination approach of IT development suggests less developed countries can participate in international trade as both users and producers of products and services in international markets. Companies from the industrial world that regard China or other industrialising economies as a competitive threat still exist in certain sectors. But China’s experience indicates that the extent and effectiveness of oligopolistic control is much smaller than it was thought. Even more important, the new trend in application-driven development seems to have resulted in an absolute expansion of the international markets, in which international division of labour and continuous upgrading of technological capabilities serves the interests of both industrialised and industrialising economies.
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Implications of Intellectual Property Rights for the Access to and Use of Information Technologies in Developing Countries

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Editor's Note

With pleasure we present to our readers the special series of UNU/INTECH Discussion Papers: Information Revolution and Policy Implications for Developing Countries. Papers of the Series were originally developed for the International Workshop on The Information Revolution and Economic and Social Exclusion in Developing Countries, held in Maastricht on 23 -25 October 1996. The Workshop was an important event organized by UNU/INTECH and financed by the Dutch Government. Insights developed from the Workshop have not only been benefiting UNU/INTECH research work, but also contributing to many other initiatives in the area of innovation policy for information technology in developing countries.

There are six papers in the special series. The first five papers have been widely circulated and are provided here in the latest modified versions. These are outcomes from the two major themes set for the Workshop: ‘The Developments of Access and Effective Use of Information Technology and Exclusion’, and ‘The Gender Dimension in Exclusion’. The sixth paper, by Ludovico Alcorta, is a summary of the three country cases on Burkina Faso, South Africa and Tanzania organized for the Workshop.


#2002-2* Constantine Vaitsos, “Policy Agenda for the Information Revolution and Exclusion Phenomena in Developing Countries”


#2002-4* Carlos M. Correa, “Implications of Intellectual Property Rights for the Access to and Use of Information Technologies in Developing Countries

#2002-5* Cecilia Ng Choon Sim, “Making Women’s Voices Heard: Technological Change and Women’s Employment with Special Reference to Malaysia”

#2002-6* Ludovico Alcorta, “The Information Revolution and Economic and Social Exclusion: The Experiences of Burkina Faso, South Africa and Tanzania”

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IMPLICATIONS OF INTELLECTUAL PROPERTY RIGHTS FOR THE ACCESS TO AND USE OF INFORMATION TECHNOLOGIES IN DEVELOPING COUNTRIES

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INTRODUCTION

The diffusion of technologies has been extensively studied in the economic literature (see OECD 1992). Though these studies have considered many factors that may influence the rhythm and modalities of adoption of technologies, the possible impact of legal factors, particularly intellectual property rights (IPRs), has been only incidentally addressed.

The purpose of this paper is to examine recent developments in intellectual property law and the ways in which they may affect the diffusion of Information Technologies (ITs) in developing countries. Analysis and discussion will be centred around the barriers that IPRs may create for the access and use of ITs in such countries. The paper also addresses the main issues that arise, with regard to access to information as such, as a result of the digitisation of data and the development of large computer networks or “information highways”.

The problems related to access and use of ITs are considered here with regard to the application of ITs for production of hardware/software as well as with respect to their use.

While economic reasons are behind major changes in law, the latter also has a definite influence on the economy. The interaction between law and economics is complex. It is often very difficult to isolate the “legal factors” and measure their impact on economic decisions. However, rules created by law establish implicit prices for different kinds of behaviour, and the consequences of those rules can be analysed as the response to those implicit prices (Cooter and Ulen 1988).

The relationship between IPRs and the economy has been addressed from different perspectives (Correa 1994a). During the 1970s, the impact of IPRs particularly patents on developing countries received some attention from scholars. Initiatives to develop new international rules that take into account the interests of such countries were also launched, albeit with little success. (This was the case of the initiatives to revise the Paris Convention, and to establish an International Code of Conduct on Technology Transfer.)
More recently, particularly after the launching of the Uruguay Round (1986), economists’ interest in IPRs has revived, as illustrated by work done by the World Bank (see Siebeck et al. (1990), David (1993), Mansfield (1993, 1994), UNCTAD (1996), Correa (1995)).

This paper briefly considers changes in the paradigm of protection of IPRs, particularly in the areas of patents and copyright (Section 1.1). It describes the nature and scope of the standards of protection negotiated during the Uruguay Round (Section 1.2), and new developments in progress (Section 1.3).

The relationship between information technologies (ITs) and intellectual property rights (IPRs) is examined with respect to computer programs (Section 2.1), including the trends in the areas of multimedia products (Section 2.2) and integrated circuits (Section 2.3). Issues related to the protection of and access to databases and digital information in general are dealt with in Section 2.4.

The implications of the trends described for the access, acquisition, and use of ITs in developing countries are considered in Section 3.1. Sections 3.2 to 3.5 analyse the impact of copyright, patents, and integrated circuits protection with regard to the production and use of ITs, as well as to the access and use of digital information. Section 4 includes the main conclusions of the study.
1. THE PARADIGM OF IPRS PROTECTION

1.1 Changes in Patent and Copyright Law

The IPRs system has dramatically changed in recent times. As a recent study notes: “The ongoing shift toward a global, knowledge-based economy has resulted in the law and economics of intellectual property rights changing more in the last five years than in the last two centuries” (Acheson and McFetridge 1994: 239).

Under the original patent system, explains Merges, society’s benefit “was the introduction of a new art or technology into the country”. By the late eighteenth century, however, a major change in the economic role of patents took place, shifting the emphasis from the introduction of finished products into commerce to the introduction of new and useful information. The “primary benefit was seen as the technological know-how behind the inventor’s patent. The beneficiaries on this view were not just the public at large, but instead others skilled in the technical arts who could learn something from the patentee’s invention” (Merges 1992: 6).

During the present century, a new shift in emphasis took place towards a system mainly concerned, on the one hand, with the encouragement of investors rather than of inventors, and, on the other, with the commercialisation, on an international scale, of protected goods and services. Changes in the patent system reflected the growing internationalisation of the economy and, particularly, the interest of large industrial corporations in being able to flexibly select the channels for the world-wide exploitation of their innovations, through trade, technology transfer, or foreign direct investments (Penrose 1951).

Several factors contributed to prompt during the last decade a far-reaching reform of the intellectual property system. These relate to the increase in research and development (R&D) costs, the shortening of the life-cycle of products, difficulties in appropriating R&D results, particularly in the field of easy-to-copy new technologies (such as computer programs), and the globalisation of the economy (Correa 1994b; David 1993).
Under the currently dominant conception, it is assumed that by making products available (which would not occur, by hypothesis, without protection) and stimulating investments in research, society is fully compensated for the monopoly it grants. Some U.S. court decisions reflect this approach: in Platex Corp v. Missinghoff (758 2d 594, 599, Fed. Circ. 1985), for instance, the court stated that “the encouragement of investment-based risk is the fundamental purpose of the patent grant”.

A similar transformation has taken place in the copyright field. The original intent of copyright law in the United States was described by the Supreme Court in a famous case (Wheaton v. Peters), as follows:

The enactment of copyright legislation by Congress under the terms of the Constitution is not based on any natural right that the author has in the writings, for the Supreme Court has held that such rights as he has are purely statutory rights, but on the ground that the welfare of the public will be served and progress of science and useful arts will be promoted. Not primarily for the benefit of the author, but primarily for the benefit of the public such rights are given. (OTA 1986: 38)

This model assumed that “by granting economic rights to the creator of intellectual works, information would be created and disseminated, and thus a number of other social and economic objectives would be achieved. In this model, not only were other societal goals understood to be furthered by fostering the learning environment, these goals were also seen to be mutually compatible and self-enforcing” (OTA 1986: 56).

A new conception has developed, however, in the field of copyright. There has been a fundamental shift from a system based on non-commercial considerations the benefits that the society will derive from creative authorship and the dissemination of ideas to a “law of misappropriation” the ultimate objective of which would be to protect the commercial value of creative outputs. The encouragement of investment and the availability to the public of their results would be sufficient, in accordance to said conception, to justify the awarding of monopoly positions. “Whatever copyright may have rested upon in the past, the primary goals of copyright are now economic considerations” (Swanson 1988: 224) (see also Dreyfuss 1987).

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1For instance, a U.S. Supreme Court decision (Mazur v. Stein), stated that “the economic philosophy behind the clause empowering Congress to grant patents and copyrights is the
1.2 The TRIPs Agreement

An outstanding illustration of the new emerging paradigm on IPRs is provided by the Agreement on Trade-Related Aspects of Intellectual Property Rights (the “TRIPs Agreement”), which was negotiated in a trade-forum GATT to address the economic, trade-related, aspects of IPRs. This Agreement represented a “conceptual leap” and a major achievement of U.S. industrial groups that have advocated linking IPRs to trade issues since the early 1980s (Sell 1995), in order to exert pressure on foreign countries to adopt higher standards of IPRs protection.

Negotiations on the TRIPs Agreement were initiated by request of, and under strong pressure from, industrialised countries. Their objective was to establish minimum standards, with regard to substantive as well as to procedural rules, with a universal application, on practically all areas of intellectual property. Developing countries reluctantly negotiated such standards, but finally agreed to make important concessions in terms of future reforms of their intellectual property legislation.

The initiative to negotiate the TRIPs Agreement can be explained, on the one hand, by the effective action of industrial lobbies (particularly the pharmaceutical, software, semiconductors, and phonograms industries) and, on the other, by the changes in intellectual property law occurred in response to new technologies.

The TRIPs Agreement sets forth the minimum standards to be applied by all Members of the WTO. Such standards are, at the same time, the upper limit that many countries are prepared to accept. This is reflected, for instance, in the recent Argentine patent law (1995).

If a WTO Member does not observe the prescribed minimum standards, no other Member can unilaterally apply trade sanctions against that Member, as provided for, for instance, under section 301 of the U.S. Trade Act. Any complaint must be brought to and dealt with under the multilateral procedures established by the Dispute Settlement Understanding (DSU).

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conviction that the encouragement of individual effort by personal gain is the best way to advance public welfare through the talents of authors and inventors.” (247 U.S. at 219)
There are a number of areas where the TRIPs Agreement has left freedom to legislate, where further harmonisation of IPRs protection does not seem possible or desirable. This includes many aspects of authors’ rights/copyrights and of industrial property law.

This freedom can be effectively used by any country to develop legislation in accordance to article 7 (“Objectives”)\(^2\) and article 8 (“Principles”)\(^3\) of the Agreement, which provide for a pro-competitive framework to implement IPRs protection.

The concepts of “mutual advantage”, “social and economic welfare”, and “balance of rights and obligations” in article 7 mean that the recognition and enforcement of intellectual property rights are subject to higher social values and, in particular, that a balance needs to be found with other users of technological knowledge.

Under these provisions, national legislation can provide for a variety of measures that promote competition and balance, to some extent, the interests of the title-holders with those of the users of the technology. Such measures may include parallel imports; non-patentability of substances existing in nature and of animals and plants; compulsory licenses of various types;\(^4\) and reverse engineering of computer programs, among others.

In the area of ITs, the TRIPs Agreement contains several important provisions:

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\(^2\) Article 7 states that: “The protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conductive to social and economic welfare, and to the balance of rights and obligations”.

\(^3\) Article 8 states that: “(1) Members may, in formulating or amending their national laws and regulations, adopt measures necessary to protect public health and nutrition, and to promote the public interest in sectors of vital importance to their socio-economic and technological development, provided that such measures are consistent with the provisions of this Agreement. (2) Appropriate measures, provided that they are consistent with the provisions of this Agreement, may be needed to prevent the abuse of intellectual property rights by right holders or the resort to practices which unreasonably restrain trade or adversely affect the international transfer of technology”.

\(^4\) It should be noted that the TRIPs Agreement does not limit (except for semiconductor technology) the grounds under which compulsory licenses can be granted, but only defines the conditions therefore.
• Computer programs, whether in source or in object code, are to be protected as “literary works” (article 10.1).

• Protection of computer programs shall last at a minimum for fifty years, and shall include exclusive rights to rent the programs (“rental rights”, article 11).

• Compilations of data (databases) shall be protected under copyright, provided that they constitute an intellectual creation due to the selection or organisation of materials (article 10.2).

Finally, it should be noted that all WTO Members within one year after the date of entry into force of the WTO Agreement (1.1.95) agree to apply the obligations relating to intellectual property protection (article 65.1). Developing countries have an additional period of four years and least developed countries of ten years, except for obligations concerning national and most-favoured-nation treatment, which will become applicable after the expiry of the aforementioned one-year period. Enjoyance of these transitional periods does not require any specific declaration or reservation by the concerned country. They are automatically applicable.

The establishment of these periods was not a generous concession by industrialised countries. It was the result of hard negotiations in which developing countries obtained, in exchange, long transitional periods for complying with their obligations in agriculture and textiles. In other words, the transitional periods in TRIPS had a “price” and a high one for developing countries, in terms of export losses in agriculture and textiles.

Transitional periods are nevertheless essential for many developing countries, which need time to introduce new legislation and adapt the affected economic sectors to the new regulatory framework.

The United States is, however, threatening several developing countries with sanctions under section 301 of the U.S. Trade Act. It requests, among other things, not only immediate introduction of the TRIPs standards but their retroactive application (under the so-called “pipeline” solution).

5 In addition to the general transitional periods referred to above, a further period of five years is contemplated for countries which are bound to introduce product patent protection in areas of technology not so protected in their territory on the general date of application of the Agreement for that country (Article 65.4)
Such a request is completely illegitimate under the TRIPs Agreement. It disregards binding international rules, and deprives developing countries of their right to take the necessary time to introduce legal reforms and adopt measures that mitigate the eventual negative economic and social impact of the standards.

To sum up, the adoption of the TRIPs Agreement represented a major victory for industrialised countries and their most active industrial groups. The Agreement, however, contains a number of elements of flexibility that allow under certain limits the development of a pro-competitive approach towards intellectual property.

1.3 New Developments

Further changes seem under way in the IPRs system. On the one hand, the incremental nature of innovation in key industries, such as electronics, is not well captured by existing rules, and may lead to a crisis of the current model of IPRs protection. According to Foray:

_Innovative activity has shifted away from models based on absolute novelty and first improvement towards a model in which innovation is no longer driven by technological breakthroughs but by the routine exploitation of existing technologies. This change has precipitated a crisis in the area of intellectual property rights, particularly in the sectors where the new innovation model is most wide-spread (biotechnology, software, consumer electronics)._ (Foray 1995: 120)

On the other hand, the need to extend IPRs protection to “information products” which are not copyrightable, patentable, or subject to other existing IPRs has been voiced. It is recognised that “fact and functional material” are the building blocks upon which scientific and technological progress depends, and that their content is so closely tied to facts and laws of life and nature that there is little room for creation (Dreyfuss 1993: 196, 214).

However, it is argued that determining what information the market wants and conveying that information clearly and in appropriate formats can require a high level of ingenuity. In addition, “lead time” which allowed in the past to recover the investments made for the generation of new knowledge has shortened or vanished. A new, eventually “hybrid” form of protection would be,
according to some experts and industry views, required in order to provide the adequate incentives to innovate (Dreyfuss 1993: 210, 234; Samuelson et al. 1994)

This changing approach on the IPRs regimes reflects itself in two major developments:

- Expansion of the subject matter of protection. New areas of knowledge are becoming subject to property rights. One outstanding example is the protection of semiconductors’ layout designs under a new, *sui generis*, system of protection, established for the first time in the United States in 1984. An international obligation (under the TRIPs Agreement) to protect such designs has been already adopted.

Patents have been extended in most countries to living matter, including plants and animals, though this still causes considerable debate (Crucible Group 1994). As discussed below, the granting of patents on computer programs is currently admitted in the United States.

A new form of *sui generis* right has been also developed within the European Union in order to protect investments made for the development of databases that are otherwise unprotectable under copyright (see Section 2.4.1 below).

- Universalisation of minimum standards of protection. Under the principle of national treatment, each country could frame in the past its intellectual property system in accordance with its own needs and long-term interests, provided that it granted foreigners the same treatment accorded to nationals. However, the adoption of minimum standards under the TRIPs Agreement (including such aspects as definition of protected subject matter, terms of protection, extent of exclusive rights, etc.) has reduced national freedom and increased to an unprecedented level the degree of universal harmonisation of IPRs (see Frischtack 1995).

This process means, in particular, that developing countries are bound to incorporate standards of protection basically in accordance with those so far in force in industrialised countries.

Even though a new international intellectual property regime could be “Pareto improving”, it is likely “to impose institutional arrangements that may be well adapted to the national purposes and legal contexts of one country (or several similar countries) on societies that are quite different in those respects” (David 1993: 55).
In sum, intellectual property law has substantially evolved in response to changes in technology and market trends. The emerging system is centred on the economic dimensions of intellectual property rights. The primary concern is rewarding investors, rather than the encouragement of individual creation and the public dissemination of knowledge: “even if the rhetoric of argument occasionally appeals to notions of justice and equity, modern economic analysis, and its characteristic preoccupation with questions of efficiency, now set the terms for policy discussions about the protection of intellectual property” (David 1993: 20).
2. ITS AND INTELLECTUAL PROPERTY LAW

The development and rapid diffusion of information technologies has posed major challenges to various aspects of public and private law. The birth of new products and of whole new branches of industry, such as semiconductors, computers, computer software, multimedia, and databases, has called for the adaptation or creation of new legal principles and rules.

Pre-existing rules and institutions of intellectual property have been deemed applicable to some of the new areas, with certain adjustments. This is, for instance, the case of computer software: following a number of precedents established by national laws, computer software has become protectable under copyright as literary work. The TRIPs Agreement has explicitly obliged all Member countries to adopt that approach. Though this has proven the adaptability of copyright to new situations, the outcome does not seem to satisfy everybody considerable debate still goes on due to the functional character of software and its problematic assimilation to literary works (see Samuelson et al. 1994).

In other areas, as in the case of semiconductors, new legal approaches have been developed. Based on the regime adopted by the United States under the Semiconductor Chip Protection Act of 1984, countries which thereafter legislated on the matter have followed the *sui generis* approach first established by that Act, which also influenced the Washington Treaty concluded in 1989.

Though these and other regulations, and case law, addressed many of the emerging issues, technological developments have continued to pose new and increasingly complex problems to intellectual property law. One of the main directions of such developments has been the convergence of different types of applications, based on the common infrastructure provided by digital technology.

Digitised text, speech, graphics, images (moving or not), music, and sound can be combined using appropriate computer software and associated hardware. This combined use gives rise to a
wave of new products and services with an expanding market. The products may be either fixed in material form (such as CD-ROM) or stored and directly accessible on-line as digital data.

2.1 Protecting Computer Programs

2.1.1 Technologies for Software Development

Technologies for software development are not proprietary, although the use of certain tools, platforms, or interfaces may require the negotiation of a license and the payment of royalties. Different languages and architectures offer software producers options to develop their products, with different technical (and commercial) advantages and disadvantages.

Technology for software development is largely available at university and research institutions. The basic knowledge to create computer programs is accessible to individuals of various disciplines (not necessarily software specialists) with a mathematical background. The nature of software technology from time to time permits outsiders to challenge the market position of major software producers, a few of whom dominate the market. (“Linux” provides a good example.) Due to these characteristics, software has been deemed a strong candidate for “leapfrogging” by developing countries that possess a good scientific infrastructure (Pérez 1987).

The knowledge involved in software development, however, constitutes a more complex technology where other skills (relating to, e.g., information systems, hardware architectures, project management, etc.) are required, depending on the type of software to be produced. Besides, as argued elsewhere (Correa 1996), availability of technology is not enough to overcome the formidable commercial entry barriers prevailing in the software market.

Innovation in software development is typically incremental (Samuelson et al. 1994: 2,330). Software products are generally developed using previously existing programs and algorithms. Software is a “cumulative systems technology”, as opposed to the “discrete invention model”. It is a “technology that builds on and interacts with many other features of existing technology to create a new technology” (Nelson 1994: 2,676-77).
Though software development is subject to the limits imposed by the particular problem to be solved, there is no unique way of developing a certain product. Software producers make strategic choices, taking the type of products and markets envisaged into account.

Considerable room is, hence, left for creativity and ingenuity. Tacit knowledge, based upon experience, plays an important role in software development, which may be described despite the introduction of software engineering tools as still being an “amateurship, craft-based discipline” (Cane 1992: 1,726) rather than a proper “industrial” activity (Zimmermann 1993).

2.1.2 Copyright Protection
Copyright has been applied to computer programs, with some hesitation at the beginning, and with a lot of still ongoing controversy about the extent of protection. By pushing the copyright way, United States government and industry strategically opted for a form of protection which is cheaper to obtain than industrial property rights, that does not require disclosure, and, above all, that permits almost universal and automatic protection without registration, from the very date of creation of the program.

This latter feature is of utmost importance for any internationalised industry, such as the software industry. Copyright protection does not require applications and procedures in individual countries. It has practically a global reach as a result of the large membership of the Berne Convention.

The recognition of computer programs as a copyrightable work was actively sought by major software producers and the United States government. Under section 301 of the Trade Act, the United States Trade Representative (USTR) initiated several procedures against developed and developing countries that did not adequately protect, in USTR view, such programs. The cases of Brazil (Bastos 1995), Thailand (where a government was forced to step down due the reaction created by its attempt to accept U.S. pressures in the software area see (Correa 1990a)), and, more recently, China, are illustrative of such actions.
The pro-copyright campaign also reached GATT. The TRIPs Agreement clearly states that computer programs are to be protected “as literary works”. This provision entails the internationalisation of a legal framework of protection for computer programs, on the adequacy of which doubts continue to be voiced (Samuelson et al. 1994). The functional aspects of computer programs pose difficult questions that copyright law has so far been unable to resolve (OTA 1992: 22).

Copyright only protects the expression of an idea, not the idea as such. This basic dichotomy contained in U.S. copyright law has been explicitly stated in the TRIPs Agreement (article 9.2).

As a result of said dichotomy, the production of an identical copy of a program is prohibited by law, if it is the result of access to the pre-existing program. There is no infringement if an identical program is independently created without such an access. Likewise, there is no infringement if a program has the same behaviour but a different expression, even if the new program has been created on the basis of access to and reverse engineering of a pre-existing one.6

It should be noted, finally, that computer programs, are not only protectable as copyrightable works. The “source programs” can also be protected as trade secrets or undisclosed information. Such programs contain the most valuable information for software producers, information not made available to the public through the distribution of copies in magnetic form.

In sum, copyright protection (as supplemented by trade secrets protection) erects barriers against imitation and competition via incremental innovation, but it presents important shortcomings for those looking for stronger means of preventing the development of competitive products via reverse engineering (Correa 1993). Different ways have been utilised, particularly by major software producers, to neutralise the weaknesses of existing IPRs protection. These have included extension of the scope of, and search for new forms of, IPRs protection, and strict and aggressive enforcement of available IPRs.

6 It is debated, however, whether a “substantially similar” imitative program is infringing or not (Kitagawa 1994: 2,613).
### 2.1.3 Extending IPRs Protection

**Beyond expression.** A large number of cases (see Box 1) were brought to courts in the United States in order to obtain copyright protection of user interfaces (“look and feel”), a crucial aspect for the development and marketing of competing products.

“User interfaces” determine the way in which a user interacts with the computer through the use of “menus”, certain forms of entering commands, etc. External consistency of a new program with an existing one permits “transfer of learning”, and therefore increases the likelihood of adoption by potential users, who may be reluctant to invest time in learning how to use new programs.

Protection was recognised for the overall set of command terms and their organisation into menus, the menu “structure”, the order of commands in each menu line, and the choice of letters, words, or “symbolic tokens” (OTA 1992: 143).

Unsuccessful demands for protection of “user interfaces” included particular menu styles, the use of pull-down menus, the use of a two-line moving cursor, and ways of entering commands, among others.

### Box 1

**Limiting competition on expressive elements of computer programs**

Suits against competitors have been due to their copying of expressive elements of computer programs, including the following:

- Placing screen captions at the top centre of the screen
- Using the colour blue as screen background
- Designating which keystrokes a user should press to enter the program function that a given Screen menu word designated by capitalising and highlighting (making brighter) the letters of The menu word corresponding to the keystrokes
- Labelling the opening menu of a program as “Opening Menu”
- Use of pull-down menu windows in reverse video
- Use of the same command language to operate program functions that the plaintiff’s earlier Program used for those functions
- Having the same switch patterns on a machine’s front panel to actuate the machine’s software
- Imitating the plaintiff CADAM’s computer program by being “too CADAM-ish”.

**Limiting reverse engineering.** Innovation in the software industry is very dependent, as mentioned before, on the improvement of existing products. Development costs can be significantly reduced by evaluating products on the market and designing new products with enhanced features. A crucial aspect for innovation and competition in the software industry is, therefore, the extent to which the evaluation (reverse engineering) and improvement of computer programs are feasible and legitimate.

In contrast to the tacitness present at the production phase, software products are fully formalised and codified. This affects the appropriability of the results of development work, since much of the embodied know-how is “borne on the face” of the product (Kitagawa 1994: 2,615). Other embodied elements of the know-how may be obtained through decompilation and disassembly.

“Decompilation” and “disassembly” are technical procedures that permit the reverse engineering of software products. “Decompilation” allows one to translate a machine language program into a high-level representation program, i.e., a more understandable form. By “disassembly”, a machine language program is translated into an assembly language program (OTA 1992: 146). Though such procedures are useful for small products, this is not necessarily the case for large ones, at least under the current state of the art, since decompilation in the latter case is extremely costly and time-consuming (Samuelson et al. 1994: 2,336, 2,341). This provides a *de facto* protection to innovators against imitation.

In principle, under the idea/expression dichotomy, reverse engineering is a legal method of acquiring knowledge of the internal organisation and structure of a program, with a view to producing a new program differently expressed. Reverse engineering is also legitimate with regard to trade secrets, except if unfair practices are used to obtain the relevant knowledge (Neff and Smallson 1994: 102).
The admissibility of the reverse engineering of computer programs has set off, however, a heated debate and hesitant case law. Major U.S. firms and the U.S. government have strongly lobbied to limit that activity.

Thus, when the European Commission decided to clarify, by means of a specific Directive, the scope and extent of protection of computer programs, major software producers who are able to determine de facto market standards campaigned for the restriction of reverse engineering in this field. They confronted other firms (including ones from Japan, the United States, and Europe) that regarded the prohibition of reverse engineering as a potentially insurmountable barrier to competition.

As an outcome, European Council Directive 91/250 on the Legal Protection of Computer Programs set out a compromise: reverse engineering was deemed legitimate only if it was intended to achieve “interoperability” with the evaluated program. The Directive permitted decompilation when it was “indispensable to obtain the information necessary to achieve the interoperability of an independently created program with other programs” (article 6).

One important manifestation of the trend toward extending protection of computer programs, even within the framework of copyright law, was United States case law holding that such a protection could embrace not only the literal code (expression) of a program, but also its “structure, sequence, and organisation” (Whelan Assoc. v. Jaslow 1987). This extended protection was, however, denied in subsequent decisions (Atari v. Nintendo; Sega v. Accolade, 1992). In Sega v. Accolade the court held that:

Where disassembly is the only way to gain access to the ideas and functional elements embodied in a copyrighted computer program and where there is a legitimate reason for seeking such access, disassembly is a fair use of the copyrighted work as a matter of law.

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7 In NEC Corp. vs. Intel Corp. (67,434 (N.D. Cal. Feb. 6, 1989), for instance, a U.S. court did not condemn the disassembling of an Intel microcode (8086/88 microprocessor chips) for the purpose of researching and developing a competitive microcode program.

8 U.S. action blocked the explicit legalization of reverse engineering in Japan (Kitagawa 1994: 2,617).

9 A group of these firms constituted the “European Committee for Interoperable Systems” to lobby in favor of decompilation to get access to unprotected elements.
The possible negative impact on innovation of an eventual limitation to reverse engineering, has been pointed out by many scholars, who warn that overprotection can not only stifle creativity but also limit developing countries’ access to technology (see Mody 1989: 2, 34).

**Applying for patents.** Despite the efforts made to extend the rights conferred by copyright protection, dissatisfaction of major producers has continued. The difficulty of appropriating the functional aspects of a program and the need to prevent reverse engineering have prompted a growing use of the patent system, notwithstanding the high inventive standards and the required disclosure of the invention.

Two categories of software-related inventions may be distinguished: (a) computer programs that produce a technical effect within the computer or on other hardware components; and (b) computer programs that produce technical effects different from those described in (a), entailing changes in the state of physical matter, such as effects on equipment applied to a specific industrial task (Guglielmetti 1996: 70).

In the United States, the possibility of obtaining patents on computer programs has found a favourable attitude from the Patent Office and case law. Since the decision in the leading case Daimond v. Diehr until 1994, more than 3,500 software patents have been granted (Warshofsky 1994: 162).

U.S. courts distinguished non-patentable, purely mathematical algorithms from inventions in which such an algorithm is “applied”. In Diamond v. Diehr, a patent on an algorithm used to control a process for curing rubber was upheld. However, patents have also been granted in cases where there is no transformation of physical substance into a different physical state, and only manipulation of data is involved. Some examples of granted patents (including both categories defined above) are given in Boxes 2 and 3.

Attempts have been also made to claim protection on computer languages. Adobe, for instance, “a software house that created a popular desktop publishing program, claims that its PostScript language is copyrighted, although it has not sued those who reject this claim” (Warshofsky 1994: 152).
The Arrythmia case (958 F.2d 1053 (1992)) is illustrative of current trends in the United States. The invention involves a formula that analyses heartbeat signals, assigns an arithmetic value to the analysis, and compares that value with a predetermined level. The comparison allows a diagnosis as to whether the individual tested is at risk for heart failure. While the Court reiterated that inventions consisting solely of an abstract mathematical formula or equation are not patentable, it stated that the patent claims did not result in patenting a mathematical formula, but “only foreclosed others from using that formula in conjunction with the diagnostic and computer-run steps of the particular invention” (Fishman 1994: 5/32).

Software patents to the extent that, unlike copyright, they protect ideas, and not their expression may have important implications, independently from the technical importance of the involved “invention”.

**Box 2**

**Examples of software patents granted in the United States**

The patented invention:

- translates between natural languages.
- determines boundaries of graphic regions on a computer screen.
- governs removable menu windows on a computer screen.
- generates and overlays graphic windows for multiple active program storage areas in the computer.
- qualifies and sorts file record data in a computer.
- compresses and manipulates images in a computer.
- handles the data structure and search method for a database management system.
- automates spelling error corrections as in some form of a spell-checker system.
- set up a securities brokerage cash management system.
- operates a system that values stocks, bonds, and other securities automatically makes a two-dimensional portrayal of a three-dimensional object; specifically, it transfers a 2-D drawing of an object into a computer-presentable 3-D drawing.
- allows information to be stored on a hard drive and retrieved by multiple users at different locations.
- measures the performance of a general purpose digital computer.

Box 3

Patenting prime numbers

A troubling case has been identified by the British Parliamentary Office of Science and Technology: a patent on prime numbers. “A patent was issued by the U.S. Patent and Trademark Office (PTO) for a mathematical method (the Partial Modular Reduction Method) which is of use in cryptography and security systems. The claims included the use of two prime numbers (comprising 150 and 320 digits) which have a property that speeds up decryption. Indeed, the claim in the patent extends to using any prime number that allows the short cut to be made. The U.S. PTO agreed that the two prime numbers in the claim represent novel discoveries that have some utility, and can, therefore, be patented under U.S. patent law”.


Thus, Warshofsky reports that Cadtrak Corporation applied for a patent on a computer screen display and included the exclusive-or statement as one of 15 claims. “They were granted U.S. Patent No. 4,197,590, and as a result, anyone who wants to put a cursor on a computer screen either pays Cadtrak or runs the infringement gauntlet. More than 300 hardware and software companies, including IBM, Texas Instruments, and Fujitsu, chose the easy way and are paying royalties to license that single patent” (Warshofsky 1994: 164).

In another case, “Paul Heckel, a California programmer, was granted U.S. Patent Nos. 4,486,857 and 4,736,308 for a system that displays records or strings of information and then allows the operator to scroll, or browse, through them. Heckel sued Apple computer, alleging their HyperCard program violated those patents. Despite the fact that scrolling and sub-windows, the techniques incorporated in the patents, were quite well known, using them in combination may now be considered illegal. Rather than fight what is considered a nuisance suit, Apple simply took out a license” (Warshofsky 1994: 163).

In Europe, the patenting of computer programs has been less permissive than in the United States. The European Patent Convention forbids the patenting of computer programs as such. Patents have not been granted in cases where the program only undertakes mathematical operations, analyses test data (e.g., application by Siemens, 1989), or permits the graphic presentation of data (IBM, 1993), among others. In exchange, computer programs that generate a transformation in physical reality by guiding the operation of other means have been deemed patentable, such as a computer-operated radiological device (Koch & Sertzel, 1987), and a system to automatically manage the order of the supply of services to clients at different sites (Queuing System, 1994) (Guglielmetti 1996: 78-89).
**Enforcing IPRs.** Several cases illustrate how aggressively and extensively IPRs may be enforced. One example was the IBM-Fujitsu case relating to the infringement of IBM’s software. IBM obtained from Fujitsu a compensation for infringement amounting to US$833 million, plus annual royalties between US$26 and 51 million. The arbitration process, however, determined that Fujitsu should have to be allowed continued access to IBM’s software (Mody 1989: 34).

Further, major software producers have individually or jointly (through the “Business Software Alliance”) undertaken “anti-piracy” campaigns and brought judicial action against distributors of “pirated” software, as well as against corporate users that did not respect contractual or legal restrictions (particularly those preventing the making of copies other than for back-up purposes).

The piracy levels reported by interested groups are high in both developing and developed countries (see Table 1). Though the basis and mode of calculation of these estimates is unclear, they reflect the concern with what seems to be a widespread phenomenon. It is almost impossible to monitor and prevent private copying of computer programs. Litigation costs are disproportionately high to prosecute individual users or small firms.

In the case of Latin America, legal actions have been initiated against large local (private and public) companies and foreign subsidiaries, as well as against public research institutions. Their aim has mainly been to give a signal to major software users in order to discourage illegal copying.

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10 In some cases, software suppliers have made global arrangements with universities in order to allow the legal distribution, at low cost, of copies of old versions of computer programs.
Table 1  U.S. Computer Software Industry  Losses due to piracy, and levels of piracy  
(1995)

<table>
<thead>
<tr>
<th>Region</th>
<th>U.S. Losses (in US$ millions)</th>
<th>Piracy Level (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td>2,542</td>
<td>78</td>
</tr>
<tr>
<td>Western Europe</td>
<td>3,001</td>
<td>52</td>
</tr>
<tr>
<td>Central &amp; Eastern Europe</td>
<td>619</td>
<td>92</td>
</tr>
<tr>
<td>Middle East &amp; Mediterranean</td>
<td>300</td>
<td>93</td>
</tr>
<tr>
<td>The Americas &amp; Caribbean**</td>
<td>1,074</td>
<td>86</td>
</tr>
<tr>
<td>United States</td>
<td>2,358</td>
<td>35</td>
</tr>
<tr>
<td>Total</td>
<td>9,894</td>
<td>---</td>
</tr>
</tbody>
</table>

* includes data for the world’s business software industry, not just the U.S. industry  
** includes Canada but not the U.S.  
Source: Smith 1996.

2.2 Multimedia Products

The development of multimedia products involves a variety of knowledge and skills, and often the combination of pre-existing works developed by different authors. Producers of multimedia integrate multiple technologies and works in a creative form. Producers’ skills are required to select the materials and to determine the form in which they are organised and presented in an interactive way.

Multimedia producers may be divided in four categories:

- professional video producers, including TV producers;
- industrial producers, such as corporate graphics and video producers in advertising;
- commercial organisations that produce their own multimedia material;
- educational institutions and educators (Buckner 1995: 33).

As a result of the complex nature of multimedia products, a “package” of intellectual property rights, belonging to the same or different title-holders is involved. Such rights include:

- Copyrights and related rights. Authors of text, computer programs, databases, music, photographs, and motion pictures as well as performing artists may claim copyright and related rights with respect to the works partially or totally included in multimedia products.

Those rights should be differentiated from those belonging to the multimedia producer as such, i.e., to the person or persons who have combined the various components in an original form.
The multimedia producer may develop by himself the different components of the product or may use existing works. The latter is the most common situation. The multimedia producer needs in this case to obtain permission from each author to use the respective work.

Obtaining permission and determining the remuneration to be paid to all possible title-holders involved is one of the outstanding problems in the area of multimedia. It may be extremely difficult to determine authorship and to contact all possible authors, as well as to evaluate the level of the remuneration to be paid. Transaction costs are high.

- Patents. Patent law may also apply to multimedia products, though in a limited and, probably, controversial way.

A patent granted to Compton New Media in the United States is an example of the possible extension of patents to the multimedia world. Compton New Media obtained a patent for a computer-controlled system for retrieving text and images from a database and claimed a 1% royalty from companies producing interactive multimedia products. The patent created wide concern in industry. It was successfully challenged and finally overturned (Keck 1995).

- Trade secrets. Finally, as in the case of computer programs, trade secrets may also be relevant for multimedia products. The source-code of computer programs, as mentioned above, is generally deemed to be protected by trade secrets, in addition to copyright.

The production of multimedia is one of the opportunities that developing countries might try to exploit. However, legal issues are so intricate and complex, that unless a general solution is implemented (e.g., by means of compulsory licensing), transactions costs for obtaining all required authorisations may be prohibitive and block any possible significant development in this field.

2.3 Integrated Circuits

The semiconductor industry is highly concentrated. A few transnational corporations account for the overwhelming share of semiconductor production and trade and for the technologies necessary for state-of-the art semiconductor manufacture. Among developing countries, only South Korea has emerged as a world-class competitor. Taiwan has also developed some

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11This section is partially based on (Correa 1990b).
capacity. Other developing countries participate as exporters of semiconductors locally assembled by subsidiaries of transnational corporations. The high investment required for mass chip production and the intensity and cost of R&D in an extremely competitive market constitute formidable barriers for potential new entrants, particularly from developing countries.

While the production of integrated circuits is beyond the reach of most developing countries, the design, particularly of custom and semicustom chips, has been undertaken in many of them, particularly in new industrialising countries (NICs). This has been facilitated, on the one hand, by the development of CAD tools that can run on relatively small-size computers, and, on the other, by the possibility to contract with various silicon-foundries the manufacture of a chip according to independently-made designs.

Technological advance in the semiconductor industry is an interactive, cumulative process where improvements are directly based on the pre-existing stock of knowledge. Studies on the role of IPRs in promoting innovation in this industry have shown that gaining lead time and exploiting learning curve advantages are the primary methods for appropriating the returns of investments in R&D (Levin et al. 1987: 788).

The protection of layout designs of integrated circuits as a specific subject matter was born in the United States in 1984, with the approval of the Semiconductor Chip Protection Act (SCPA). The growing concern on the decline of U.S. competitive advantages in chip production and trade during the 1980s prompted Congress to adopt a sui generis protection.

It was assumed, in particular, that the increasing strength of Japanese firms was linked to the copying of American designs.

The sui generis regime for integrated circuits established under the SCPA provided for a ten-year protection; registration was made compulsory within two years of the first “commercial exploitation” of a mask work; a special provision allowing for “reverse engineering” was contemplated, following the practices prevailing in the semiconductor industry.

The SCPA, in addition, included stringent reciprocity rules that forced Japan to adopt similar legislation (“Act concerning the circuit layout of a semiconductor integrated circuit” (law No
followed by the European Communities (Council Directive on the legal protection of topographies of semiconductor products 87/54/EEC)).

The World Intellectual Property Organisation (WIPO), shortly after the enactment of the SCPA, initiated studies and consultations in order to establish an international treaty on the matter, based on the *sui generis* approach. Negotiations led to the adoption, in 1989, of the Washington Treaty. The United States and Japan, however, did not sign it, due to disagreements with respect to compulsory licenses, the treatment of innocent infringement, and the protection of designs when they are incorporated in industrial products. These perceived shortcomings were expeditiously addressed a few years later. The TRIPs Agreement practically derogated the Treaty provisions that had been rejected by the two chip-powers, and added those obligations that they felt were missing.

So far, very few developing countries, such as South Korea and Taiwan, have considered legislation to specifically protect integrated circuit designs, but all WTO Member Countries are obliged to do so.

One of the main reasons for the enactment of the SCPA and of its internationalisation was the alleged copying of original chip layout designs, particularly by Japanese competitors. However, the very little litigation that took place on the basis of that regime would indicate that the copying of chip layout designs was not the main battlefield.

The main purpose of the *sui generis* regime on integrated circuits is to prevent copying of original chip designs, and the commercialisation either of the infringing chips or of the products that incorporate them. As mentioned, the *sui generis* regime does not prevent reverse engineering.

The important controversies did not relate to the layout designs, but to technical ideas underlying them that may obtain patent protection. Thus, Texas Instrument was reported to have earned (by 1994) more than US$1.5 billion in royalties from its patent portfolio. Its main source of income was a broad patent originally filed 30 years ago “covering an old-fashioned technology that has been extended by peculiarities unique to the U.S. patent system”. Intel also
has an aggressive IPRs strategy, with a litigation budget of at least US$100 million, that few companies can match. Based on its patent U.S. 4,338,675 it has attempted to bar competition not only from other major chip producers, but also from small design houses (Warshofsky 1994: 252, 256).

Action by Texas Instruments reached competitors world-wide. It sued seven Japanese companies on the same charges at the same time, which have reportedly paid an average of around US$30 million per firm. Samsung was also sued, but it paid over US$90 million. The reason of this different outcome seems to be that Japanese firms held “several patents of their own ad were able to negotiate cross-licensing agreements and thus lower the amount of royalty payments to Texas Instruments” (Mody, 1989, p. 38).

2.4 Digital Information

The current trends in IPRs may, finally, affect access to information. As mentioned above, there are attempts to extend protection to factual materials that are unprotectable under existing IPRs. Some authors (Catala 1984) argue for the application of property rights to such. Even if such theories are rejected, developments with regard to databases and information in “cyberspace” may lead to similar effects, i.e., restraining or excluding access to and use of information, even if unprotectable under IPRs.

2.4.1 Databases

Databases are protectable, under copyright, as compilations. In principle, however, only those databases that meet the copyright originality test are protectable. In other words, simple compilations of data are in the public domain.

This is what the U.S. Supreme Court decided in a case (Feist Publication Inc. v. Rural Telephone Services, III S Ct 1282, 1991) where it considered whether an alphabetical arrangement of telephone subscribers’ names and numbers was copyrightable. The Court held that information consisting solely of facts arranged in a straightforward manner do not constitute “original works of authorship” within the meaning of the Copyright Act.

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12 The SCPA was described, for that reason, as “a solution in search of a problem” (Siegel and
This decision was viewed by some authors as “endangering the vitality of our information industries. To a nation that counts information as an important asset and a principal export, the outcome is (or should be) extremely worrisome” (Dreyfuss 1993: 197).

Europe shared this concern. The European Council Directive 96/9/EC, developed a new, *sui generis*, form of protection for any database if it is shown that qualitatively and/or quantitatively a “substantial investment in either obtaining, verification, or presentation of the contents” has been made (article 7).

The EC Directive provides for an “extraction right”, i.e., the right to prevent “the extraction or re-utilisation of the whole or substantial part, evaluated quantitatively or qualitatively, of the contents of the database” (article 7).

This Directive provides a conspicuous example of the emerging paradigm of IPRs protection, wherein the main goal is not to protect creativity and ingenuity, but investments. Databases are, in effect, protected under the *sui generis* right without requiring originality in the selection or arrangement of their contents. In accordance with the European Commission, the main feature of the Directive is:

“to create a new economic right to protect the substantial investment of [compilers] by a database marker. Considering the considerable investment of human, technical and financial resources necessary to create a database, and given that those databases can be copied at a much lower cost than that of their development, such legal change is important. Unauthorised access to a database and the extraction of its contents are thus acts which can have grave technical and economic consequences” (EC Commission 1995: 32).

The Directive’s sections on the *sui generis* right define two categories of restricted acts: extraction and re-utilisation. The right applies to the whole or a substantial part of a database, which means that an insubstantial part is not protected. Protection lasts for 15 years, and that period may be renewed if there has been substantial new investment. The Directive defines exceptions to the right which are similar to those existing in the chapter on copyright, but, in view of the volume of information in such databases, the exceptions are generally limited to the right of extraction. The *sui generis* right is conferred in addition to the other existing rights.

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Laurie 1989: 14).
The Directive does not prescribe, but only authorise, Member countries to provide exceptions for the cases of extraction for “private purposes”, “teaching or scientific research”, “public security or an administration or judicial procedure” (article 9). Moreover, Member countries may limit the exception relating to teaching and research to “certain categories of teaching and scientific research institution” (Preamble, No. 52).

The “information industry” has welcomed the Directive, while questioning the U.S. Supreme Court attempt to keep information products in the public domain. The Diplomatic Conference convened by WIPO to develop a Protocol to the Berne Convention in December 1996 may, however, declare the European approach as the universal standard. One of the basic proposals to be considered by the Conference aims at establishing a treaty for the protection of non-original databases whose production entailed a “substantial investment”.13

2.4.2 The “Information Superhighway”

The digitisation of information and the development of computer networks, such as Internet, are posing a new and far-reaching challenge to copyright. The way in which this challenge is finally resolved may have important implications with regard to access to information.

The main technological change behind this “new revolution” (G-7 Ministerial Conference 1995) are improvements in data storage, manipulation, and transmission. With digitisation, all kinds of data and copyright works may be recorded and compressed in the same binary, format. While this allows one to reproduce copies without any degradation (every copy is perfect), developments in software permit us to manipulate data, images, etc., make “sampling”, and otherwise alter works by interactive techniques (Pearson 1996).

Data transmission, on the other hand, is no longer limited to a one-to-one basis, but now extends on a one-to-many or even one-to-all basis. A large computer network, such as Internet, thus becomes a “broadcasting” system. The growth of the system and the improvement of transmission techniques challenges the market position of several industries and services, including those related to voice transmission (Rowley 1995), radio broadcasting and

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13 See document WIPO CRNR/DC/6, 30.8.96.
phonograms\textsuperscript{14}, and the publishing of literary works (Heker 1995)\textsuperscript{15} as well as of computer programs.

These developments have polarised opinions on the ways in which copyright law, should react in order to protect the producers and suppliers of different forms of information.

\textbf{Adapting copyright.} On the one hand, many authors and industrial groups consider that copyright only requires minor changes in order to adapt to the new technological changes (Holleyman and Steinhardt 1995: 56), particularly with respect to the scope of exploitation rights and the extent of the “fair use” exception, as conceived under Anglo-American law (Dreier 1993: 489; Dessemontet 1996: 287). This is the position held by the U.S. government in its “White Paper on Intellectual Property and the National Information Infrastructure”.

According to that paper, “no more than minor clarification and limited amendment” of the Copyright Act is necessary (IITF 1995: 17). The proposed changes would strengthen the rights of the copyright owner, particularly by “transmission” and “publication”. The only major change that would be necessary is the introduction of a \textit{sui generis} right to supplement copyright protection for databases (Lehman 1995: 80).

Thus, the concepts of distribution, publication, and transmission would be dematerialised in order to make clear that exclusive rights can be exercised with respect to the communication of works in a digital form, and not only in the form of tangible copies.

The Diplomatic Conference to establish a possible Protocol to the Berne Convention will consider a proposal by the European Union unambiguously extending the right of communication to “any communication to the public including the making available of their works, by wire or wireless means, in such a way that members of the public may access these

\textsuperscript{14} Phonogram producers, which are generally granted an exclusive right of distribution of material copies, and only a right to remuneration with regard to sound broadcasts, call now for an “exclusive broadcasting” right (Dreier 1993).
\textsuperscript{15} Individual authors have in fact the unprecedented opportunity of becoming their own publishers and distributing their works in digital form through computer networks (Dixon and Self 1994: 466)
works from a place and a time individually chosen by them” (WIPO, BCP/CE/VII/1-INR/CE/VI/1, 20.5.96).

It should be noted that, according to some domestic legislation and case law, fixation, including “reproduction” of a work, exists when any data or programs are temporarily copies in the computer RAM (Dessemontet 1996; Dixon and Self 1994). Any unauthorised “copying” of any data or program constitutes, hence, an infringement.

This is also likely to be clarified in a Protocol to the Berne Convention. In accordance with a proposal to the European Community, “permanent or temporary storage of a protected work in any electronic medium constitutes a reproduction. This includes acts such as uploading and downloading of a work to or from the memory of a computer”.

The narrowing of the “first-sale” exhaustion doctrine has been also suggested, in order to avoid re-transmissions without the authorisation of the right holder; and there are also proposals to eliminate the “private use” exception (Holleyman and Steinhardt 1995: 65) and to consider that a “private copy” is no longer, in an electronic age, an “honest use” (Antequera Parrilli 1995: 187).

The “fair use” doctrine, it is argued, is justified when the transaction costs are too high and prevent copyright owners and users from entering into a copyright license, as in the case of library photocopying or home videotaping. But technologies exist today that enable copyright owners and users to negotiate individual licenses for electronically stored works at a low cost. This may be done, for instance, through a “Copyright Clearance Centre” that collects and administers royalties for each individual use (Goldstein 1994: 127, 223, 240).

The problem, according to the EC Commission, is that the criterion of strictly private use is becoming more fluid and difficult to apply. Digital technology could make home copying into a fully-fledged form of exploitation. A work can be reproduced systematically and any number of times without loss of quality. The danger of piracy and improper use without payment to the

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16 A work may be deemed “fixed” even if it only temporarily resides on the RAM computer linked to a network. This includes electronic transmissions such as e-mail (IITF 1995:28).

17 According to this doctrine, the rights of the title-holder with respect to a protected product are exhausted after the first sale thereof.
rightholders will increase. There may be a growing need for arrangements at a community level to remunerate rightholders, and for the progressive introduction of techniques to limit copying of this kind (EC Commission 1995: 28).

Based on its analysis, the EC Commission argues that while it was necessary to permit “private copying” when there were no means to prevent it, such copying is no longer justified since such means already exist (EC Commission 1995: 50, 52).

**Reconceptualising copyright.** On the other hand, some authors consider that copyright, created in order to respond to the problems posed by printing, and adapted later to audio-visual works, needs to be reconceptualised in the digital era. The copyright subject-matter has evolved over time from symbolic representations of sensual matter to the sensual matter itself, and from works passively received by the audience to works which interactively engage the audience. (Christie 1995: 523)

According to some views, the “right to prevent copying” (as conferred under copyright) should be replaced by a “right to prevent access” to a work (Olswang 1995). This, of course, would imply the power to prevent use, in open contradiction with the still-in-force basic idea/expression dichotomy. Exclusive rights granted by copyright, which are becoming “outdated and irrelevant”, could be also replaced by mere rights to obtain a remuneration (Ricketson 1995: 898).

Others more drastically question the need for property rights at all, since on-line access to subject-matter may be allowed only to those who agree to pay for it and comply with various restrictions regarding use of it. Payment for access could be guaranteed by way of automatic, on-line, debiting of a credit card account or a bank deposit account. Developments in the technology should make it possible to “lock” the digital data constituting the subject-matter to which access is allowed, so as to prevent authorised use of it. In addition, it should be possible to detect and trace any subsequent unauthorised uses of the access subject-matter, and to automatically debit an account by way of a contractually agreed right to compensation for the unauthorised use (Christie 1995: 526).
3. IMPLICATIONS FOR DEVELOPING COUNTRIES

3.1 Access, Acquisition, and Use

The implications of the technological and legal trends described above on developing countries are felt in a multiplicity of areas and forms. They may affect both innovation and diffusion of ITs by potential users.

Diffusion of ITs is dependent upon three main conditions:

- **The access that potential users may have to certain hardware, software, and digital information.** Access may be limited by the lack of information on available options, commercial and governmental practices (e.g., restrictions on exports of technology due to security reasons), and legal impediments, such as those eventually stemming from IPRs.

- **The acquisition of the necessary hardware/software.** The acquisition of ITs is influenced by a number of factors, both internal and external. Internal factors refer to “who you are”, “what you have done” in the past, and “what you want to be” (e.g., a firm’s characteristics, past experience, and pursued strategies), while external factors refer to conditions which exist in the external environment and which may affect the adoption of decisions on technology acquisition and use (Lefebvre and Lefebvre 1995: 37, 39).

Table 2 summarises different external factors that may influence adoption of ITs by firms. IPRs are one of the multiple factors that, as a part of “national policies”, may affect adoption of ITs. The relative weight of IPRs vis-à-vis other relevant factors is unknown, though by its very nature (the fact that it confers the right to exclude competitors) may in some cases have definite and strong influence on adoption.

- **The development of the capacity to efficiently use ITs.** The efficient use of ITs is dependent, on the one hand, on general education, and particularly on the way in which it influences “readiness” or willingness” to use ITs and to obtain access to digitised information 18.

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18 Based on the conclusions of Working Group 1, Information Technology (I.T.) and Development, United Nations Commission on Science and Technology for Development (UNCSTD), Cartagena, January 30 - February 2, 1996.
3.2 Impact of IPRs

The impact of IPRs on the access, acquisition, and use of ITs has not been systematically explored so far. Examining the impact of IPRs on access, acquisition, and use of ITs (and digital information) in developing countries is a difficult theoretical and empirical endeavour.

First, as mentioned above, it is extremely difficult to isolate the impact of legal factors from other social and economic considerations. There is no solid theoretical corpus to deal, in particular, with the impact of IPRs.

Second, ITs and the legal framework of IPRs are rapidly changing, and their likely impact in many areas is still uncertain.

Table 3 External Factors in the Adoption of ITs

<table>
<thead>
<tr>
<th>Industry Characteristics</th>
<th>Macroeconomic Environment</th>
<th>National Policies</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Overall competition</em></td>
<td>*availability of capital</td>
<td><em>trade policies</em></td>
</tr>
<tr>
<td>-type of competitors</td>
<td>*availability of qualified</td>
<td><em>IPRs policies</em></td>
</tr>
<tr>
<td>-number of competitors</td>
<td>manpower</td>
<td><em>industry regulation</em></td>
</tr>
<tr>
<td>-proximity of competitors</td>
<td></td>
<td><em>government buying practices</em></td>
</tr>
<tr>
<td><em>Characteristics of demand</em></td>
<td><em>quality of industrial relations</em></td>
<td><em>technology adoption tax credits</em></td>
</tr>
<tr>
<td>-type of customers</td>
<td><em>inflation</em></td>
<td><em>manpower training policies and programs</em></td>
</tr>
<tr>
<td>-number of customers</td>
<td><em>business cycle</em></td>
<td></td>
</tr>
<tr>
<td>-sophistication of demand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-requirements imposed by</td>
<td></td>
<td></td>
</tr>
<tr>
<td>major customers</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Degree of diffusion of technologies</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-by technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-by type of competitor</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Availability of external know-how</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-agencies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-institutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>suppliers/vendors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-trade associations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: adapted from (Lefebvre and Lefebvre 1995).
Third, major differences exist in the level of current diffusion and use of ITs among developing countries, in their capabilities to incorporate ITs, and in the level of protection of IPRs.\textsuperscript{19}

Fourth, there is little empirical evidence on the conditions that affect the adoption of ITs in developing countries, and even less on IPRs-related factors.

Despite these limitations but without ignoring them the next section describes some of the possible implications of IPRs on IT adoption and use in developing countries.

3.3 Software

3.3.1 Production
Developing countries have a marginal role in the production of computer software. The capacity to produce packaged software is one of the most important indicators on the degree of development of the software industry in a particular country. Table 3 indicates world distribution of packaged software production, consumption, and trade.

<table>
<thead>
<tr>
<th></th>
<th>Production</th>
<th>%</th>
<th>Exports</th>
<th>%</th>
<th>Imports</th>
<th>%</th>
<th>Consumption</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>39.98</td>
<td>78.3</td>
<td>20.04</td>
<td>93.1</td>
<td>0.61</td>
<td>2.8</td>
<td>20.54</td>
<td>40.2</td>
</tr>
<tr>
<td>Europe</td>
<td>8.24</td>
<td>16.1</td>
<td>0.86</td>
<td>4.0</td>
<td>13.77</td>
<td>28.4</td>
<td>21.16</td>
<td>41.5</td>
</tr>
<tr>
<td>Japan</td>
<td>2.21</td>
<td>4.3</td>
<td>0.12</td>
<td>0.6</td>
<td>3.32</td>
<td>15.4</td>
<td>5.41</td>
<td>10.6</td>
</tr>
<tr>
<td>Rest of World</td>
<td>0.62</td>
<td>1.2</td>
<td>0.49</td>
<td>2.3</td>
<td>3.81</td>
<td>17.7</td>
<td>3.94</td>
<td>7.7</td>
</tr>
</tbody>
</table>

Source: (Göransson 1994).

Table 3 shows that despite the progress made by some countries, such as India,\textsuperscript{20} developing countries (as part of the “Rest of World”) account for little more than 1% of total software production.

\textsuperscript{19}This will become more harmonized once the transitional periods provided for by the TRIPs Agreement have expired, provided that the necessary changes to comply with said Agreement have been made at the national level.

\textsuperscript{20}A significant proportion of Indian software exports is, however, only “body shopping”; see (Correa 1996).
**Impact of patents.** Patents confer stronger rights than copyrights. They permit holders to obtain monopoly rents by excluding competitors, totally or partially. If software patents are granted, several effects may be expected.

First, a patented program cannot be used as a basis for further development without the authorisation of the patent holder. This may block a whole area of possible innovation. Unlike chemical patents, it may be difficult in some cases to “invent around” software patents, since mathematical rules are logical and precise, and in some cases there may be no alternative way for obtaining the same effect.

Second, if a license is sought for and obtained on a piece of software, royalties may be too high particularly for a small firm to ensure the feasibility of the project. Access, hence, will be problematic.

Third, even if patents may be “by-passed” and new technical solutions found, serious problems still remain. It may be impossible to design a program that at a certain point will not infringe an existing patent. Patent searches to establish whether patents would be infringed are extremely costly and difficult to make. What is even worse, a patent search does not guarantee that a patent would not be infringed; if this is the case, litigation costs may force a small firm out of business (Warshofsky 1994: 168).

As a result, intimidated firms may opt for cancelling development projects. In a paper attributed to Bill Gates that highlights the monopolistic power conferred by patents in this area, it is stated that

*While this approach will allow companies like Microsoft, Apple, and IBM to continue in business, it will shut new companies out of the field. A future start-up with no patents of its own will be forced to pay whatever price the giants choose to impose. That price might be high: established companies have an interest in excluding future competitors* (quoted in Warshofsky 1994: 171).

It should be noted that the patenting of software is not an obligation under the TRIPs Agreement. The Agreement does not include a definition of “invention”; therefore, any Member country may consider that computer programs as such are not patentable. This would not
prevent, however, the granting of software-related patents, for instance, for hardware systems that are operated by an inventive software.

**Impact of copyright.** Trends relating to copyright may have a significant impact on the production of software, including multimedia products, in developing countries. The impact on production will be dependent on the modalities of protection, particularly on the degree to which the idea/expression dichotomy is recognised and enforced, and the extent to which “look and feel” is deemed proprietary by domestic law.

The existence of protection against literal copying of software as required by the TRIPs Agreement clearly benefits all interested in the marketing of computer programs, whether local or foreign producers. However, the main beneficiaries are those that sell packaged software, since illegal reproduction of custom software may be prevented, even more efficiently, by means of contractual stipulations. Developing countries have made, as indicated above, little progress in the production of packaged software so far.

If legitimate reverse engineering is limited, potential producers will have to pay royalties for the use of existing programs, or remain outside the market. Allowing for reverse engineering will not, however, solve all problems. As mentioned above, it doesn’t work with large programs. In addition, decompilation and disassembly are complex, time-consuming, and laborious tasks. The process requires considerable skills, and while executing it the programmers must supply information not available in the computer-executable program. If the purpose of the process is to obtain a “clone” program, once the programmer has completed the analysis and determined the detailed specifications, he has to initiate the software engineering development in order to transform the specifications into new source code (Correa 1993).

For these reasons, decompilation and disassembly are not used routinely. The Office of Technology Assessment did not find evidence indicating that decompilation is widely used by “pirates” to decompile entire programs and then rearrange the code in an attempt to hide copying (OTA 1992: 148).

On the other hand, access to user interfaces (“look and feel”), though also requiring skills and effort, makes possible the development of competitive products. It is extremely difficult for software start-ups to compete with companies selling established products if access to such
interfaces is restricted. Users are not interested in new products for which they must learn a new set of commands.

There are no internationally accepted rules on the extent of protection of user interfaces. Even in the United States, despite the decision in Lotus v. Paperback (which recognised protection on menu command structures), other cases have been solved in a more cautious and restrictive way.

In the case of multimedia products, the re-use of existing copyrighted materials from numerous right-holders may pose great burdens and high transaction costs. The viability of a multimedia industry may be dependent upon a system of royalty collection, based on a remuneration right or compulsory licenses.

Compulsory licenses allow the use of a protected work without the consent of the title-holder. They are common in patent as well as in copyright law. In the United States, for instance, once a song is recorded with the author’s consent, anyone can record his/her own version, just by paying a fixed royalty (6.25 cents) (Goldstein 1994: 20). The Appendix to the Berne Convention (1971) provides for compulsory licenses for developing countries, which so far have been only rarely used.

As indicated above, the TRIPs Agreement does incorporate the idea/expression dichotomy (article 9.2). National legislation can, therefore, legitimately provide for reverse engineering of computer programs, to develop either interoperable or substitute programs. It may also deny protection to input and output formats (user interfaces). Compulsory licenses may be implemented under said Agreement, in accordance with the Appendix to the Berne Convention (1971).

Developing countries may, however, be under pressure not to recognise the right to evaluate and reverse-engineer. In South Korea, though an explicit “fair use” exception in this regard was considered during the process of revision of the Computer Program Protection Act, the finally approved reform eliminated such an exception (World Intellectual Property Report (1995), 9, 349).
3.3.2 Use

Strict enforcement of IPRs may negatively affect the diffusion of computer programs. If, as generally assumed, such a diffusion may foster increases in productivity and enhance firms’ competitiveness, barriers to diffusion may in turn jeopardise economic performance.

Liberal copying would arguably reduce the cost of access to software. In the last analysis, one observer suggests that for a country which is not an innovator, it may be convenient, from an economic perspective, to facilitate the obtaining of copies at low cost to stimulate a rapid software diffusion and save foreign currency (Wells 1987).

However, the advantages of unrestricted dissemination of non-authorised copies may be offset by some disadvantages (Correa 1990c). First, the lack of appropriate maintenance and after-sales support may hamper an efficient use of computer programs. Second, weak copyright protection may slow the diffusion of certain types of high-quality or complex software. Third, all WTO Member countries will be obliged (by 2000 in the case of developing countries) to provide protection of computer programs as “literary works”, in accordance to the TRIPs Agreement. Non-complying countries may be subject to trade retaliations.

On the other hand, the effect of unlimited or widespread copying on society’s economic welfare is ambiguous. It depends upon a number of factors, including relative costs (of producing a copy versus another “original”), the degree to which copying affects the demand for originals, the production of new works, and the degree to which consumers value additional variety. Thus, copying may increase consumer welfare and producer profits in the short run if private copying is efficient and the price of originals can be raised (OTA 1992: 200).

Increases in prices may be required by producers in order to recover, from paying users, income loss caused by copying. Suppliers may deliberately discriminate prices in accordance with income levels of different countries or user groups, charging some of them prices higher than the marginal cost (Gates 1995: 266).

Copying may, however, cause producers to reduce prices in order to encourage the acquisition of legal copies. It may also reduce the number of originals produced and thereby “excessive” variety. This can increase welfare in the long run (OTA 1992: 200).
3.4 Hardware

The impact of current IPRs trends on access to technology for the production of hardware in developing countries, may also be significant. The Washington Treaty, as supplemented by the TRIPs Agreement, may have significant implications for new potential entrants and for the diffusion of microelectronics technology on a world scale.

The highly concentrated structure of the industry and the growing reluctance of major firms to transfer their technology suggest that access to semiconductor technology is and will continue to be extremely difficult. Protection is not likely to favour either innovation or technology transfer to developing countries, but rather to reinforce the tendency of innovative firms not to part with their technology (Correa 1990b).

Developing countries and, in particular, NICs are likely to be the most affected by the new regulations. Such countries are basically importers of integrated circuits and of informatics products. They will be at a great disadvantage to determine whether chips imported or incorporated into imported products are infringing or not, especially if as determined by the TRIPs Agreement custom authorities are empowered to adopt measures at the border.

Title-holders are authorised, under the TRIPs Agreement, to stop the importation of industrial articles if they include an infringing chip (independent of its relevance both in terms of cost and function in the product). Trade flows may thus be significantly distorted. In addition, even an innocent infringer can be obliged to pay a compensation to the design title-holder, or be forced to stop production or distribution.

Though the \textit{sui generis} regime on integrated circuit designs allows reverse engineering of protected layout designs, very few countries have the resources and skills necessary to undertake it. The process is extremely complex and costly, and even if successfully undertaken, the production and marketing of chips presents, as mentioned, formidable entry barriers.

In addition, patent protection in this area is very extensive. It is covered by literally thousands of patents, and it is not possible, therefore, to license technology from a single firm. Moreover, a
few large firms control substantial blocks of patents, and hence exercise considerable power over the terms on which technology is available (Mody 1989: 38)

The impact of IPRs, finally, may also extend from software to hardware. While PC producers were able to develop quite successfully indeed IBM “clones” on the basis of reverse engineering the PC’s “BIOS” (Basic Input-Output-System), attempts have been made to foreclose that possibility. Thus, IBM increased royalty rates (from 1% to 5%) on IBM’s AT machines, demanded retroactive payments, and tried to prevent cloning of its PS/2 series of microcomputers by restricting access to the micro channel architecture (Mody 1989: 36).

3.5 Information

Developments with respect to the protection of databases under a *sui generis* right against “extraction” will extend coverage of the appropriation of information well beyond the limits of copyright law. The impact of this expansion is difficult to predict. As mentioned before, it may become an international rule if approved by the Diplomatic Conference on a Protocol to the Berne Convention.

Like other IT industries, the “information industry” is largely controlled by firms in industrialised countries. Some developing countries have provided low-cost labour to “input” data, but they generally lack the organisation and resources to distribute databases. On the other side, technological advances with CD-ROMs, which permit the distribution of copies of databases, is changing the “on-line” model of supply by a mix of digital and material carriers. A paradoxical implication of the new technological developments is that while they facilitate “almost unfettered access to protected works” (Dreier 1993: 488) and the easy, rapid, and inexpensive making of “perfect” copies, it also offers the technical means to control and manage such access.

Thus, devices can be implemented to allow access but not the copying of a work (Quintanilla Madero 1995: 43). Transmission is made by “pieces” and it is possible to prevent the full

---

21 According to Texas Instruments, for instance, “it is pretty impossible to make DRAM chips without using one of our patents” (Financial Times, 23 November 1988, 26; quoted by Mody 1989: 39).

22 Which is protected by copyright, and hence, susceptible of being legally accessed and reverse engineered.
recomposition of the work. Already CD-ROMs can be encrypted, and many encryption and license management technologies are under development or in use to prevent copying. For instance, within the EC ESPRIT II Program, a system of this type (see Box 4) was developed.

Databases and other suppliers of digitised information have established terms and conditions for the transfer of information that restrict both access and use of data. They condition access upon the payment of different fees (subscription, search-time, down-loading, etc.) and are able to control and charge for each and every access and use by the user of electronically processed information (who must log in and out). This control nullifies in practice the users’ right normally granted under copyright to make copies for personal uses or for research purposes \(^{23}\) (Reichman 1993).

**Box 4**

**Copyright in Transmitted Electronic Documents (CITED)**

The model that the pan-European team has come up with is built around a tamper-proof software module which acts rather like indestructible tachometers installed on long-distance coaches and lorries, recording everything that happens to the copyrighted or commercially valuable material. The basic idea is that the valuable material is linked to a specific piece of software. This software is required to gain access to the material, and it can only be converted into its usable form by someone in possession of the right key or password.

Thus, when the authorised user requests a piece of software or some pages of a report or journal, he or she will have to key in a password. From then on, each time a program is run or a print of a page is made, the associated software module sends a message back to the secure database stored on the computer. The database can then track every activity carried out by the organisation’s software modules, thus providing an audit trail which shows whether materials are being printed or copied electronically. Eventually, it may possible to forward this information to rights societies to help them determine how much artists, authors, and publishers should be paid.


Many institutional users of digital information (such as libraries) have already complained about the difficulty of managing and complying with the variety of contract terms required by their large collections of data and software packages. Moreover, “because of uncertainties about users rights to download or make copies of information, providers of digital information rely on contract to limit customers’ uses of information and do not sell information to customers, but

\(^{23}\) Other restrictions include, for instance, “one-at-a-time” use requirements that forbid networking by multiple users.

Libraries, as document suppliers, are regarded as direct competitors of database providers and other commercial services. Libraries can not only receive and store information, but repackage and electronically distribute it to an indefinite number of users.

Technical and legal developments, if combined, may result in growing barriers to the access to all types of information, which will be increasingly channelled through digital networks. Such barriers are likely to affect not only technology, but also general factual information, as well as scientific knowledge. This may consolidate existing trends not to openly diffuse the results of scientific research (Correa 1994b), thereby restricting access to the pool of science by developing countries.

24 In some cases, data providers require librarians to waive contractually the privileges that copyright law otherwise afford (Reichman, 1993).
4. CONCLUSIONS

The following main conclusions may be drawn from the study made:

- Important changes in the paradigm of IPRs regulation are taking place. The emphasis has shifted from the protection of the author/inventor to that of the investor, as epitomised by the recent EC Directive on databases. Moreover, new proposals are on the table to further expand appropriation so as to cover factual materials as such, i.e., non-copyrightable information.

- A process of universalisation of IPRs standards of protection, has been fostered by the Uruguay Round. The TRIPs Agreement has clarified and reinforced IPRs protection in three key IT areas: computer programs, databases, and layout designs of integrated circuits. The Agreement leaves, however, certain room to implement its standards in accordance with national legal systems and interests.

- The characteristics of software technology explain the key role played by IPRs in this field. Computer programs may be developed on the basis of knowledge in the public domain, and hence challenges to established firms may arise, in principle, at any place and time. Though market barriers are sufficiently high to reduce that opportunity for newcomers, major software producers have actively sought for expanding and increasing protection. The easy and inexpensive production of “pirate” copies is another reason behind that interest in IPRs.

- Trends with respect to the protection of computer programs show hesitation, conflict, and the inadequacies of copyright law to protect functional works. Despite some case law that extended copyright protection well beyond expression, the idea/expression dichotomy explicitly incorporated by the TRIPs Agreement limits the extent of exclusive rights and allows for (legitimate) reverse engineering. Countries are also free to decide about the scope and extent of protection of user interfaces.

- Given the essentially incremental nature of innovation in software, access to existing programs is crucial to keep a healthy environment for innovation and competition. Access to underlying ideas and concepts may be seriously restricted, however, by the patenting of computer programs. Patenting may lead to complete exclusion from certain market segments, and threatens eventual competitors with costly litigation that may discourage firms or force them out of business.
• Current trends on IPRs relating to computer programs may impose even harder conditions for the development of a software industry in developing countries. This will depend, however, on the way in which such countries frame their domestic laws while abiding by the TRIPs Agreement. It should be noted, in particular, that there is no obligation under existing international standards to confer patent protection on computer software.

• Barriers to participation in the semiconductor industry are very high. The *sui generis* protection of the layout design of integrated circuits does not add too much to the fortress that the few chips producers have been able to build up. Unlike the case of computer programs, such producers can survive and make progress (as happened in the past) without such a protection. Patents on key semiconductor technologies permit the erection of even higher barriers for potential new entrants.

• Strict enforcement of anti-piracy laws in the software area may lead to high prices and limit access by individuals and small firms. Such enforcement, however, is an unavoidable feature of current IPRs regime. While in developing countries it mainly benefits (foreign) producers of packaged software, it can also help local industry to avoid illegal duplication and unfair competition. It may also open opportunities in some instances to develop programs less expensive and better adapted to local conditions than imported packages.

• Finally, with the development of computer networks and the possibility of providing a digital format to any piece of information, a major challenge has arisen. Technological and legal changes (such as the elimination of the exception for private copying or “fair use”) may dramatically increase barriers for the access to and use of information of any kind, copyrightable or not. While cyberspace is opening up enormous possibilities for low-cost communication on a world scale, legal developments may close the prospects of an information society with equality of opportunities and free circulation of ideas and information.
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Making Women's Voices Heard: Technological Change and Women's Employment with Special Reference to Malaysia

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International Workshop on
The Information Revolution and Economic
and Social Exclusion in Developing Countries
Maastricht, 23-25 October 1996

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Editor's Note

With pleasure we present to our readers the special series of UNU/INTECH Discussion Papers: Information Revolution and Policy Implications for Developing Countries. Papers of the Series were originally developed for the International Workshop on The Information Revolution and Economic and Social Exclusion in Developing Countries, held in Maastricht on 23-25 October 1996. The Workshop was an important event organized by UNU/INTECH and financed by the Dutch Government. Insights developed from the Workshop have not only been benefiting UNU/INTECH research work, but also contributing to many other initiatives in the area of innovation policy for information technology in developing countries.

There are six papers in the special series. The first five papers have been widely circulated and are provided here in the latest modified versions. These are outcomes from the two major themes set for the Workshop: ‘The Developments of Access and Effective Use of Information Technology and Exclusion’, and ‘The Gender Dimension in Exclusion’. The sixth paper, by Ludovico Alcorta, is a summary of the three country cases on Burkina Faso, South Africa and Tanzania organized for the Workshop.


#2002-2* Constantine Vaitsos, “Policy Agenda for the Information Revolution and Exclusion Phenomena in Developing Countries”


#2002-4* Carlos M. Correa, “Implications of Intellectual Property Rights for the Access to and Use of Information Technologies in Developing Countries

#2002-5* Cecilia Ng Choon Sim, “Making Women’s Voices Heard: Technological Change and Women’s Employment with Special Reference to Malaysia”

#2002-6* Ludovico Alcorta, “The Information Revolution and Economic and Social Exclusion: The Experiences of Burkina Faso, South Africa and Tanzania”

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1. THE PROJECT

In 1994 the United Nations University Institute for New Technologies (UNU/INTECH) launched a major research project on technological change and women's employment in eight countries in Asia. But this was no ordinary academic research involving scholars undertaking studies in their respective fields of expertise. Indeed this was a project with a deliberate difference. From the very beginning it was meant to be innovative, participatory and exploratory, particularly from the perspective of the millions of women workers (and the organisations which represent them) who would be affected by the rapid spread of technology in their work and lives. In addition the project also wanted to elicit the responses of policy makers whose policies would have widespread implications on female employment in the region.

However one of the stumbling blocks was that these two groups, for the most part, seldom met to discuss, nor did many see eye to eye with each other. To a large extent it was felt that technology was not an important factor to be debated since developing countries heartily welcomed it as THE panacea to poverty and underdevelopment, while many non-governmental organisations perceived technology to be a threat i.e. taking jobs and incomes away from people. Yet the fact remains that the pervasive use of new technologies today is having a profound impact on the process and organisation of production, transforming the role of women in the industrial as well as the service sectors. Nonetheless there is little empirical work done to conclude whether technology liberates or oppresses society.

The impact of new technologies on the quality and quantity of women's work is a complex issue. Automation and robotic technologies have replaced women's work in labour-intensive, assembly-line work. Yet information technology has also created new types of employment for women, particularly in the services sector. New technologies have also led to the decentralisation and externalisation of work. While this implicit flexibility in working hours could be welcomed by women, it could also cause potential health hazards, if left unchecked.

It is against this background that the INTECH project was formulated - to ensure that women who bear the consequences of technological and industrial policies should have an adequate voice concerning their formulation, implementation and evaluation. With the objective of improving the advocacy skills of women workers' organisations by providing them access to
key knowledge on new technologies and work, the project strove to initiate a dialogue between their representatives and relevant policy-makers so that women workers would benefit as a result of technological change. In this way it was hoped that women would not be excluded by the process of technological advances.

This paper examines the above project and draws on the learning experiences of Malaysia - one of the country partners - representing the newly industrialising countries (NIC). It will look at the mode of research and interaction, briefly summarise the major findings from the NGO case studies, and discuss at length the Malaysian experience.
2. THE PROCESS

A series of key interactive activities marked the different stages of the two and a half year project. Initially the project team visited the various countries which were chosen to reflect the wide variety in the Asian region in terms of size, state of industrialisation and market orientation. Several women workers' organisations, trade unions, research bodies and relevant government agencies were consulted regarding their participation in the project. Finally the project team obtained the cooperation of 26 and 18 key non-governmental organisations (NGOs) and policy bodies respectively to be partners in this project.

In September 1994 the first workshop was held in Kuala Lumpur bringing together the 26 representatives from women workers' organisations, trade unions and research bodies to initiate a process of developing strategies to ensure that women are positively rather than negatively affected by technological change. Since knowledge is an important component in formulating strategies, the NGOs embarked on their own case studies in the industrial and services sectors where large numbers of women were being employed. In the following year these same representatives met at the national level to share their findings with other groups, formulate relevant policy recommendations and work out negotiating strategies to voice their concerns to their respective governments.

In the meantime in March 1995, the second workshop was held with senior policy makers who shared information about existing industrial and technological policies in their respective countries. The INTECH project team also shared the concerns and recommendations from the Kuala Lumpur workshop and possible policy changes were discussed in the light of the problems faced by women workers.

Finally in March 1996, the NGO representatives and policy makers met in Bangkok whereby they went through a process of dialogue and negotiation - the NGOs presenting their country proposals and the policy makers responding to their concerns. In most cases, dialogue was constructive and plans were made to continue this collaboration both at the regional and country level. As a result of these intense discussions, NGOS and policy-makers felt a need to have a certain level of cooperation particularly in the present context of globalisation and liberalisation where the private sector was playing an ever more important role in the world economy. Both
parties felt that new regulatory mechanisms needed to be formulated to protect employees under the changing global scenario.

To a large extent this collaboration was necessitated by the findings of the NGOs which contributed critical knowledge to what was happening on the ground - information needed by policy makers who wished to formulate policies to protect women workers affected by technological change. Promises of productivity increase, a better quality and democratisation of work and life as a consequence of the introduction of new technologies are not without their pitfalls. However different countries experienced different problems depending on their level of economic restructuring and development, the nature of the technological process, the negotiating power of their workers as well as the ability of governments to initiate policies beneficial to women workers.

Based on their case studies, the NGOs were concerned that the information revolution would threaten less developed, poorer countries which cannot leap-frog - thus widening the gap between the "haves" and have-nots". Poorer nations which are completely left out of the Internet map for example, will be left further behind due to unfair competitive positions and inequitable access capabilities. Moreover two types of groups will appear - a minority which will secure employment with good career paths and the majority, including women, who will be socially excluded from this process and thrown into increasingly casualised employment.

Another important finding was that the new technologies accompanying globalisation are reorganising production processes all over the world with wide-ranging employment implications. Globalisation also means the increasing control of MNCs of production and markets, increasingly dependent on innovations in computerisation and telecommunications (telematics). The growth of new services markets propelled by globalisation and IT include banking, construction, accounting, advertising, management, data processing, software production and insurance. Telework and teletrade point out to future directions in the changing pattern of employment, both nationally and internationally.

The descent of new technologies is also effecting profound changes in women's work. The case studies confirm the insights provided by Mitter (Ng and Kwa, 1995:67), in that employment is being transformed in three major ways:
1. By altering the process of production in manufacturing and service industries through:
   * automation;
   * de-skilling of workers;
   * augmenting the skills requirements of key jobs;

2. By introducing "new" products or services in the market, such as electronics, computer peripherals or information processing work; and

3. By shifting production - that often uses 'old' technologies to locations that are distant from the main sites of commercial units or to home-based workers.

The shift to a more knowledge-based production has not impacted uniformly on women nor on men. Some have gained while others have lost. New jobs have been created for women but others face vulnerable forms of employment. Women have found employment especially in the growing services sectors (e.g. Vietnam and Malaysia) and have even developed hi-tech homeworking as in the case of Korean professionals in the publishing industry. At the same time thousands of Korean women have been retrenched as a result of automation and downsizing in the light industrial sector. Many of these are older women who do not have the skills to enter the new technology multi-skilled jobs. There is also a trend towards production decentralisation, subcontracting and the development of small scale industry, where flexible work is the rule rather than the exception as in the South Asian examples.

Thus the fears of women workers are real; these include technological redundancies, flexibility and the casualisation of labour, concentration of women in low-skilled jobs and in the small and unorganised sector as well as the health and safety hazards associated with new technology, such as computerization. Where before women workers had protection in the socialist countries, the opening up of the market to foreign capital has led to a loss of these rights and increased health hazards. Yet if there were sufficient mechanisms, some of these rights could be maintained (e.g. China).
3. MALAYSIA'S LEARNING EXPERIENCE

**Industrialisation and Technological Change in Malaysia**

Suffice to say that Malaysia's economic development over the past decade has posted growth rates which is the envy of most industrialised economies. Today Malaysia is the nineteenth largest trading nation and is ranked seventeenth in competitiveness in the world (Mohamed Jawhar, 1994). The present buoyant economy is based on a liberal industrialisation policy which aims to fully integrate the country into the global economy. The fact that Malaysia is the third largest recipient of FDI (foreign direct investment) flows in Asia, after China and Singapore has ensured rapid economic growth second to none in the region. To quote the Sixth Malaysia Plan,

- "This new approach to industrialisation will emphasise the development of export-oriented, high-value added, high technology industries...the objective of the industrial policy is to move towards capital-intensive and technologically sophisticated industries producing better quality and competitive products that are integrated with the markets of the developed countries...and in the long run, industrial development will emphasise greater automation and other labour-saving production processes to reduce labour utilisation" (6MP, 1991-1995, pp. 137-139).

Nonetheless, despite impressive growth performances in manufactured exports, several weaknesses remain. These include a very high concentration and hence reliance on a few products in the export market, the domination by multinational corporations (MNCs) of these exports, particularly of electrical and electronic goods and the low local content of these exports. In addition there is little R&D undertaken by both local and foreign firms and in terms of marketing, it was found that Malaysian exporters depended on parent companies or foreign buyers for their products. Technological transfer from the developed countries to Malaysia has also been found wanting (UNDP, 1994).iv

Notwithstanding these weaknesses, industrial policies have had a significant impact on the employment and educational opportunities of Malaysian women. The labour force participation rate for women increased to 47 percent in 1993; and although the majority of women are still at
the bottom of the occupational hierarchy, the composition of the female labour force is changing. Women are increasingly entering the urban economy as production and white-collar workers in the manufacturing, sales and services sectors.

With the increased educational levels of younger women, there is a distinct shift of more women entering white collar employment. The labour force participation rate of women in the 20-24 age group was 62 percent in 1993 while those with college and university education was 72 percent (Nagaraj, 1995; Jamilah, 1994). This trend reflects the expanding opportunities for female graduates in the expanding information technology (IT) related sectors of banking, insurance and telecommunications (Ng and Yong, 1995).

However these new technology jobs have also become differentiated between 'high-skilled' and 'low-skilled' work, that is between computer analysts and the like in the professional and technical category and the data processing workers on the other end of the technology spectrum. The majority of computer-related jobs, which are predominantly held by women, are still in the direct and indirect low-skilled categories.

The entry of women into new technology jobs has been facilitated by the educational system. Indeed, academic programmes offered by tertiary institutions in the area of computing, information technology and related fields have grown largely because of national policies which have encouraged their development. It has been an encouraging sign that women have shown great interest and inclination in this new field of information technology - much more compared to women in western countries.

For the 1990-1991 academic year, women comprised 51.4 percent of total enrolment in the IT field in the seven local universities. The latest count (1993-1995) at Universiti Teknologi Malaysia disclosed that females comprised 42.3 percent of total enrolment in the Computer Science and Information System programme (Maimunah, 1995). The entry of females into tertiary high technology studies has also been greatly helped by the establishment of the Computers in Education Programme which aimed to create computer literacy in schools. It was found that half of the members in these computer clubs were girls.

The following case studies conducted by the Malaysian NGO partners and the author in the services (telecommunications) and manufacturing (electronics) sector provide a deeper insight of the workings of technological change on women's employment at the firm level.
4. MALCOM - A TELECOMMUNICATIONS COMPANY

The telecommunications company (MALCOM) was in a state of transformation during the period of research in mid-1995. Since the beginning of the year a major organisational restructuring has been taking place. As stated in the 1994 Annual Report (p. 23),

- "The National Telecommunications Policy announced in May 1994 and, combined with the deeper liberalisation of the market called for new initiatives on our part. We saw the need for a fundamental review of our strategies and organisational competence to engage in competition... and to take charge of the future".

Employment Status

As of December 1994 there were 29,011 employees at MALCOM compared to 28,011 at the end of 1990, and 30,186 a year ago. Females form 26 percent of total staff, the majority of them being telephonists and clerical workers. In terms of ethnicity Malays dominate in all job categories (74 percent). Eighty percent of the employees are less than 40 years old reflecting the recruitment of younger workers, particularly at the executive level, as older workers at the manual category retire off without being replaced.

There has been a decrease in total staff of nearly 1,000 employees despite the rapid expansion of its services, network and customer base. Labour productivity on the other hand has grown as lines per employee increased from 15.6 in 1980 to 40.0 in 1987 and to 97.0 at the end of 1994. As noted by the Executive Director in 1991 "the most remarkable thing about the organisation is how it has been able to achieve and manage growth without practically any increase in the number of employees". Apparently, the company in current corporate mould, is over-staffed. However no staff can be retrenched as this was the agreement with the union before privatisation could take place.
Table 1: Employment Distribution by Industry and Sex, 1990 and 1995 (%)

<table>
<thead>
<tr>
<th>Industry</th>
<th>1990</th>
<th>1995</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Agriculture, Forestry, Livestock &amp; Fishing</td>
<td>65.6</td>
<td>34.4</td>
</tr>
<tr>
<td>Mining and Quarrying</td>
<td>87.1</td>
<td>12.9</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>53.6</td>
<td>46.4</td>
</tr>
<tr>
<td>Construction</td>
<td>93.1</td>
<td>6.9</td>
</tr>
<tr>
<td>Electricity, Gas and Water</td>
<td>95.7</td>
<td>4.3</td>
</tr>
<tr>
<td>Transport, Storage and Communications</td>
<td>61.4</td>
<td>38.6</td>
</tr>
<tr>
<td>Wholesale &amp; Retail Trade, Hotel &amp; Restaurants</td>
<td>88.9</td>
<td>11.1</td>
</tr>
<tr>
<td>Finance, Insurance, Real Estate &amp; Business Services</td>
<td>65.8</td>
<td>34.2</td>
</tr>
<tr>
<td>Other Services*</td>
<td>62.1</td>
<td>37.9</td>
</tr>
<tr>
<td>Social &amp; Related Community Services</td>
<td>47.2</td>
<td>52.8</td>
</tr>
<tr>
<td>Personal and Household Services</td>
<td>47.0</td>
<td>53.0</td>
</tr>
<tr>
<td>Public Administration</td>
<td>81.5</td>
<td>18.5</td>
</tr>
<tr>
<td>Total</td>
<td>68.6</td>
<td>31.4</td>
</tr>
</tbody>
</table>

*This category comprises six sub-categories and only three major sub-categories are shown.

**Source:** Seventh Malaysia Plan 1996-2000 (1996), Kuala Lumpur, Government Printers, p. 623: Table 20-1

Table 2: Employment Distribution by Occupation and Sex, 1990 and 1995

<table>
<thead>
<tr>
<th>Industry</th>
<th>1990</th>
<th>1995</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Professional, Technical &amp; Related Workers</td>
<td>6.4</td>
<td>9.4</td>
</tr>
<tr>
<td>Administrative and Managerial Workers</td>
<td>2.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Clerical and Related Workers</td>
<td>7.0</td>
<td>14.1</td>
</tr>
<tr>
<td>Sales and Related Workers</td>
<td>11.4</td>
<td>11.4</td>
</tr>
<tr>
<td>Service Workers</td>
<td>9.9</td>
<td>14.1</td>
</tr>
<tr>
<td>Agriculture Workers</td>
<td>29.4</td>
<td>28.1</td>
</tr>
<tr>
<td>Production and Related Workers</td>
<td>33.1</td>
<td>22.3</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Source:** Seventh Malaysia Plan 1996-2000 (1996), Kuala Lumpur, Government Printers, p. 624: Table 20-3

Tables 1 and 2 reveal changes in the employment pattern in the last five years. Reflecting the trend towards a more computerised workforce, the number of executive and technical staff has doubled while there has been a drastic reduction in the manual and teleprinter categories, with males being the most affected. It is also interesting to note the 100 percent increase in the intake of women as systems programmers and computer operators while the position of typist
has been eliminated. Although the absolute number of telephonists and data-processing operators has decreased, these are still female-dominated categories.

Thus the introduction of computers has led a varied impact on employment pattern. Job losses are experienced by both men and women at the lower levels, while the largest job gains are obtained by men, especially at the technical and executive level. There have not been any radical changes in the gender nor ethnic division of labour revealing that pre-existing divisions of labour still mediate the impact of technology on the employment pattern in this industry. What has changed is a distinct flattening of the occupational hierarchy and the positive recognition of the skill levels (in terms of upgrading) of computer-related jobs.

**Computerisation and the Changing Organisation of Work**

Although MALCOM embarked on computerisation in the early 1970s, it is only in the last 10 years that there has been major upgrading with the development of new systems as well as the integration of existing systems to provide more functions with up-to-date technology. What has been its impact on the organisation of work? The findings of the case study show several trends - a decrease in the number of workers needed and a more efficient work process coupled with a concomitant increase in the intensity of work. At the same time the decentralisation of work has allowed for more autonomy at the lower levels. Let us illustrate by a few examples, mainly from the accounts and international exchange section.

Computers were introduced in this particular Accounts Section of the company in 1990. Prior to that all office work, including the printing of bank cheques, was done manually with the help of type-writers and calculators. According to the Senior Accounts Assistant the advent of computers has eased office work quite substantially making it more efficient; the work of eight persons who were preparing staff payroll is now done by three persons.

Computers have allowed work in this accounts section to save time, to save space and work is more accurate and clear. For example employees' salaries are paid on time compared to delays before. The number of files, ledger-books and paper has been reduced; the computer is also programmed to avoid errors while the printed document is clear and clean compared to the earlier carbon copies which fade over time with different and confusing hand-writing styles.
Another unit visited was the panel doctor unit which before computerisation, had 16 staff who manually processed payments for the medical bills within the Central Region. According to the chief clerk, this was a mammoth task as it entailed manual matching of medical bills between employees and the 400 clinics they visited. Each week 15 staff would sort out more than 400 claims coming from the 5,000 employees in that region with one staff sorting an average of 1,500 bills per person per month. After matching the receipts, vouchers had to be manually written and payments calculated and written. The obvious outcome was delays in payments for as long as six months or more leading to inefficiency, a bad image for the company and poor relations between the company and medical community.

In 1992 a computerised personnel system was introduced throughout the company whereby all relevant information about personnel were keyed in and stored electronically. To the relief of the panel doctor unit, half their problem was solved as machines not only matched bills but could make payments automatically. A considerable amount of time was reduced and together with other changes introduced through the initiative of the chief clerk, additional (and useless) paper work was eventually eliminated. Payment time was then shortened from six to three months and eventually to three weeks when she introduced the auto payment system. Now there are seven staff although the chief clerk points out that she actually needs only four clerks, compared to the 16 before computerisation. She credits the new technology with meeting company targets of efficient payments while the technology has also allowed her to make her own study of the work process and to reduce redundant work.

Full-time data entry operators are the main ones experiencing the negative impact of computerisation - from employment loss to health hazards. However, different groups of data-entry operators working in various sections and on different tasks are still needed at the moment. One group translates (from photos) and keys in information daily into computer readable format from telephone calls made. However once the Call Data Information System (which will connect on-line the information from calls directly to the Data Centre) is implemented, their services will no longer be needed.

Another group of data entry workers is involved in billings. When computers were introduced to process billing in 1986, typists who used to write and type between 3,000 to 6,000 bills a month became redundant and were relocated to other sections. Subsequently data-entry operators were hired to key in bills at a rate of 10,000 - 14,000 key strokes per hour per day. Research conducted in 1992 (Ng and Yong, 1995) predicted this group would be made
redundant once the Post Office went on-line. However this Data Unit was still operating in 1995, although with a much reduced staff.

There are now 19 compared to 45 data entry workers before while the work load is still the same. Many workers have left, unable to take the work strain while others have been promoted to clerical levels. Because this unit is expected to close down soon there has been no new intake to replace those who have left. Meanwhile the remaining operators carry on under a more pressured and intensified regime, working overtime till the late evening and into the week-ends to cover the back-log. Now the number of records entered is the criteria for efficiency and not the number of key-strokes. As before, daily productivity charts are posted on the wall for peer pressure effect and evaluation purposes.

A third group of data-entry operators keys in all types of vouchers and bills (rebates, medical information, salaries, petrol claims, local orders, smartphone) although they are designated as clerks. They are lined up along with their terminals facing glass windows which are pasted with all kinds of paper (from pop-stars to computer print-outs) to keep out the glare.

It is obvious that full-time data-entry women workers face the most problems in terms of work intensity, pressure to perform under the "computer gaze" and suffer various types of health and safety problems associated with the continuous use of VDT. They have eye problems, headaches, neck, back and shoulder aches and feel exhausted during and after office hours. Moreover after work, they have to do the housework and take care of the family giving them no time to rest at all.

Similar intensification and control over work is also experienced by the international telephonists at MALCOM. During the days of manual response the telephonists seem to have more control over their work processes. They are required to write down customer and booking information on ticket slips; calls were limited to six minutes and there was more interaction with customers. At the end of the day they would collect and check their own tickets, arrange them by country and send the final accounts to the billing section. There was more time to move around, more cooperation with other telephonists, and one knew how many calls were made per day.
However, with the introduction of computerised exchange in 1985 and with privatisation, their work is more hectic and there are "endless calls without knowing where they start and end". Now they have to fulfil a quota of 3,000 calls a day. While in 1990 a call had to be completed within 10 seconds, apparently the current time given is five seconds. To make matters worse the computer is programmed to receive three calls at a time which the telephonist has to respond to. According to the all-female crew there is insufficient staff - traffic has increased but the staff is the same yet "management says we are over-staffed". What management does not take into account is the number of non-monetary calls they have to respond to, but rather calculate the calls which bring in revenue - an attitude arising from privatisation.

The computer also monitors their productivity and an hourly performance report is randomly recorded. There is not much time to move about and the supervisor also keeps a "movement record book" to trace their whereabouts (e.g. toilet, prayers, tea-break etc.). Nonetheless they do admit that with computers work is faster and more sophisticated ("canggih"), although they, like the data entry operators, suffer from VDT blues.

**Participation in Union Activities**

As of March 1994 the MALCOM union had about 17,000 members - 13,027 are men and 3,891 are women (23 percent), reflecting an underrepresentation of female union members, who form 35 percent of non-executive staff. Recently a Women's Section was set up and the extent of support for women-focused activities among the predominantly male-dominated leadership at the national and branch levels remains to be seen.

It seems that the union is an important arena where social conflict is being negotiated. While it seems to have some clout over economic issues (e.g. pay rise, increased allowances, and upgrading of job designations), it does not have a strong bargaining position where fundamental changes are being introduced in the organisation. For example there is no agreement between the union and management when new technology is being introduced, nor did the recent restructuring exercise consider seriously the views of union members. According to the President, the union was "informed but not consulted".
5. THE ELECTRONICS INDUSTRY

The electronics industry has been dominating the export-oriented industry for more than the past two decades so much so that Malaysia has become the world’s leading exporter of semi-conductors and the third largest producer, after the United States and Japan. In 1992, 58.5 percent of the manufactured exports in Malaysia, were electrical and electronic products. In terms of employment the electric/electronics industry generated about 31 percent of manufacturing employment. The majority of workers, particularly at the production level are women while the technical and management positions are mainly held by men.

The 1980s saw the electronics industry, particularly the semi-conductor subsector shifting towards higher capital and technology intensive production. Apparently the workforce is supposed to acquire new and perform multi-skilled operations in line with the requirements of technological innovations and the introduction of new production techniques such as just-in-time (JIT) and quality control circles (QCC). Company management policy has also changed from tight labour control practices common in the 1970s to one which promotes more employee participation and empowerment (Rasiah, 1994).

However in sharp contrast, the consumer electronics subsector is still labour intensive with its workers operating under more controlled spaces and receiving much lower wages than their counterparts in the semi-conductor firms. These firms mushroomed in Malaysia in the late 1980s and are mainly from Japan and the East Asia NICs.

The three case studies below highlight the differences in the technology and employment pattern in these two sub-sectors. One is a major American multinational semi-conductor firm located in the vicinity of Kuala Lumpur, the second factory is a joint venture between Japanese and Taiwanese capital, while the third is a small local factory situated in rural Selangor which produces parts sub-contracted for a larger consumer electronics firm in the city.
Case Study of MOTOR - a Semi-Conductor Firm

MOTOR started operations in Malaysia in 1972 and presently manufactures about 140 different types of semi-conductor components for the world market. It is linked to its parent company in North America which is the world's leading semi-conductor supplier to the automotive market. According to the Human Resources Manager, the firm is in the process of shifting gear. In the 1970s, production was manual and of the assembly type; products were of low value and labour was unskilled. The 1990s saw a move to product testing - a process which demanded high technology using semi-automatic equipment. Apparently by the year 2000, the high level of factory automation will see workers doubling up as both operators and technicians at the factory floor.

At the present moment the firm hires about 5,000 workers, 3,900 of whom are predominantly Malay female production workers. There used to be a larger workforce before but the advent of automation reduced the number of direct production workers. Wages start from RM450 a month, minus allowances and are purported to be one of the highest in the electronics industry.

A survey of 200 respondents was conducted, representing various sections/departments in the factory. The results showed that only 15 percent of the respondents were between the ages of 17-24 while 22 percent were between 35-44 years of age. The majority of the workers (66 percent) were married and were relatively well-educated as about two-thirds of them had had 11 years of schooling. In addition more than half of the respondents had served MOTOR for at least 11 years with 19 percent of them having worked between 16-20 years. This reflects that workers in this component firm are actually quite a stable, if not permanent workforce in the industry and are not the young and nubile factory workers according to popular imagination.

Nonetheless, despite their long service there does not seem to be much upward mobility for them. The majority of them have remained stuck to their original designation as production operators and, contrary to the statement of the management, do not seem to move up the occupational hierarchy. They might rotate within the operator ranks doing different jobs in different sections, and might be more flexible and multi-skilled, but chances for promotion appear to be very limited. The higher skilled and better paying jobs, such as technicians, engineers and managers, are still male dominated reflecting an unequal gender division of labour.
Does this mean that these women workers are being upgraded in terms of their skills and technological competence? Automation requires workers to read operating instructions/specifications and some machines require quick visual and motor coordination. Workers also rotate on the job in line with the multi-skilled concept of management. Others are taught how to do small repair work when the machine is stuck. The introduction of automation has led to an increase in work intensity. At least half of the respondents handle more than one machine while less than 10 percent handle between 4-8 machines at a time. Nonetheless these workers do not seem to be recognised in terms of occupational designation nor job advancement although they perceived themselves to be skilled workers. The trend seems to indicate a shift of worker characteristic from being cheap unskilled to cheap skilled labour in the electronics industry.

Recently MOTOR started a two year training programme to upgrade operators to become technicians. About 25 operators are selected after which they are promoted to the position of junior technicians. Although theoretically all can apply, and many do, there seems to be certain restrictions to being accepted. For example those who have a Form Five qualification, can speak English and have credits in Maths and Science are preferred over others. This effectively cuts off the older workers who came in during the 70s with a much lower qualification. While this is a praiseworthy scheme to upgrade women workers, in terms of practice, only three percent of the total operators can be promoted.

**Decision-making and empowerment**

As the MOTOR enters its new phase of high-value added production, it seems to be accompanied by a distinct change in management style and outlook. The key word today is that human resources is an important asset in production where workers are considered as partners in the company's operations. MOTOR has conceived of a number of "empowerment" programmes which have received favourable approval among its workers. In fact since the introduction of these programmes the zero defect target has been almost achieved. Ten years ago the number of rejects were 50,000 parts per million; today it has been reduced to 3 parts per million - a remarkable achievement indeed!

From the management point of view, MOTOR seems serious in pointing out that "the days of control in the Company are over". Indeed its role is to teach the workers to challenge the existing paradigm, to empower them and help them to learn, grow and expand their capacities. The importance of being creative and critical is in fact crucially needed to support the new
technologies that are being introduced whereby production relations have become more inter-
dependent and workers have to work as a team to achieve zero-defect quality and to chase the
ever increasing productivity curve.

Bearing this in mind, management has made it compulsory that every worker be given 40 hours
of training per year in "problem solving". Some of these activities are formalised and
incorporated into activities which will assist firms to achieve better quality products as well as
increased efficiency and productivity. For example, management has devised various human
resource development strategies and training programmes, couched in corporate familial
language and metaphors, to get what it wants. Some of these strategies designed to obtain
worker participation are a) Participative Problem Solving  b) Participative Management Process
and c) I recommend.

**Participative Problem Solving**

The participative problem solving process started in 1985 whereby workers in a particular
working area form a group, pick a problem in the line and discuss how to solve it together. This
group meets twice a month and are paid four hours overtime. The leader who leads this group is
called the empowerment leader. The various teams then compete with each other with the best
team being monetarily rewarded or winning a holiday to a resort island. This method is
extremely useful in cutting down costs and increasing efficiency as it provides workers with a
sense of participation in the production process. Actually they are the ones who monitor each
other rather than the supervisor who is fast disappearing as an occupational category in the firm.

An extension of this strategy is the **Participative Management Programme** which combines
operators and management in solving problems at the workplace. Again competition among
teams is held with the best team heading to the United States to visit the company headquarters.

**‘I recommend’**

These are suggestions in writing to improve the line, two of which must be sent in before the
middle of every month. Every suggestion is evaluated and the operator with a good suggestion
wins RM2. If the suggestion is implemented then the worker earns another RM5. Those who do
not send in their recommendations will be reminded as their names will appear on the bulletin
board. The owners of the top 200 suggestions will receive prizes such as umbrellas, clocks, bedsheets etc.

Women Workers' Responses to the Changing Technology

Several long-serving production workers were interviewed about company changes; their responses indicate the different and sometimes contradictory feelings of the women.

Susie started as an operator in 1976 and is presently a Quality Assurance worker. Through the years she observes that management has become more open and workers do get a sense of being "empowered". There are less supervisors now as the workers themselves can motivate each other to be more efficient and productive. She is also quick to add that "underlying all this, they (management) get what they want. They give you good machines but the target has to be met...in the long run the company gains".

She points out that management gives the illusion that one can be promoted easily. She herself applied to the training programme but was rejected both times. Susie has reached her maximum pay and position in the firm and can go no further. Why doesn't she apply to work elsewhere? She replies that she has no skills outside the firm. With only nine years of schooling, she lacks the paper qualification; moreover she is too old (35 years old) to move elsewhere.

Susie tried to form a union and wrote about it in a Speak Out programme (i.e. an avenue to voice complaints). However she said she was harassed by management and in the end had to retract the letter. As she put it so succinctly, "There is a hierarchy in the company. The operator cannot win".

Comparing the old and the new, Anne states, "Before the workers have time to rest, relax. But now there is no rest or else the machines will break down. There is more pressure now. The workers must write the "I recommend". The workers have to work non-stop like the machines. After training there is no increase in wages. In my 13 years of work the management only cares about quality and targets. Before workers could sit down, now it is eight (8) hours standing up. When I wrote in the speak out about increase in annual leave, I was called for a personal interview. They brainwashed me and told me it was not necessary. The problem is that we ordinary workers do not know how to argue our case".
On the other hand Maureen says there is freedom of speech. "Now we have empowerment. Even the GM when he meets a worker would greet her before the worker thinks of greeting him". Yet Maureen who started work in 1982 wants to quit her job in the near future. She discloses, "Shift work is tiring. Now I suffer from insomnia and heart problems; the doctor has prescribed sleeping pills for me". Her husband quips in "The company runs for profit at the expense of the workers".

**Freedom or Control?**

In MOTOR technology has changed work organisation with skills being dependent on judgement. Production processes which seem to be less dehumanising enhance productivity and decrease conflict. This change, coupled with management attitude, has made it difficult to organise workers. Nevertheless, a coercive labour force is maintained through the decentralised nature of new technologies. While on the one hand these new technologies are being employed through a decentralised arrangement, on the other, management control of workers is being made more centralised through their "participative" and "empowerment" programmes. According to Kuruvilla (1995) this may actually represent a more sophisticated form of worker control.

Besides, these programmes are very carefully administered to steer away from issues that are related to social benefits, wages and terms of employment. Workers are given the sense that they are participating in production improvements and increase. They actually do contribute in this way as the new information-based form of production depends more and more on the participation of these emerging cognitive, multi-skilled workers. Clearly "empowerment" programmes are promoted to coincide with the needs for production innovation and productivity, rather than for the enhancement of workers' social benefits.

A major finding from this study indicates that workers have a positive attitude towards their job, are willing to be trained and retrained, are not averse to technology and machines and have a high self-esteem of themselves as being skilled. Certainly, these are necessary pre-conditions for the development of an even more productive human resource base in the country. Yet, from another perspective it also indicates that in the more capital-intensive electronics industry, management has been quite successful in eliciting worker consent and cooperation in its pursuit for greater production and efficiency. Indeed the changes in production technology necessitate
greater levels of worker participation in the production process. Yet it is also in such companies that the effort to avert workers inclination towards unionisation is most strongly prioritised.

The Consumers Electronics Industry - MABUCHI and PERM

MABUCHI - A Japan-Taiwan Joint Venture

MABUCHI is situated in a recently established Free Trade Zone area, stretching 22 kilometres along the Tasek-Sungai Siput road in the central state of Perak. Most of the firms produce electronics products where women, mainly Malays and Indians, form 70 percent of the workforce. Apparently thousands of foreign workers, mainly Filipinas and Bangladeshis, also work there.

The factory was set up by Japanese and Taiwanese capital in 1990 to produce motor components for television, video players and refrigerators. It employs more than 4,000 workers; the production workers are all women earning a basic wage of RM10.50 a day. Other allowances include attendance allowance (which is forfeited if medical leave is taken), performance bonus and food allowance. All in all their take home pay is less than RM350, a monthly income which is below the poverty line in Malaysia.

The work process is labour-intensive and of the typical assembly-type where the operators are seated in a row next to a conveyor belt which moves the respective products down the line. Magnifying glasses are used to fit in specific minute components down the line with the operators working at a brisk pace set by the conveyor belt. Most of the lines entail soldering work and the use of chemicals, the names of which are not known to the workers.

Since 1995 the management has introduced new machines which can take over the jobs of a line which formerly required 20 workers to run. Now only two workers are needed to "woman" the machine. As a result workers have been laid off, the ones most affected being foreign workers whose contacts are not renewed. Apparently their numbers dropped from 1,800 in 1993 to about 330 today.

ALAIGAL found that these women workers, who have less than nine years of education, enter the industrial job market without any technical skills at all. As a result they are employed at the
lowest levels in the factories. Whatever skills they learn in the factory are not useful to go into other types of employment. Like most other firms in the Free Trade Zone, they work on shifts, do not receive any in-house training programmes, are not unionised, are pressured to do overtime and suffer from health problems (skin diseases, backaches, watering eyes) which they did not experience when working in the estates.

Despite these working conditions, many of the workers interviewed seem satisfied with their employers. This is because the company organises outings, dinners and fashion-shows for the workers generating a new kind of modern consumer lifestyle. Some even celebrate the birthdays of the workers showering them with small presents and parties. Apparently these modern methods of management have been effective in cushioning, if not curtailing labour discontent.

**Case Study of Sub-contracted work - PERM ELECTRONICS SDN BHD**

Perm Electronics is a factory located in Semenyih, a small town about 40 km south of Kuala Lumpur. Semenyih was formerly surrounded by rubber and oil palm plantations many of which have been re-developed into housing estates and golf courses. Small factories have also sprung up to take advantage of the displaced plantation workers in their workforce. The factory itself, which consists of two shop lots, is located in a commercial area surrounded by low-cost housing schemes. The factory runs behind closed doors and is not well ventilated, tending to become hot and stuffy in the afternoons.

PERM, incorporated in November 1985 - is a small company which grew out of the electronics industry in the country. Owned and managed by Chinese Malaysians it assembles and processes electronic components for electrical appliances. The work that is performed is essentially sub-contracted from the large companies in the vicinity. Initially the company produced switches for M. Sumida Electric Sdn. Bhd. which is a factory located in the Bangi Industrial Estate. However, in December, 1993 the workers were given one month's notice of dismissal because the factory was shutting down. In early 1994 the factory once again resumed operations with 40 workers. Initially 10 machines were utilised but later on six machines were sent to two new plants in two other rural towns.
**Workers Profile**

The company has a total of 36 workers, 92 percent of whom are Indian females from the surrounding housing estates where a large number of former plantation families live. The age of male workers range from 16 to 20 years, while female workers' age range from 16 to 40 years. There are six temporary workers three of them girls between 14 to 16 years of age. The workers receive RM260 per month as their basic salary; the other economic benefits include RM25 and RM12 per month for transport and meal allowances respectively. As far as the temporary workers are concerned, they are paid a flat rate of RM12 per day.

**Working Conditions**

All benefits such as leave and rest days are at statutory minimum levels. The only benefits that are above the statutory requirements are reimbursements for outpatient medical treatment and an annual bonus of one or two month's basic wages. Temporary workers do not get any benefits as they are paid only on the days they turn up for work. Most of these temporary workers are school children who attend school in the morning and work in the afternoons or vice-versa. Others are school drop-outs who cannot work in factories with machines until after the age of 16 years.

The planning in the company appears to be quite arbitrary in some ways. For instance workers will not know if they have to do overtime beforehand as this is only determined minutes before closing time. As the workers live very close to the factory, the management would send someone to their homes to ask them to come back to the factory even though they are on annual leave.

Despite this flexibility, workers have to meet daily production targets which keep the pace of work fast and stressful. They produce about 6,000 units in the switch department, that is 12 units per minute, while in the mechanised section a worker has to make about 10,000 units a day averaging 20 units per minute.

**Technology and Production in the Switch Assembly**

There are two types of switches which are produced in the factory. One is assembled manually while another is assembled by machine. The manual assembly of the switches involves great
dexterity of the fingers and good eyesight which is often under great strain because of the small size of the units.

Machines assemble another type of switch. In this process the worker has to insert in the bottom part of the switch while the machine fits in the top part. The worker has to step on a leg pedal to operate the machine. There are three machine operators with two line leaders above them who ensure that the quality requirements are met. A third production activity is also carried out by seven workers in the factory. Small parts of a type of switch are examined for defects before being sent to another company plant nearby.

There does not appear to be any significant change in the use of technology as the same machines continue to be used. However, the production targets have risen and quality requirements are more stringent. The low level of technology has also kept workers in a job where they do not acquire any useful skills for future job mobility. No adult men work in the factory as the young men leave as soon as they obtain another job. Similarly, girls leave just as quickly. The only ones who stay are women with young children who want a job that is within walking distance of their homes; or women who do not have the academic qualification to obtain jobs in the better-paying factories.

The factory does not have any training schemes. The older workers who are already adept at the work processes train the newcomers without incurring any additional costs. Even the production targets are maintained by other workers in the line producing more to make up for the fewer units assembled by new workers.

**Sub-contracting - the Other Side of New Technology**

It can be seen that Perm Electronics represents the low end assembly process of the consumer electronics industry. It is similar to the scores of other rural-based factories which undertake sub-contract work of the simpler work processes in the industry - the result of the introduction of new technologies and rationalisation strategies in the larger plants. However, although Perm Electronics is a small factory it is trying to be competitive in many ways by using a small workforce producing more units of better quality. The use of machines is also being maximised through the use of fewer machines but higher total production targets. It is also able to survive due to the low wages it pays to workers.
6. CONCLUSION: THE WAY FORWARD

In a space of less than forty years, Malaysia has shifted from an agriculture based economy to one whereby manufactured products have dominated the export market. Current industrialisation policy aims to move to a capital-intensive information-based system of production by the turn of the century. Much of the impressive economic growth has been spurred by foreign investment which, while ensuring Malaysia's entry into the global economic order, has also made the country vulnerable to MNC influence. For example, the recent global slowdown saw the retrenchment of 10,000 workers in the electronics industry - or about 10 percent of the female labour force. (NST, 15 September 1996).

In a sense the Government is caught between building a skilled, disciplined and knowledge-intensive labour force with concomitant improved working conditions and the desperate need to make its workers internationally competitive. Thus in order to continue attracting foreign investment, the state has often aligned with employers in restricting workers' rights to build a "harmonious working environment". It is with this scenario in mind that one has to comprehend the impact of technological changes on women's employment in Malaysia.

The paper has shown that despite Malaysia's wish to emulate the East Asian NICs it still lags behind in terms of technology capacity and the existence of a skilled human resource base which the government has been making efforts to upgrade. Companies are also turning to more capital-intensive technology not only to increase productivity and efficiency but to also address the labour scarce economy.

Cutting edge technology combined with restructuring has yielded some positive impact in terms of a vastly expanded network and services, better performances and economies of scale. However the impact on women has not been uniform. A small group of women, mainly graduates, has managed to make inroads into the information processing arena representing positive opportunities for women in this dynamic field. This shows that if women are provided the opportunities for training they can adopt quite easily to the employment opportunities offered by new technologies in this information era.
However the employment situation of the majority of women are still in the low-skilled or semi-skilled areas - a situation not unlike the position of women in other Asian countries. Thus even in the hi-tech industries, the case studies have shown that women workers form the majority of clerical workers, data-entry and production operators. Their lack of start-up technical skills puts them in a vulnerable position in the changing labour market.

Technological change has also resulted in job losses where large groups of lower level employees (men and women) are replaced by a smaller groups (mainly men) who possess higher skill levels. Differentiation by skill levels then polarise workers with women still remaining at the bottom of the skills ladder. In the last five years of increased liberalisation of the economy, the income gap has widened between these two skills groups. Despite Malaysia's robust economy and equity rhetoric, the 1996 UNDP Human Development Report showed that Malaysia has the highest rate of income inequality in Asia (STAR, 20 August 1996).

In terms of the case studies, MALCOM has not directly felt the impact of job losses so traumatically as being a public sector body (before privatisation) has prevented it from the worst economic disruptions. Moreover the relatively strong union struggled for its workers affected by restructuring to be retained in the new corporate company. However other negative effects regarding the work organisation are felt - such as intensified work environment and increased health and safety problems. These problems are mainly faced by lower-level female workers, who, as a result of the introduction of computers, are required to work harder and faster, with quotas monitored by the machine.

In MOTOR, women production workers are keen to learn new technological skills with the shift towards greater automation and computerisation. Management strategies have also been quick to adapt to these changes which need more cooperation and polyvalent skills at the floor level. These strategies which enhance worker participation should be emulated by other organisations wishing to progress forward in the post-industrial society. Technology should be viewed as a holistic process in which the human dimension is of crucial importance to its successful incorporation. Hence workers should have the knowledge as well as a voice in the content and method of technological adoption.

In order to meaningfully enhance the status of women workers in the technological era, these new skills which surely lead towards greater productivity should be recognised and amply
rewarded. A significantly large number of workers profess loyalty to the company, hence contributing to the success of the industrialisation drive. As such companies should award workers more social security benefits and to consider a policy of profit sharing, with worker equity.

At the other end of the electronics spectrum is the existence of small rural-based companies which undertake sub-contracting work for the larger factories. Again the majority of the workers are women who, unlike their labour aristocrat sisters in the component firms, are employed under exploitative and flexible working conditions. Policies have to be designed to ensure that their basic rights, particularly the right to organise, are upheld.

Firms which recognise the right of workers to organise seem to offer a better deal for workers. This can be seen in the case study of MALCOM where the union fought for the right of workers made redundant by computerisation to be deployed to other departments. The State must realise that the promotion of workers’ organisations is not antithetical to productivity and profit making, as disclosed by a World Bank study that Malaysian firms with unions had a higher productivity rate compared to non-unionised ones (NST, 6 December 1995).

Which brings us back to the original intention of the project - to bring women's voices on the agenda of technological change and industrial policy-making in Asia. The critical information gathered by the NGO partners in the project has made them realise the complex nature of technological change and women's employment, and the realisation that it is not possible nor realistic to adopt a pro or anti technology position. For the policy makers, they have also come to accept, from the ensuing discussions, that new strategies and policies have to be formulated, with input from NGOs, to "manage the market", so to speak, at national, regional and global levels.

While the state and peoples' organisations have generally shied away from each other in the past, both are now recognising the need to collaborate (in a critical fashion) with each other to counter the negative consequences from the encroachment of global capital - united by the lowest common denominator of ensuring that women are not excluded from the spread and benefits of new technologies.
As gleaned from the Bangkok meeting, various shades of state-NGO relationship exist - from openness on both sides to veiled antagonism. Nonetheless a start has been made with specific policy-makers willing to listen if the NGOs had "valid" knowledge, and the NGOs understanding a little better the monstrous bureaucracy of policy formulation.

Surely, different strategies might need to be adopted to suit the concrete and complex situation of different countries. In this context, the UNU/INTECH project has performed a credible task in providing the legitimacy, expertise and the forum to bring the two groups together.

However cooperation of all sorts and open communication are needed to ensure any successful outcome. Economic and technical cooperation rather than competition (the underlying rhetoric of globalisation and liberalisation) will be more beneficial and equitable to all in the long run. States need to provide more protection in this period of deregulation - they cannot renege on this responsibility and it is up to civil society - the NGOs and other organisations - to dialogue and to remind them constantly of their role. I believe a small start was made in this project.
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8. ENDNOTES

i. This project was originally initiated by UNIFEM (United Nations Development Fund for Women) and later drawn up and supported together by UNU/INTECH and the Ministry of Development Cooperation, The Netherlands.

ii. These countries were Bangladesh, China, India, Indonesia, Korea, Malaysia, Sri Lanka and Vietnam. The project team was headed by Professor Swasti Mitter of UNU/INTECH. The author joined INTECH from mid-1994 till June 1996 while Rohini Banaji was engaged as a consultant until August 1995.

iii. Of the total 30-40 million Internet users, 69 percent are from North America, 45 percent are professionals and 56 percent are between the ages of 21 and 30 (New Straits Times, 6 February 1995). An interesting discussion of the use and abuse of IT can be found in the October 1995 newsletter of the IFIP Working Group 9.4 entitled "Information Technology in Developing Countries".

iv. A UNDP commissioned study (1995) pointed out that Malaysia is still within the first stage of technology transfer i.e. adoption stage as opposed to the rooting and diffusion stage. The bulk of the transfer was between the lower-to-moderate level of sophistication while the majority of the technology transfer agreements concerned foreign-owned firms operating in Malaysia rather than Malaysian firms. Nevertheless the study was optimistic that Malaysia would move to the other two stages.

v. For example Wacjman (1991) informs us that the number of female students taking computer courses in England is decreasing, further strengthening her theory that technology is engendered.

vi. It would be useful to expand these clubs which at present are mainly concentrated in the urban areas and thus cater to specific socio-economic groups, mainly non-bumiputras (Ng and Yong, 1995). A study of the gender, class and ethnic dimensions of computer education and teaching would enlighten us on the direction and future of the much vaunted information society in Malaysia.

vii. The research was conducted by Safiah Suaimi from the Women's Committee of the Malaysian Trades Union Congress. She was assisted by the author and Neeraj Joshi.

viii. This case-study is part of a larger SIDA-funded study undertaken by the author and Maznah Mohamad.

ix. The Mabuchi study was conducted by Sarasvathy of ALAIGAL, a workers' organisation dealing with estate and more recently factory workers; Devaki Arumugam of Sahabat Wanita, a women workers' group studied PERM. Both of them conducted their case studies with the help of key women workers who worked in the respective factories.
x. Apparently local educational institutions can only provide 58 percent of engineers and five percent of the skilled workers needed. Only 200,000 out of the annual projected demand of 500,000 skilled and semi-skilled workers can be met, revealing a near crisis shortfall in human resources.
The Information Revolution and Economic and Social Exclusion: the Experiences of Burkina Faso, South Africa and Tanzania

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Maastricht School of Management
The Netherlands

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Editor's Note

With pleasure we present to our readers the special series of UNU/INTECH Discussion Papers: Information Revolution and Policy Implications for Developing Countries. Papers of the Series were originally developed for the International Workshop on The Information Revolution and Economic and Social Exclusion in Developing Countries, held in Maastricht on 23 - 25 October 1996. The Workshop was an important event organized by UNU/INTECH and financed by the Dutch Government. Insights developed from the Workshop have not only been benefiting UNU/INTECH research work, but also contributing to many other initiatives in the area of innovation policy for information technology in developing countries.

There are six papers in the special series. The first five papers have been widely circulated and are provided here in the latest modified versions. These are outcomes from the two major themes set for the Workshop: ‘The Developments of Access and Effective Use of Information Technology and Exclusion’, and ‘The Gender Dimension in Exclusion’. The sixth paper, by Ludovico Alcorta, is a summary of the three country cases on Burkina Faso, South Africa and Tanzania organized for the Workshop.


#2002-2* Constantine Vaitsos, “Policy Agenda for the Information Revolution and Exclusion Phenomena in Developing Countries”


#2002-4* Carlos M. Correa, “Implications of Intellectual Property Rights for the Access to and Use of Information Technologies in Developing Countries

#2002-5* Cecilia Ng Choon Sim, “Making Women’s Voices Heard: Technological Change and Women’s Employment with Special Reference to Malaysia”

#2002-6* Ludovico Alcorta, “The Information Revolution and Economic and Social Exclusion: The Experiences of Burkina Faso, South Africa and Tanzania”

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THE INFORMATION REVOLUTION AND ECONOMIC AND SOCIAL EXCLUSION: THE EXPERIENCES OF BURKINA FASO, SOUTH AFRICA AND TANZANIA

Ludovico Alcorta
Maastricht School of Management
The Netherlands
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1. INTRODUCTION

The information revolution, led by advances in information and communication technologies (IT), has already made a significant impact in the lives of the world’s population and has the potential to make even deeper transformations. The new hardware, applications and resulting services are already changing the ways individuals go about their daily home, work and leisure activities and the means they use to communicate with each other. For society as a whole the emerging technologies have helped to create new job and output growth opportunities, a global market, new forms of social organisation and an emerging ‘world’ culture. Fundamentally, the information revolution is providing businessmen, workers, governments and the public at large with the possibility of using an ever-growing amount and variety of information and knowledge. The capacity to benefit from the proceeds of the increasing availability of knowledge is, however, crucially dependent on accessing and effectively using existing information technologies.

Accessing the information revolution, or inclusion, is per force a relative concept. As Cooper points out in his chapter in this volume, even in the most ‘informatised’ of societies, one is always being excluded by the rapid pace of present day technical change. By the same token, even in the least of ‘informatised’ societies it is possible to find individuals or groups that have access to the latest IT hardware and applications available and thus benefit from up-to-date information and communication. Inclusion and exclusion are, therefore, a matter of degree. Yet, at the same time there seems to be a significant amount of the world population that have hardly ever come across a computer or been reached by the effects of the new hardware and applications. Indeed, by improving the capacity for making judgement by those that have access to IT the information revolution may also have the pernicious effect of widening the knowledge gap between the ‘have’ and the ‘have not’.

This paper aims at synthesising the findings of studies on Burkina Faso, Tanzania and South Africa studies addressing the issue of economic and social exclusion in developing countries.\(^1\)

Three questions guided these studies: How far away from the information revolution are these

\(^1\) The three studies by Bamogo et al (1996), Hodge and Miller (1996) and Wangwe et al (1996) were commissioned by the Institute for New Technologies, United Nations University and presented at an International Workshop on Technological Change and Exclusion. This paper, therefore, draws freely on the original contributions.
countries? What factors lead to existing patterns of inclusion and exclusion? What is being done to improve access? The regional focus on sub-Saharan Africa is purposeful, as it is in this region where the ‘distance’ to the information revolution would seem to be larger. It is, at the same time, the region with the largest potential for ‘leapfrogging’ into the information age, as there is little commitment to previous technology.

The paper will be structured into five sections. Following the introduction will be a section analysing the emerging patterns of inclusion and exclusion both internationally and domestically. The third section examines the investment, physical infrastructure, learning and market size factors accounting for such patterns. The fourth section discusses the potential for turning exclusion into inclusion arising from the market, government policies and international cooperation. In the final section some conclusions will be presented.
2. PATTERNS OF SOCIAL AND ECONOMIC EXCLUSION

2.1 The IT infrastructure base in international perspective

The quintessential hardware of the information revolution is, of course, the personal computer (PC). Although computers had already been around for some forty years it was only after developments in microelectronics in the early seventies, and the resulting increases in the performance/price ratio of microchips and in a vast array of applications, that their diffusion became widespread. Together with PCs, over the last ten years INTERNET has become a key source of storage and dissemination of private and public information. Finally, telephones have now become not only a major device for interpersonal and business communications but also one for accessing and transferring data.

The diffusion of personal computers (PCs) in Burkina Faso and Tanzania only began in the eighties but has proceeded at a very rapid pace since. In Tanzania, there were an estimated 470 computers, mainly PCs, in 1986. By 1995 the number had increased to an estimated 2,919 computers (Table 1) or one computer for every 9,832 inhabitants. In Burkina Faso, PC diffusion is slightly higher with an estimated 1,000 PCs in 1990 and 2700 PCs at the end of 1995, or one PC per 3,474 inhabitants. There were no INTERNET hosts or users in either country in 1994 although attempts to establish them were beginning in both of them.

Table 1. Stock of computers in 1995

<table>
<thead>
<tr>
<th></th>
<th>Burkina Faso</th>
<th>South Africa</th>
<th>Tanzania</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Computers</td>
<td>2,700</td>
<td>1,110,000</td>
<td>2,919</td>
</tr>
<tr>
<td>Micro-computers</td>
<td>25</td>
<td>10,327</td>
<td>n.a.</td>
</tr>
<tr>
<td>Mainframes</td>
<td>6</td>
<td>153</td>
<td>n.a.</td>
</tr>
</tbody>
</table>


Telephony in Burkina Faso and Tanzania is a state monopoly. In Burkina Faso the National Office of Telecommunications (ONATEL) is the unique operator for telephony, radio and television but licences are being granted to private companies for the supply of telecommunications equipment and maintenance aimed at businesses. Public and private efforts to increase telephony have resulted in the number of telephone lines increased from 7,947 in
1985 to 30,625 in 1995, around 333 inhabitants per telephone line. The Tanzania Telecommunication Company Limited (TTLC) is the main operator in Tanzania although permits have also been extended to two cellular mobile operators in Dar es Salaam. By 1994 there were 88,100 telephone lines installed, also around 333 inhabitants per line.

Private providers had added a further 2,500 mobile telephone lines by the end of 1995 but this was far less than the 145,000 applications for telephone lines that year (UNCTAD, 1997).²

Despite the rapid increases in the stock of computers and telephones in Burkina Faso and Tanzania, available hardware would seem to be lagging behind that of most countries. In developed countries there were an estimated 5.7 inhabitants per PC in 1994, with the US having the highest ratio of 3.4 inhabitants per PC (UNCTAD, 1997). The equivalent figures for developing countries and Eastern Europe was 250 and 111 inhabitants per PC respectively. A similar pattern emerges with telephone lines. In developed countries one out of two inhabitants has a telephone line, while in the whole of the developing world and Eastern Europe there were 27.5 and 6.2 telephones per inhabitant. Hardware availability in Burkina Faso and Tanzania would seem to be trailing behind even if compared with the 238 inhabitants per telephone line in Sub-Saharan Africa. Together with Afghanistan, Bangladesh, Burundi, Cambodia, Central African Republic, Chad, Mali, Madagascar, Niger, Rwanda, Somalia, Uganda and Zaire, the two mentioned countries have the lowest access to IT in terms of PC, telephone and INTERNET use (UNCTAD, 1997).

Contrary to Burkina Faso and Tanzania, South Africa seems to be far more ‘included’. By the end of 1995 the ratio of inhabitants per PC was 40.6, similar to that of Chile, Mexico and Malaysia and not far from the world average of 28.6 inhabitants per PC (UNCTAD, 1997). Diffusion is also proceeding apace, with the number of PCs growing at an annual rate of 12.5%. Furthermore, the fact that 82% of the stock of computers is used by the business sector and that 60% of them are connected to a network, as compared with 65%-70% in developed countries, suggests that some businesses may be operating under very advanced conditions of PC usage and connectivity. Indeed, South African financial institutions are significant users of mainframes, PCs and automatic teller machines (ATMs) by international standards and one of its leading banks was placed in 1995 in the Computerworld Premier 100 users of IT world-wide. INTERNET use is also very advanced for the African region and the developing world as a

² The average waiting time for a telephone line in Tanzania is 10 years (UNCTAD, 1997).
whole, with an estimated 27,040 hosts and 148,720 users in 1994, figures similar to those of Denmark, Italy and Spain. By the end of 1996 there were around 88,000 hosts and 420,000 INTERNET users in South Africa.

As with most African countries, telecommunications in South Africa has historically been a state monopoly, although this is now changing. Fixed wire telephony was, until 1991, provided by the Department of Post and Telecommunications (DPT) and is today in the hands of the government owned company Telkom SA Ltd. Telkom’s establishment made it possible for main line installation to outstrip population growth and has averaged a 4.4% annual growth rate at the beginning of the nineties so that by 1995 South Africa had 3.8 mn telephone lines, an equivalent of one line per 10.5 inhabitants (see Table 2 for details). South Africa’s transmission network is extensive and is based on microwave, optical fibre, radio, copper wire and coaxial cable systems. International communications are handled through the INTELSAT global satellite system and South Africa is one of the hubs for transit and switching services for sub-Saharan Africa.

Table 2: Summary of Telecommunications Statistics in South Africa (1995/1996)

<table>
<thead>
<tr>
<th>Category</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Telephone Lines (thousands)</td>
<td>3,844.5</td>
<td></td>
</tr>
<tr>
<td>Business</td>
<td>1,325.1</td>
<td>34.5</td>
</tr>
<tr>
<td>Residential</td>
<td>2,459.8</td>
<td>64.0</td>
</tr>
<tr>
<td>Payphones</td>
<td>59.6</td>
<td>1.8</td>
</tr>
<tr>
<td>Telephone sets</td>
<td>5,300,000</td>
<td></td>
</tr>
<tr>
<td>Exchanges</td>
<td>2096</td>
<td>100.0</td>
</tr>
<tr>
<td>Manual</td>
<td>155</td>
<td>7.4</td>
</tr>
<tr>
<td>Automatic</td>
<td>1,941</td>
<td>92.6</td>
</tr>
<tr>
<td>Analogue</td>
<td>547</td>
<td>26.1</td>
</tr>
<tr>
<td>Digital</td>
<td>1,394</td>
<td>66.5</td>
</tr>
<tr>
<td>Lines connected to digital exchanges</td>
<td></td>
<td>70.0</td>
</tr>
<tr>
<td>Exchange capacity utilisation</td>
<td></td>
<td>82.0</td>
</tr>
<tr>
<td>Transmission Circuit (km)</td>
<td>120,209,000</td>
<td>100.0</td>
</tr>
<tr>
<td>(of which) Optical Fibre</td>
<td>233,000</td>
<td>1.9</td>
</tr>
</tbody>
</table>


In addition to Telkom there are three additional telecommunications networks, sectorally related. Transtel is the communications business unit of Transnet Ltd., the transport state-owned company that operates the national airline, the rail network and the harbours. Transtel’s communications infrastructure is reportedly the largest private network in Africa and consists of cable and microwave infrastructure, a direct dialling PABX voice network, data communications networks and trunked radio and mobile communications. Eskom is the state
company provider of electricity. Eskom operates a similar range of facilities and has expanded its network to support the power plants, substations and transmission lines located in rural areas. SANDF is the telecommunications infrastructure of the defence forces.

Cellular telephony began in South Africa in the early nineties and two licenses were issued, one to Vodacom (whose major shareholders are Telkom S.A. and Vodafone), and one license to MTN (whose major shareholders are Cable & Wireless, M-Net and Transtel). South Africa has become the largest GSM market outside Europe and the fourth fastest growing GSM market in the world (Table 3). The market is now estimated to be between 650,000 to 700,000 subscribers.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MTN</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>120,000</td>
<td>190,000</td>
</tr>
<tr>
<td>Vodacom</td>
<td>5,680</td>
<td>7,100</td>
<td>12,510</td>
<td>40,000</td>
<td>220,000</td>
<td>330,000</td>
</tr>
<tr>
<td>Total</td>
<td>5,680</td>
<td>7,100</td>
<td>12,510</td>
<td>40,000</td>
<td>340,000</td>
<td>520,000</td>
</tr>
</tbody>
</table>


Clearly, the South African physical telecommunications infrastructure is quite developed and is by far the best in Africa. Yet, South Africans are ‘excluded’ from the information age in a perhaps more frustrating way: the quality of the telecommunications service. The number of days required to activate a new service in areas where infrastructure exists has come down in recent years, but is still high at 29 days. In comparison, the top international operators take 3 to 5 days to activate new residential service and less than one day for a business service. More importantly, however, South Africa has an exceedingly high number of faults per 100 lines per year (90 faults), comparing poorly with the top operators who record fewer than 15 faults per 100 lines per year, making the telecommunications network, in practice, unreliable.

### 2.2 Local production of IT goods and services

Despite having been economically isolated for several years South Africa has not tried to develop a computer industry. It is estimated that around 95% of hardware revenues by distributors are from imported products and components. Yet, the country is not totally excluded from production, as a vibrant PC assembly industry is developing, propped initially by tariff differentials between built-up products and components and now by transport costs and the need to satisfy customer’s varying configuration demands. The industry operates on the basis of
flying or shipping PC components and sourcing cables and packaging locally. Around 60% of all PCs are assembled locally.

Parallel to PC assembly have emerged the IT professional services and the customised software industries as well as some research and development (R&D) capabilities. The professional services focus on the selection, installation, integration and maintenance of hardware, systems software and package application software. They also provide training and the analysis, development, implementation and maintenance of custom applications. The local software industry is aimed at specialised niche markets where local requirements differ from international standards. These include accounting, legal information and specialised financial service packages, logistics programs and various geographic and climatic monitoring software. Both industries are thus underpinned by the specificity and non-tradability of their products, a growing local demand for computers and the availability of a small but well trained workforce who is occasionally complemented with foreign professionals for very specialised and cutting-edge tasks. R&D capabilities are mainly in computer sciences, which accounts for 2.3% of total R&D expenditure in South Africa. Around two-thirds of this expenditure is funded by the business sector, suggesting that R&D efforts has industrial application.

Production of IT goods and services in Burkina Faso and Tanzania is practically non-existent. All Burkina Faso’s mainframe computers are imported by representative agencies of IBM or BULL while around 40 local companies import PCs. After-sales service including accessories, maintenance and training is always provided by the supplier. Only international commercial software is available locally and prices tend to be considerably higher than abroad. Until 1986 the government’s National Information Processing Centre (CENATRIN) held the monopoly of information processing services in the country, a situation that is now being undermined by the emergence of private companies with the capacity to process information for other users. CENATRIN is also the only local institution with software development capacities particularly for government applications such as civil servants payroll and fiscal accounting. In Tanzania software R&D is also restricted to a few government or government funded institutions such as the University of Dar es Salaam, the Commission of Science and Technology, the Bank of Tanzania and the National Bank of Commerce (NBC).
2.3 The use of IT applications

Another major component of IT is a vast range of hardware and software applications to specific circumstances. These applications are already aiding decision making and increasing the productivity, diversity and quality of areas such as education and training, health, public information and participation, finance, commerce, travel and entertainment and management.

Use of IT applications in Burkina Faso and Tanzania is heavily concentrated in the government sector. Ministries and public institutions are main users of office automation and other applications. Within government, the area of finance is the largest user. IT applications have been adopted for handling taxes and customs information, for civil servants’ payroll and for some other items of government expenditure. The Ministries of Education and of Science and Technology, in turn, have adopted IT applications to monitor the progress of schools and universities and have endowed some universities and research centres with library management systems and CD ROM literature search facilities. In Burkina Faso, between 1986-1991 a project to provide twelve secondary schools in different areas of the country with a six PC computing centre and a printer was undertaken. In Tanzania ministries such as Health and Infrastructure are using hospital management and geographic information systems and there are plans to introduce an automated property/land valuation system.

Government use of IT applications in South Africa is much more extended than in the other two countries although lower than in the business sector. Most ministries and public institutions have financial administration and personnel payments systems and national identification, patient registration and pension payment systems have been introduced. Several public offices have established web pages and a number of official documents, news and policy papers are available on-line. Some provinces are implementing the ‘one-stop-shop’ concept, where general information, statistics and governmental procedures are explained to citizens through kiosks and terminals conveniently located in the communities that they serve. The Department of Health is beginning an e-mail and communication system called HealthLink connecting doctors and sources of medical information and allowing the preparation of supply requisitions and statistical reports. The Department of Education is developing and supporting a number of initiatives using IT in education, including the connection to INTERNET of several schools in

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3 The average usage of PCs in the public sector is 7 per 100 employees as opposed to a national average of 15.7. Highest usage is in financial services, wholesale and retailing and manufacturing with 74, 24 and 17 PCs per 100 employees respectively.
areas of the Western Cape and the development of educational material to be used in the emerging network.\textsuperscript{4} IT use for university level distance learning is being promoted, particularly at the University of South Africa, which has around 50,000 students enrolled for this type of education and is the fifth largest open university in the developing world (UNESCO, 1996). An important initiative by the official Council for Scientific and Industrial Research (CSIR) is the Community Information Delivery System (CIDS). Although still in the pilot stage, this project is with the help of wireless satellite networking, connecting local nodes with no fixed line infrastructure in under-privileged communities around Pretoria. Users have INTERNET and distance learning coursework access, especially developed for them.

Government use of IT applications in South Africa is as advanced as in other upper middle income countries. A recent survey of potential and actual use of IT in developing countries by Mansell and When (1998) points at government administration, provision of public information and linking rural communities as the main usage areas, much in the way they it is used in South Africa. Also, applications of IT to patient care, often called tele-medicine, and to distance learning, including educational content, are at par with those in Brazil, Costa Rica, Malaysia, Mexico and Turkey.

South Africa’s government efforts in developing IT applications, however, are limited in other respects. Available hardware is outdated and consists basically of mainframe computers, which require time-consuming own systems development. Furthermore, the government infrastructure consists of a large number of networks unevenly spread across tiers of government and between departments. Efforts to link government offices through a national computer network are facing the insurmountable problem of insufficient bandwidth. The result is lack of structure and fragmentation of the information available, duplication of data and difficulties in communication between most computers in the network. In addition, where the computer facilities are adequate, they are not always efficiently used. For instance, the Department of Trade and Industry has 800 PCs linked together but only 30 staff members actively use available e-mail facilities for communication.

Turning to the business sector, IT applications are used by the largest, and often state- owned electricity, water, transport, finance and telecommunications monopolies in Burkina Faso and Tanzania. In Tanzania, for example, the government owned National Bank of Commerce,

\textsuperscript{4} There is no precise data on the usage of computers in secondary schools; generally schools in white areas are well endowed. In black urban areas government efforts and corporate sponsorship has resulted in a few schools obtaining basic computing facilities.
accounting for around 90% of all commercial banks deposits in the country, had automated all call and time deposit accounts, international operations and overall accounting and clearing in its cities’ branches (Vitor, 1995). Computer-aided-design (CAD) was used by engineering consultancies and architect’s firms, particularly for public works projects; desk-top publishing applications were used by large publishing houses, while a few news and media companies had computerised their processes. Beyond this, there was not much use of IT applications by the business sector in these countries.

By contrast, use of IT applications by South Africa’s business sector is far more developed. Comparisons of international IT application use by manufacturing industry in US, Canada, Brazil, Mexico, Europe and Japan show that South Africa lags in the use of product/process applications such as CAD or Computer-aided-engineering (CAE), expert systems and factory automation, but is highly advanced in the use of Manufacturing Resource Planning (MRP II) and across functions information systems. However, these capabilities are concentrated in a few large firms, with the bulk of medium and small firms lagging far behind.

Use of IT applications in wholesaling and retailing is fairly advanced among major chain stores selling food, groceries, apparel, furniture and other household durables, even by international standards. Pick & Pay, a major food retailer, has implemented a system that enables customers to pay for purchases directly from their bank accounts. Point of sale terminals, which generate simultaneously inventory, financial and customer behaviour information, are becoming standard in most chain retailers. Retailers are also beginning to invest in more advanced data management systems, in electronic commerce applications between members of the same supply chain and in virtual retailing, including electronic catalogues and web pages.

Finally, use of IT in financial services is also fairly advanced. It is estimated that the sector accounts for around 50% of the installed IT base in the country, with banking alone accounting for 33% of total spending in IT. All major financial institutions operate nationally on the basis of electronic networks and ATMs are available even in medium sized towns. Efforts to extend the networks further into rural areas have resulted in the development by First National, a major domestic commercial bank, of unique fingerprint recognition technology, which has already won an international innovation prize.
2.4 The profile of the excluded

The description of the use and production of IT hardware and applications masks thus far the key fact that not all sections of society are included or excluded equally. Clearly there is differential access within studied countries depending on geography and race.

Taking geography first, a clear urban-rural divide is emerging. In Burkina Faso, around 87% of telephone subscribers are located in the larger cities, such as Ouagadougou and Bobo-Dioulasso, which also have digital switching exchanges. Out of the 15 switching exchanges available in the country only eight are digital. Analogue exchanges are in use in the smallest towns and surroundings and are well known for their poor sound quality and long connection times. In addition, there are 15 rural radio-based telecommunications networks that connect 143 stations in villages but can only be used for inter-personal conversations. Around 83% of Burkina Faso’s population lived in rural areas in 1997 (World Bank, 1999).

The extent of exclusion of rural areas does not seem to be very different in South Africa. Table No. 4 summarises household telephone access by location. Only one in twenty rural dwellings has access to a fixed telephone line, while the equivalent ratio in the cities is one in two. Of those rural dwellers without a telephone, 57.3% have to walk more than a kilometre to reach the nearest set. More than half of the rural population has no walking distance access whatsoever to a fixed telephone line. For most of these families a cellular telephone is just too expensive.

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5 Ouagadougou has, in addition, 30 kilometres of optical fibre links.
### Table No. 4. South Africa: Household Telephone Access by Location and Race in 1994 (%)

<table>
<thead>
<tr>
<th>Telephone Access</th>
<th>TOTAL</th>
<th>Location</th>
<th>Race</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Urban</td>
<td>Rural</td>
</tr>
<tr>
<td>Telephone in Dwelling</td>
<td>31.1</td>
<td>50.8</td>
<td>5.2</td>
</tr>
<tr>
<td>Communal Telephone</td>
<td>12.6</td>
<td>14.5</td>
<td>10.1</td>
</tr>
<tr>
<td>Access to telephone at neighbour</td>
<td>7.8</td>
<td>7.3</td>
<td>8.5</td>
</tr>
<tr>
<td>Access to telephone at shop</td>
<td>12.9</td>
<td>6.9</td>
<td>20.7</td>
</tr>
<tr>
<td>None</td>
<td>35.6</td>
<td>20.4</td>
<td>55.4</td>
</tr>
</tbody>
</table>

Distance to nearest telephone from dwellings with no set:

<table>
<thead>
<tr>
<th>Distance to Telephone</th>
<th>TOTAL</th>
<th>Location</th>
<th>Race</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 100 meters</td>
<td>25.7</td>
<td>43.5</td>
<td>13.5</td>
</tr>
<tr>
<td>100 – 200 meters</td>
<td>16.5</td>
<td>21.6</td>
<td>13.0</td>
</tr>
<tr>
<td>200 – 1000 meters</td>
<td>16.0</td>
<td>15.7</td>
<td>16.2</td>
</tr>
<tr>
<td>More than 1000 meters</td>
<td>41.8</td>
<td>19.1</td>
<td>57.3</td>
</tr>
</tbody>
</table>

Source: Hodge and Miller (1996)

Table No. 4 also depicts the extent of exclusion according to race in South Africa. Nearly nine in ten white South Africans have a telephone at home while for black South Africans the equivalent ratio is one in ten. Also, nearly one in every two black household dwellers without a set has to walk more than a kilometre to the nearest telephone set, while only one in five white dwellers with no set has to walk the same distance. On the whole, a rural black South African has either no access to a telephone set or has to walk a long way to get to one.
3. FACTORS LEADING TO EXCLUSION

3.1 Capacity to invest

One major factor restricting access to IT in the countries studied is the limited capacity to invest by the country as a whole, particularly in the cases of Burkina Faso and Tanzania, and by significant sectors of the population. Acquiring IT requires allocating a portion of national and personal income that may not be available or that involves choices with regards to satisfying even more pressing demands than the need for information.

Investment in IT in Burkina Faso between 1990-1995 averaged around 1.7% of GDP.\(^6\) It is estimated that the investment requirements for the period up to the year 2000 and from then to the year 2005, just to keep up with existing demand growth rates of IT, would range between 2-3% and 2.5-3.5% of GDP respectively. Already investing around US$ 40 million pa during the first half of the nineties involved a major effort for the country, given a very low savings rate and the country’s near complete dependency on foreign finance and aid at times when international funding to African countries was being curtailed.\(^7\) Indeed, the project of introducing PCs into secondary schools, which already had reached twelve schools, could not be extended to four other schools because of lack of finance. The fact that Burkina Faso is landlocked and that the transport infrastructure is weak, requiring air shipment of most of the equipment, only adds to the investment needs.

Burkina Faso’s IT investment predicament is compounded by more fundamental demands. According to World Bank (1999) figures, one out of three children under the age of five is malnourished and the life expectancy is amongst the lowest in Africa and similar to countries that have recently been involved in wars, such as Rwanda and Sierra Leone.

Only 18% of the total population have access to basic sanitation, while 22% of the population have no access to safe water. Agricultural labour productivity is the fourth lowest in the world. Under these circumstances it is not at all clear from a society point of view whether the country

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\(^6\) GDP in 1997 amounted to US$ 2.6bn (World Bank, 1999).

\(^7\) Gross domestic investment in 1997 amounted to 25% of GDP, of which only 9% was funded from domestic savings, the remainder being foreign finance (World Bank, 1999).
could afford, and will be able to continue to afford, allocating investment resources, even if they could be financed, to improve the IT infrastructure.

The limited capacity to invest is also evident in Tanzania. A survey of importers and suppliers of IT equipment pointed out at lack of finance as the major limitation in accessing IT. Of those interviewed, 56% pointed at this cause as very serious while 28% considered it as moderately serious. Firms are not generating the resources to be able to pay for IT equipment and even less so for maintaining and replacing what they already have. The low per capita income means that the average Tanzanian requires approximately eight years of work to be able to afford an up-to-date PC. At the aggregate level, Tanzania is also facing a low savings rate and high dependency on foreign funding together with the same stark choices in terms of basic need satisfaction as Burkina Faso.

Even South Africa is facing difficulties in financing upgrading its IT infrastructure. In 1996 the South African government decided to end Telkom’s monopoly over fixed line telephony and to open the sector to competition. The rationale underlying this decision was the need to improve on efficiency through competition and to raise additional resources to finance further expansion.

Telkom has been allowed to remain as a monopoly for six years in order to expand fixed line telephony into rural and black-populated areas. Telkom has developed its Vision 2000 Programme aimed at installing 4 million digital lines, 3 million new lines and 1 million replacement lines, by the end of its exclusivity period, which would double the size of South Africa’s existing network. The first stage is to install 1 million lines in some of the most underserviced areas of the country and double them in a second stage. However, to achieve this requires the support of a strategic equity partner to provide the capital and knowledge necessary to implement Vision 2000. Telkom is also having to restructure itself through shedding non-core business and personnel and up-grading its skills in order to generate the profits and creditworthiness that will allow it to finance the new investments.

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8 In 1997 GNP per capita was US$ 210 in Tanzania and US$ 240 in Burkina Faso (World Bank, 1999).

9 Gross domestic investment in Tanzania in 1997 amounted to 21% of GDP of which only 3% was funded from domestic savings, the remainder being foreign finance (World Bank, 1999).
Lack of capacity to invest is apparent in South Africa in other ways too. The CIDS project, mentioned above, is facing difficulties to raise funding to move beyond the pilot stage. The project implies that disadvantaged communities will eventually pay for the services received and that private investors will be forthcoming in financing the expansion of the network. It is unclear, however, that even the communities presently involved in the project have the resources to pay for the cost of the connections and content, let alone those communities that have yet to experience the benefits of it. Hence, it is proving difficult to find entrepreneurs willing to invest and the government cannot afford to pay for the up-scaling of the project. Lack of funding also means that except for private schools and a few pilot projects here and there, it is not possible to massify the use of IT in support of the educational process in primary and secondary schools.

3.2 Human resources

Accessing the information revolution not only requires having the necessary funding but also an adequate supply of human resources. Making use of the information and communications potential involves basic literacy, as applications using icons and multimedia, although simplifying the use of IT, still provide most of the content in text. Fully processing the information available, in turn, requires basic analytical, communication and numerical skills that are normally learnt in secondary education. There is also the need for people with application-specific skills, which are provided through on-the-job training or vocational training. Finally, there is a range of technical and scientific skills necessary for activities related to maintenance at one end, IT training and education at the middle and programming and developing new applications at the other end.

Basic literacy levels and secondary school enrolment ratios in the three countries studied vary considerably. Despite having increased its expenditure in education as a share of GDP by 40% to 3.6% of GDP and doubling the share of relevant age group enrolled in primary school to 31% between 1980 and 1995, Burkina Faso’s adult (over fifteen years old) illiteracy rate was 71% for men and 91% for women in 1995 (World Bank, 1999). Only 7% of relevant age group attend secondary schooling. A major implication of these figures is that, at the moment, most of Burkina Faso’s population just cannot benefit from the information revolution even if they had all the required infrastructure available.
Literacy and secondary school enrolment rates in South Africa and Tanzania are, by contrast, far better. Tanzania has made immense efforts in improving its educational record, at least as far as its male population is concerned: by 1995 the illiteracy rate stood at 21% for men and 48% for women (World Bank, 1999). South Africa literacy levels have also been improving over recent years from an average of 74% for both males and females in 1980 to 82% in 1995 (World Bank, 1999). In addition, one out of two South Africans of the required age attends secondary school and the expected stay at school averages 12 years. Yet, the literacy rate among black South Africans is 77% compared to nearly 100% among white South Africans.

Computer training in Tanzanian secondary schools is limited to international private schools and a few state schools. In South Africa, around 17,000 students, or 1.6% of students in classes 8-10 (16-18 years) were taking computer sciences as a subject in 1992. This represents a 20.7% average annual increase over the 1988 figure. The highest proportion of enrolment in computer sciences between peers was among male and Asian students (Table No. 5). White students accounted for 69% of total enrolment in computer science courses although they only accounted for 2% of the total student population of that age.

Table No. 5: Computer science courses student enrolment (classes 8-10) in South Africa, by gender, race and type of institution, 1988 and 1992

<table>
<thead>
<tr>
<th>Category</th>
<th>% of Group Enrolled</th>
<th>% of Total Enrolled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Female</td>
<td>0.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Race1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>0.9</td>
<td>10.4</td>
</tr>
<tr>
<td>Black</td>
<td>0.02</td>
<td>0.012</td>
</tr>
<tr>
<td>White</td>
<td>3.0</td>
<td>5.5</td>
</tr>
<tr>
<td>Total</td>
<td>0.9</td>
<td>1.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Institution</th>
<th>No. of Students by Institution</th>
<th>% by Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>5502</td>
<td>72.5</td>
</tr>
<tr>
<td>Private</td>
<td>1273</td>
<td>16.8</td>
</tr>
<tr>
<td>Special3</td>
<td>816</td>
<td>10.7</td>
</tr>
<tr>
<td>Total</td>
<td>7591</td>
<td>100.0</td>
</tr>
</tbody>
</table>

1 Excludes coloured population.
2 1991.
3 For the physically or mentally disabled
Source: Hodge and Miller (1996)

Some efforts are being made in South Africa to develop voice-text conversion technology but is requiring significant financial, technological and linguistic efforts to adapt to the diversity of languages within the country, let alone to countries such as Burkina Faso and Tanzania.
Turning to the availability of professional human resources for IT, the differences between Burkina Faso and Tanzania on the one hand, and South Africa, on the other, could not be more startling. In Burkina Faso, only in 1993 did the first locally trained IT specialist emerge. Until then the country could count on less than 10 computer professionals mainly trained in France and in the African Institute of Information Technology in Libreville, Gabon. By 1995, the country had less than 300 computer specialists in all fields and levels of specialisation. Most of the available IT human resources are concentrated in ONATEL.

IT education and training is nowadays provided at university level as part of the curriculum of other specialities. In addition, engineering students with at least three years of higher education can become computer specialists by transferring to the College of Information Technology (ESI). The college is well equipped and has trained around 100 computer engineers since 1990 but there are serious concerns about the quality of the training, since qualified teachers are unavailable locally, and about the lack of areas of specialisation, particularly network design engineering.

Vocational training is provided by private institutions and on-the-job. Several private training institutes for programmers and network administrators have emerged. Entry requirements include two years of higher education and around 25 pupils per year obtain their certificates at these institutes but the qualifications of the teaching staff as well as the quality of the facilities have been questioned. Equipment and software suppliers also provide application use and technical training as part of their sales strategy. ONATEL, through its National Telecommunications Institute, provides training to its middle-level executive and technical personnel and most courses are open to outsiders. Finally, a major on-the-job training programme teaching government officials the use of computers has been undertaken. The programme has already reached 10% of all government staff and is being administered on a competitive basis by private and public training institutes.

Efforts to develop human resources for IT in Burkina Faso do not only face a qualitative constraint but also a quantitative one. Already in 1995 the supply of IT specialists, including only engineers, analysts, programmers and technicians, was estimated to be around half of the demand. More importantly, however, on the basis of projections of current use of PCs, Burkina Faso will require between 3000-3600 IT specialists by the year 2000. Also, the range of
specialisation will be broader to include, in addition to available areas, those of management of information systems and IT school teachers and university professors, something that existing education and training facilities do not have the capacity to do.

IT human resource availability would only seem to be slightly better in Tanzania. Although no figures are available, the market for IT specialists is characterised by shortage of relevant personnel, particularly at the professional level, high wages for the country’s standards and high rate of staff turnover. A survey of users of IT in Dar es Salaam found that at the level of managers of information systems around 43% of staff was foreign while at the level of systems analysts the equivalent figure was 11%. Programmers and technical support staff was local.

Graduate education in computer sciences and electronics is provided at the University of Dar es Salaam. However, the programs are not very popular due to the insufficient availability of academic staff, teaching materials and equipment. Dar es Salaam Technical College offers computer engineering and computer technology diplomas and courses and has been able to attract a growing number of students (see Table No. 6 for enrolment in IT courses). State-owned management schools offer IT specialities within their programs and the Eastern and Southern African Management Institute (ESAMI) offers short courses in systems analysis and design, programming and database and information systems planning.

State-owned management institutes and private companies all run short commercial courses on the use of specific applications, some of which are provided at the customers’ location. One major problem with IT diplomas and courses is that there is no national standard syllabi or an effective monitoring agency that could guarantee the quality of the delivery. As a result, there is great variability in what is taught and often the training does not produce the necessary computer skills. The Computer Association of Tanzania, a professional body grouping computer engineers and scientists, has been voicing its concern on this issue, so far to no avail.

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11 Senior executive training takes place mainly in France, Gabon, Senegal and Switzerland through programmes of development cooperation.
Table No. 6: Tanzanian enrolment in IT coursework, 1992-1996 (No. of pupils)

<table>
<thead>
<tr>
<th>Year</th>
<th>Course</th>
<th>Degree</th>
<th>Advanced Diploma</th>
<th>Diploma</th>
<th>IT Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>25</td>
<td>20</td>
<td>20</td>
<td>494</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>25</td>
<td>30</td>
<td>50</td>
<td>514</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>25</td>
<td>30</td>
<td>50</td>
<td>699</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>25</td>
<td>30</td>
<td>50</td>
<td>705</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>25</td>
<td>30</td>
<td>130</td>
<td>636</td>
<td></td>
</tr>
<tr>
<td>Total enrolment</td>
<td>125</td>
<td>140</td>
<td>300</td>
<td>3048</td>
<td></td>
</tr>
</tbody>
</table>


South Africa is much more gifted than its fellow African nations in terms of its IT human resources, both quantitatively and qualitatively. In 1995 there were an estimated 25,000 IT professionals, around 0.5% of the non-agricultural workforce and 48% higher than 1989. In 1992 the shares of IT professionals accounted for by programmers, system analysts, managers and others, including database administrators and IT consultants, were 32.2%, 36.8%, 11.4% and 19.7% respectively. Most of IT professionals are whites, who make up 83% of the industry while accounting for only 13% of the total population. Whites also hold a disproportionate share of IT professional jobs as compared with all professional jobs (Table No. 7). Also, males account for over two-thirds of IT professionals and this bias becomes more acute at the managerial level.

Professional computer science education is given at public universities, technikons, technical colleges and teacher training colleges. In 1992 there were 13,819 students enrolled for a computer sciences degree at a university, technikon or technical college, with enrolment growing at around 9% per annum. All of the growth, however, is accounted for by the latter type of institutions, as potential candidates for computer sciences at universities have switched to information management systems courses, normally given at other departments, with far better employment opportunities. There were only 314 computing science pupils at teacher training colleges in 1992, growing at a rate (12.7% pa) that was far below the rate of growth of the demand for computer courses at secondary schools (20.7% pa).
Table No. 7. South Africa: Composition of IT Professional Employment by Gender and Race, 1992 (%)

<table>
<thead>
<tr>
<th>Category</th>
<th>IT Professionals</th>
<th>IT Managers</th>
<th>All Professionals</th>
<th>All professionals excluding nurses and teachers</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>67.5</td>
<td>82.8</td>
<td>52.0</td>
<td>70.0</td>
<td>49.4</td>
</tr>
<tr>
<td>Female</td>
<td>32.5</td>
<td>17.2</td>
<td>48.0</td>
<td>30.0</td>
<td>50.6</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>7.4</td>
<td>4.0</td>
<td>4.2</td>
<td>3.9</td>
<td>2.6</td>
</tr>
<tr>
<td>Black</td>
<td>3.4</td>
<td>0.6</td>
<td>33.4</td>
<td>14.6</td>
<td>76.3</td>
</tr>
<tr>
<td>Coloured</td>
<td>6.2</td>
<td>5.1</td>
<td>9.6</td>
<td>5.6</td>
<td>8.5</td>
</tr>
<tr>
<td>White</td>
<td>83.0</td>
<td>90.4</td>
<td>52.8</td>
<td>75.9</td>
<td>12.7</td>
</tr>
</tbody>
</table>

Source: Hodge and Miller (1996)

Indeed, despite the rapid increase in the number of IT professionals, South Africa still faces a shortage of IT personnel. Salaries for IT professionals are 6% higher than for other similar professions, although some specialities such as database administrators can command premiums of up to 20%. There is also a more rapid career development, with IT professionals taking 7-8 years to reach a managerial post as opposed to an average of 10-12 years for other professions. Vacancy rates of 3.3%, although falling, are higher than the national average. Indeed, surveys of IT professional services firms show that holding to IT personnel is extremely difficult due to supply shortages and competitive bidding from other companies.

In addition to public education, private colleges offer a range of IT courses. These include short up-to-a-week courses that seek creating computer literacy and knowledge of applications and are aimed at interested individuals, the unemployed and corporate clients. Also, they include medium term programming courses as well as occasionally professional IT qualifications fully accredited by the Ministry of Education. In 1993 there were 6114 students enrolled in around 60 courses. Private computer training courses is a fast growing area, expanding at 20% per year and estimates put the value of the industry at around R330 million in 1995.

3.3 Computer literacy

The potential to use IT does not depend only on the capacity of a country to invest and the extent of formal IT training, but also on the ability of the population to use the new
technologies. Although highly correlated with available hardware and formal training in IT at different levels, the concept of computer literacy attempts to capture the effects not only of formal IT education efforts but also of learning processes undertaken individually at home and collectively through on-the-job training and learning. Arguably, learning by doing is one of the main mechanisms of computer education and computer experiences are a key source in successful access. Hence, the concept of computer literacy is an attempt to measure the generic ability of people to tackle IT applications by themselves.

There are few scientific surveys of computer literacy. The only attempt known to have applied this notion in Africa, and exclusively to South Africa, is the World Competitiveness Report that tries to estimate the degree of computer literacy by surveying executives in several countries. The result of a survey of 10 develop and developing countries finds South Africa at the bottom end of the list with a computer literacy rating of 3.1 in a scale reaching a maximum rating of 10 (Table 8).

<table>
<thead>
<tr>
<th>Country</th>
<th>Rating (0-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singapore</td>
<td>7.6</td>
</tr>
<tr>
<td>Japan</td>
<td>7.3</td>
</tr>
<tr>
<td>Chile</td>
<td>5.9</td>
</tr>
<tr>
<td>USA</td>
<td>5.7</td>
</tr>
<tr>
<td>Malaysia</td>
<td>5.3</td>
</tr>
<tr>
<td>UK</td>
<td>4.9</td>
</tr>
<tr>
<td>India</td>
<td>3.4</td>
</tr>
<tr>
<td>South Africa</td>
<td>3.1</td>
</tr>
<tr>
<td>Brazil</td>
<td>3.1</td>
</tr>
<tr>
<td>Pakistan</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Source: Hodge and Miller (1996)

The figures from the previous table, however, are not informative as to the number of individuals that may be computer literate. In order to reach an estimate of computer literacy of the South African population it is necessary to consider that those younger than 5 and older than 65 by and large do not use computers. Given the availability of PCs at homes and schools and primary and secondary school enrolment rates it has been estimated that around 5% of the 5-18
year old population are computer literate. As to the working age group, only around 2-3% of those with primary and secondary education are computer literate, as most are unskilled informal workers and therefore have little access to on-the-job training and computers skills. Of those with vocational training, it has been estimated that around 40% are computer literate, given the group’s relatively higher levels of formal employment (41%), which is where the majority of South Africans learn their computer skills. Of those of working age and with tertiary level education, around 80% are computer literate as, with the exception of nurses and school teachers, who get little computer training, most other professions receive significant computer exposure. All in all, around 3.2 million South Africans or 7.7% of the total population is estimated to be computer literate, although the precise extent of their computer knowledge is far more difficult to ascertain.

3.4 Language ability

Even though the colonial heritage established some of the major international communication languages in the countries under study, their use is far from widespread, something that may be also leading to exclusion.

There is a great variety of languages and dialects being spoken in the three countries, all of which are not at all used for international communication. In Burkina Faso, for instance, around 80 tribal languages belonging to the Sudanese family of languages are spoken by 90% of the population. Tanzania too has a variety of home languages although Swahili is widely understood and generally used for communications while English is only used in commerce, administration and higher education. In South Africa there are eleven major home languages and, while English is taught in the majority of schools, the level of mastery required to make use of IT resources is far from sufficient. It is estimated that on this account alone around 42% of the South African population would be excluded.

It is also worth noting that the fact that the official language in Burkina Faso is French means that not all the information available through INTERNET, which is mainly English, is at the disposal of even the few users in that country.

Like in the case of voice-text conversion techniques, some research is taking place in South Africa on putting more IT resources in some of the other languages and developing language conversion software to translate English-based information. However, the first approach would provide access to IT resources only within limited regions of South Africa and not to those of
the rest of the world and hence probably will not be pursued. At the moment both options are being constrained by lack of financial and linguistic support given the small number of potential users and the several languages involved.

3.5 Apartheid

A major factor of exclusion of South African blacks from the potential benefits of the information revolution has been the apartheid regime. Apartheid was applied in multiple dimensions of economic and social activities and as such had also specific IT angle. Perhaps the best illustration of this is provided by the training of IT professionals.

Apartheid utilised two main interrelated mechanisms to exclude potential black IT professionals, namely, a highly unequal educational system and labour market entry restrictions. Inequalities in the education system materialised in the allocation of resources to black and white universities teaching computing sciences. The latter were endowed with hardware, software and library facilities comparable with newly industrialising countries and in some areas with those of developed countries while most of the former did not receive any allocation for this purpose. Lack of resources was also reflected in the nature of the curriculum offered in computer sciences and in the teaching staff available, with white universities being able to offer a variety of computer specialisations, advanced programming training and a combination of conceptual and applied training, while black ones could only offer more ‘generic’ and conceptual training.

As to labour market restrictions, particularly for management jobs, the most important ones involved either a bias for white universities during the recruitment process because of their better training or simply the outright rejection of a black applicant because of race. An indication of this was already shown in Table No. 7 as blacks accounted for only 3.4% of all IT professional jobs despite accounting for 33.4% of all professional jobs. Indeed, even after nurses and teachers are excluded, two of the professions that were completely open to the black population during apartheid and thus had a less skewed racial distribution of professional employment, black IT professionals accounted for 14.6% of all professional employment. It must be noted too, that the demand for IT professionals is geared towards young new entrants, something that also limits the access of young blacks who lived through the social and political turmoil of the eighties that resulted in even poorer education than that received by their predecessors.
4. MARKET AND PUBLIC RESPONSES TO ECONOMIC AND SOCIAL EXCLUSION

4.1 The role of the market

Markets have a key role in reducing social and economic exclusion and are already doing so. Markets can provide some of the information, products and services that are required by IT users. Markets can also assist with some of the training that is needed in order to access IT. Finally, markets can contribute with some of the specific applications that may help narrow the gaps between those with access to IT and those without it.

Tanzania’s Computer and Telecommunications System (CATS) group, for instance, performed its first mainframe installation in 1975 and was among the first companies selling software in 1987. Since, the company has diversified widely and has become the first distributor of Oracle and Microsoft products, the first to provide IT consultancy and turn-key projects and has established the first computer and IT training centre in the country. The company employs 130 professionals and seems to be profitable. Infotech Computers Limited is another case in point. Launched in 1989 by a Tanzanian entrepreneur as a hardware maintenance and training company, it has become an exclusive dealer for Siemens Nixdorf Information Systems and employs 25 professionals. In Burkina Faso, although fewer than Tanzania, there are similar companies providing IT products and training. Their number is, nonetheless, expected to grow as more IT users emerge.

In addition to companies dealing with ‘routine’ IT-related activities, there are a number of private efforts specifically aimed at ‘including the excluded’. One particularly relevant attempt is the containerised phone shops (CPS) established by South African subsidiaries of foreign telecommunications equipment manufacturers, such as SIEMENS or ALCATEL. The CPS consist of refurbished freight containers housing up to ten telephone booths that can be connected to GSM cellular network and through it to fixed lines. Each booth is equipped with its own radio equipment, a metering unit and a management system to monitor calls and set charges and can be installed in a matter of hours. CPSs have been installed in some rural communities and remain until fixed line telephony is received, after which, they are moved to other communities.
Also, these subsidiaries are locally developing technologies that reduce the cost of connecting fixed lines in rural areas. Linking geographically dispersed users usually requires large investments in cabling and equipment. Usually, telephones or small exchanges are connected to concentrators bringing together a number of lines, which in turn are attached to the public switching system. Concentrators are, however, expensive pieces of equipment that require large numbers of users to be profitable. To reduce costs the SIEMENS subsidiary in South Africa has developed smaller and cheaper concentrators to handle rural areas and a 1000 Km. optical fibre ring that connects these smaller concentrators directly into a larger, primary concentrator. This has made it possible to incorporate a number of previously unconnected rural areas into the fixed line network.

4.2 The role of government and public policy

While private companies can contribute to reduce social and economic exclusion, there are still a number of areas where state and public policy still has a significant role to play. Specifically, there are two areas where the government is already contributing and will continue to do so: provision of basic infrastructure and overall promotion, coordination and regulation of IT developments.

Taking the provision of infrastructure first, the small size of Burkina Faso’s local telecommunications market is forcing ONATEL to take a major role in attempting to modernise the telephone network. There are still a number of manual lines in rural areas that ONATEL has committed itself to replace by automatic lines. Also, around half of the exchanges are analogue and there are plans to convert all of them into digital so that lines throughout the country could be integrated and the speed and reliability of the telephony service improved. ONATEL has also set up the technical specifications and made a call for tenders for the supply and installation of cellular mobile communications equipment, initially to serve the Ouagadougou region and later to expand to other regions of the country.

ONATEL is also convinced that, whatever the short-term opportunity costs of investments in IT, the long-term benefits will far outweigh them and is carrying ahead with plans to provide access to INTERNET to as wide number of users as possible in Burkina Faso. ONATEL is beginning work for establishing a 64 Kbits/second specialised optical line to which private and public computer networks will be linked. ONATEL will be the owner and manager of a backbone line that is expected to be established nationally, although localised private service
providers will be allowed to operate on a commercial basis. It is intended that access to INTERNET will be eventually possible from the public telephone network as well as from cyber-centres to be located in different urban and rural sites.

Other measures undertaken by the Burkina Faso government to improve the establishment of infrastructure include a major investment in IT equipment for the public sector and a significant reduction of import duties for IT-related hardware as a means of stimulating the diffusion of the new technologies beyond the telecommunications sector.

The provision of basic IT infrastructure, particularly telephones, in South Africa is taking a different route. As was mentioned, Telkom has committed itself to add another 4 million lines by the year 2000 through its Vision 2000 programme. Indeed, Vision 2000 is part of a wider government plan to provide 'universal access' to IT. The plan also includes the expansion of the cellular network to rural areas by conditioning the granting of licenses to private firms providing a community telephone service in under-privileged areas at less than half the standard cellular rate. Between the two private cellular providers an additional 29,500 community telephones are to be installed in South Africa. On the basis of developments in fixed and cellular telephony, the government intends then to develop multi-purpose community centres across the country that would provide on-line information, IT training, small and medium enterprise support and community media and resources services. These centres would eventually be run on a commercial basis.

In order to attract more investment into IT infrastructure, the South African government will end Telkom’s monopoly over fixed telephony after the year 2002. New entrants are expected to compete in this market adding new switching networks and international services.

In addition Telkom’s shares will be sold to potential investors and the company may eventually be totally privatised.

Turning to the overall promotion, coordination and regulation of IT, a number of initiatives are beginning to take shape. Burkina Faso has already established an independent body, the Délégation Générale à l’Informatique (DELGI), to propose and implement IT policy. DELGI is involved in researching the diffusion of IT in Burkina Faso, is estimating the demand for IT equipment and human resources, and is spearheading the development of new IT professional
and vocational training programs. Its findings have been incorporated in the National Plan 1996-2000, which prioritises IT development after food and health. DELGI is beginning to take a leading role in disseminating information about the potential uses of IT in government, education and industry within Burkina Faso, developing INTERNET-based promotional content aimed at foreign tourists and publicising the Pan-African Festival of Cinema which regularly takes place in Ouagadougou. DELGI is attempting to assess the IT needs of government and to seek the necessary external funding to purchase the new technologies.

The absence of local private IT companies in Burkina Faso is also prompting policy makers to consider new incentive measures. In order to bolster the local assembly of computers and local software development, proposals are being made to the government to treat these activities as subject to promotional investment benefits. This would mean fiscal support for training and non-wage labour costs. It is expected that the benefits would encourage the emergence of several small and medium IT companies and the development of a local know-how in the field.

In contrast to Burkina Faso, Tanzania has no explicit IT policy. Indeed, until 1986 imports of computers and related equipment was banned on grounds that the country was not ready for them. With the decision to lift the import prohibition in 1986 came several efforts to design an IT policy, particularly by the Planning Commission in 1991 and the Communications Commission in 1996, recommending designing a national strategy to incorporate the new technologies, but few concrete recommendations and actions have come out from these attempts. The only measure taken so far in this direction was the reduction of import taxes on IT hardware and software in 1996.

The lack of official IT policy is prompting the private sector and non-governmental organisations to take a lead in suggesting policy initiatives. The private sector is requesting the government to reduce even further import taxes and red tape for IT products as well as to introduce tax incentives for purchases of IT goods. It is asking for an educational curriculum that integrates IT learning from early stages and for public investment into school computerisation. The private sector also wants a stronger commitment to local science and technology development and lower reliance on foreign expertise. For their part, non-governmental organisations, together with the private sector, are requiring the government to conduct the IT efforts of its different ministries under a single direction as well as to take a lead in bringing together IT specialists, professionals, users, suppliers and relevant official bodies.
IT policy formulation and implementation in South Africa is much more elaborate than in the other two countries. First, it is part of the Reconstruction and Development Programme (RDP), the overall blueprint for post-apartheid transition seeking to balance growth with development and redress the existing racial, regional and structural imbalances in the country. Second, it is embedded in a staged process involving the publication of a ‘green’ or initial discussion paper setting the basic ideas of a new policy, a ‘white’ or framework paper which is the basis for legislation in any field and finally an act of parliament. In the IT field the process has yielded a number of science and technology and telecommunications papers.

In essence, IT policy in South Africa seeks providing ‘universal access’ to all its citizens while at the same time delivering the quality and quantity of products and services required by an expanding economy. In addition to the gradual privatisation of Telkom, this means in the field of telecommunications the establishment of a ‘Universal Service Agency’ in charge of promoting affordable and accessible service in historically disadvantaged communities. The agency will be funded from a levy to be imposed on all fixed and cellular telephone carriers.

Access to IT products will be made more affordable by gradually phasing away any protective measure of local IT products that is inconsistent with the World Trade Organisation (WTO) agreement. However, the government intends actively to promote the exports of South African IT goods, services and technology, particularly within Africa, where it believes the country has unique assets and the ability to develop and deliver African solutions. Indeed, the containerised phone shops developed by Siemens are already being exported to Angola, Burkina Faso, Burundi and Tanzania.

Given that the private sector will take on the lion’s share in the development of the telecommunications and information services industries, the government has also established an independent regulator called the South African Telecommunications Regulatory Authority (SATRA) which will monitor telecommunications on behalf of the public interest. SATRA has also the task of developing human resources for the telecommunications sector through the promotion of interest in IT at school level, training of workers and technicians, designing undergraduate and post graduate educational content and by engaging in relevant research.

Finally, the government has engaged in several major national and international IT initiatives. The first one is the National Information Project aimed at digitalising and harmonising all
available government information. The second one is a complete review and assessment of current information management policies and resources within the public sector. The third initiative is the Research and Technology Foresight Project that includes a focus on IT. This project seeks identifying the key technologies and market opportunities that are most likely to generate benefits for South Africa, developing consensus among the different stakeholders involved in IT development, coordinating research activities and reaching agreement on the actions that are needed to reap desired rewards. Last but not least, the government is actively taking part in shaping what is known as the Global Information Society, i.e. the international forum for discussing and seeking ways of implementing global access to the information revolution. South Africa organised in 1996 a G-7 conference bringing together delegates from government, business and civil society to examine how to reduce the IT gap between developed and developing countries. Since, South Africa has been involved in several follow-up pilot projects aimed at finding technical solutions to existing disparities.

4.3 The role of the international donor and funding agencies

Foreign bilateral and multilateral donor and funding agencies have played a major role in the diffusion of IT, particularly in Burkina Faso and Tanzania (Derniame, 1996). Although no figures are available specifically for IT, an indication of the extent of foreign donor financing for IT hardware and software can be obtained from the ratio of aid to total goods imports. In 1996 the proportion of merchandise imports ‘financed’ by foreign aid amounted to around 55% (World Bank, 1999). Given the limited capacity of these countries to invest and to generate foreign exchange by these countries, there is no doubt that foreign donor agencies will continue to have a key role in the diffusion of IT.

Foreign aid promotes the diffusion of IT by directly funding the acquisition of IT products or through the IT component of most aid projects, as budgets are allocated for computers and related services. For many this is the only means of access to IT. The equipment, software and personnel, however, normally originates or is built to the standards of the donor country, something that is not always relevant to the recipient country nor bodes well for the compatibility of available hardware. Training is provided with different ‘IT philosophies’ in mind complicating even further the possibility of identifying solutions that are widely applicable nationally. Sometimes the objectives and aspirations of donors and recipient institutions do not coincide resulting in unwanted and, as a consequence, unused equipment. Once donor funded projects end, it is difficult to keep the new technologies operating and even more so, to maintain knowledge acquired around them.
Local non-governmental organisations in Burkina Faso and Tanzania have also taken the lead in requesting governments and donor agencies to take into account these factors in formulating their IT policies. Suggestions have been made to governments to monitor, and if necessary to regulate, the flow of IT to avoid unnecessary diversity. It has also been suggested that donated IT equipment and training programmes must always involve a ‘local adaptation’ component. It has been pointed out that it is necessary to introduce mechanisms that ensure intense communication between stakeholders and donors during the lifetime of projects and the continuity of technology and acquired knowledge long after projects have been completed. Donors for their part are being requested to incorporate into their project designs the needs for IT homogeneity in recipient countries and adaptation to local circumstances.
5. CONCLUSIONS

Two patterns of exclusion/inclusion would seem to be emerging in the studied countries. On the one hand, there is a pattern of ‘basic’ or ‘fundamental’ exclusion, as exemplified by Burkina Faso and Tanzania. In these cases, although there is some local availability of IT hardware and applications, the number of computers and telephones is so small and quality of telecommunications infrastructure and services so shoddy that they cannot provide the minimum levels of information and knowledge required for improved judgement and, hence, for enhanced economic and social prosperity. Exploiting the content of the information revolution requires a critical mass of users and levels of literacy, language proficiency and data processing and analysing skills that are not widely available in these societies.

‘Network externalities’, i.e. the benefits obtained by initial members from increasing the number of participants in a network, cannot be reaped because the users are relatively few and the IT resources so scarce, and will continue to be so for some time despite the initial rapid growth given the extent of financial requirements, that they are not able to generate synergies and to become pervasive.¹²

On the other hand, there is a pattern of ‘limited inclusion’ as in the case of South Africa. There is access to a wide range of IT hardware and applications and there are some areas of international excellence. There is also public and private commitment to make access to IT as widespread as possible, including developing special purpose and innovative applications, investing in human capital and leveraging the business potential of the new technologies to create resources for the ‘excluded’. Yet, the quality of access is limited throughout while its distribution is highly skewed towards the minority of the population. Black South Africans have been particularly marginalised from the information revolution.

¹² Bedi (1999) provides the following example: “..., consider a project that permits e-mail access to additional subscribers. New subscribers derive benefits from these services, but so do all other subscribers already connected to the system. The expansion of the system allows all earlier subscribers to communicate and exchange information with new subscribers and vice versa. Thus the gains that accrue to each subscriber rise with the number of other individuals and organizations that have access to the system.” (pg. 5). It follows that maximum gains are only achieved when all potential users are connected to the system.
Reducing the ‘distance’ to the information revolution will continue to require the concerted effort of private and public institutions, non-governmental organisations and the international donor community. Private firms’ role is to exploit arising market opportunities while at the same time creatively generate new technical and business solutions that are applicable to local circumstances. Governments will have to create an enabling environment for IT individual and institutional initiatives to emerge while at the same time provide overall direction and regulation to the acquisition of IT, the necessary basic research and IT focused schooling and training. Non-governmental organisations, in turn, will have to partially bridge the demands and promote dialogue between society at large and key actors. International donor agencies will have to take into account more systematically the local needs in their IT transfer programmes while continuing to be a major provider of funding for new technologies, particularly in basic exclusion situations.
6. BIBLIOGRAPHY


