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Panel II New technologies, innovations and competitiveness



Background Paper

Information and communication technologies: Growth, competitiveness, and policy for developing nations

Prepared by

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Introduction

Information and communication technologies (ICT) have been heralded as the tools for the post-industrial age and as the foundations for a new industrial order. The enormous scale of current investment in ICTs (see Table 1) indicate that this belief is shared by developed and most developing nations. What do these technologies promise that has attracted this level of investment in both developed and developing nations? Have these promises been kept, or will they be, sometime soon?

Evaluating the promise of ICTs has a great deal to do with their role in the particular historical era in which they have come into widespread use, the latter half of the present century. The dramatic and continuing liberalisation of world trade that followed World War II, and proceeded unevenly for several decades, now seems to be well-established, indeed to be a central feature in the global economy. With liberalisation in world trade, the spread of ICT technology and goods derived using ICTs has been rapid with an accompanying emphasis on the issue of "competitiveness." The widespread use of the term competitiveness reflects the growing need of business enterprises to examine their relative position with regard to competitors in the international market and, increasingly, foreign competitors vying for a share of domestic markets. At the level of the business enterprise, competitiveness may be defined in terms of market competition--an enterprise is competitive if it can win a share of domestic or international markets from rivals. The same term, competitiveness, used at the level of a national economy has a somewhat different meaning. It is not simply that the collection of business enterprises comprising a national economy can win a share of the market from rivals, but rather whether the nation is forging ahead in building market shares in business sectors that foster economic growth, employment, and other measures of social welfare. The theory of comparative advantage guarantees that national economies will always have a comparative advantage in the production of some product or service, i.e. they will always be able to win some market share and thus be "competitive" in the sense that competitive is used to describe businesses. However, the product and services in which a nation has a comparative advantage within the international trade theory need not be ones that are dynamic contributors to growth or employment. On the contrary, a perfectly acceptable theoretical outcome for international trade theory is that a nation will continue to trade in goods in which it has a comparative advantage, i.e. ones in which its relative productivity

Table 1.
Apparent Consumption of Electronic Equipment in 1993 (US\$million)

Area/Country	Total*	EDP**	Consumer	Components
<i>Developed World</i>	609,644	168,336	60,164	154,316
United States ¹	251,993	60,186	21,332	61,797
West Europe	196,098	60,633	20,932	40,339
Japan	137,018	39,135	14,820	48,297
Other OECD countries ²	24,535	8,382	3,080	3,883
<i>Emerging Economies</i>	136,341	27,263	20,537	48,784
East Asian NICs ³	35,550	5,034	4,324	18,363
ASEAN countries ⁴	30,060	6,190	2,865	13,678
Latin America ⁵	23,461	7,670	3,222	5,350
Eastern Europe ⁶	11,803	2,414	2,715	2,056
China	18,903	2,549	4,160	5,983
Middle East ⁷	9,332	1,939	1,954	1,991
India	4,119	545	979	936
South Africa	3,113	922	318	427
<i>Major and Emerging Economies</i>	745,985	195,599	80,701	203,100

Source: Yearbook of World Electronics Data Vol. 4, 1995

* EDP, Consumer, Components, Office, Control and Instrumentation, and Medical and Industrial.

**Electronic Data-Processing equipment

¹ Including Puerto Rico

² Australia, Canada, New Zealand. Exclude Turkey and the States of Former Yugoslavia

³ Hong Kong, Taiwan and South Korea

⁴ Indonesia, Malaysia, Philippines, Singapore, Thailand

⁵ Brazil, Mexico, and Venezuela.

⁶ Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Russia, Slovak Republic, Slovenia, and Ukraine

⁷ Israel, Egypt, Turkey, and Saudi Arabia. Data for Israel are of the base year 1993; data for the other countries are estimates on the base year 1991

with respect to trading partners is favourable, while continuously diminishing the real wages of its citizens. As we will explore in this paper in some detail, the use or production of ICT technologies is not itself, a principal determinant of social welfare measures like growth or employment, but it does play an important role in the ability of nations to participate in economic activities where growth and employment prospects are more favourable than would otherwise be available under a pure "comparative advantage" model. Thus, the second theme that we will address is how ICTs strengthen or undercut the efforts of enterprises in developing nations to achieve high levels of international "competitiveness" defined by the contribution of these enterprises to the dynamic expansion of growth, employment, and other measures of domestic social welfare.

The evaluation of the promise of ICTs and the assessment of their contribution to competitiveness are intertwined. To have any hope of untangling the issues and offering a policy agenda for the role of ICTs in developing nations, the claims and counter-claims about these technologies must be clearly stated and tested against experience and the plausibility of projections. In advance, it must be admitted that there are still more questions than answers in this field. For example, Robert Solow (the Noble Prize Winner responsible for modern growth theory) has said that "we see information technology everywhere but in the numbers." Ironically, this statement parallels his earlier discovery that increases in capital and labor inputs could only explain a small share of aggregate economic growth. The huge, unexplained, residual that some have attributed to improvements in knowledge and technology have also been called by Abramovitz, "the measure of our ignorance." It was, however, the identification of the residual that became the basis for a renewed interest in the contribution of knowledge and technological change to economic growth. Economics can best support its claims to being a science when theory responds to facts. ICTs present a number of facts that suggest revision of theory. In particular, the presence of substantial "intra-sector" trade suggests that neither models of comparative advantage nor models of "competitive advantage" are appropriate to the actual patterns of trade in many products including electronics (see Tables 2 and 3 which are discussed in more detail below).

Assuming, for the moment, that ICTs are able to make significant contributions to economic growth and competitiveness, the question arises, what roles might the market and government

policy have in augmenting or limiting this contribution? Answers to this question are closely linked to the specifics of how ICTs contribute to growth and competitiveness. If, for example, it could be shown that the use of ICTs brought a disproportionate share of gain compared to the production of ICTs, we would conclude that the allocation of scarce public resources should favour the promotion of their use rather than their production.¹ Policy interventions are of direct interest because of the dissatisfaction with laissez faire policies for promoting competitiveness² and the urgent need to improve the economic growth of developing nations so that these societies can provide higher material standards of living for their citizens.

In this paper, we survey what can be said in answer to the three big questions: what are the contributions of ICTs to economic growth, how do ICTs influence competitiveness, and what can public policy do to affect ICTs contribution to growth and competitiveness? Our answers to these questions are provisional in the sense that we find that the limits in current knowledge bound what can be definitively concluded and, in particular, limit what can be said about the magnitude of effects that ICTs may have over any relatively short time period. This is a very important constraint because it prevents a detailed setting of priorities or a quantitative allocation of resources in the promotion of ICTs as a pro-growth and productivity industrial policy. Nonetheless, each of the three sections takes up one of the questions we have presented, and offers ideas about how to proceed despite this constraint.

¹ With the additional assumption that learning produced through ICT production has adequate (i.e. similar or lower opportunity cost) substitutes, it is possible to conclude that policy should always favour use over production.

² Neither developed or developing nations are willing to accept market outcomes in the area of competitiveness. Moreover, neither are willing to limit efforts to promote competitiveness to traditional prescriptions such as improving educational standards, maintaining a stable climate for investment, or remedying market failure in the provision of public goods such as scientific knowledge.

Table 2.
Production and Apparent Consumption of Data Processing Equipment and Total Electronic Equipment in Selected Emerging Economies, 1993 (US\$ million)

	Data	Processing	Total	Electronics
	Production	Market	Production	Market
Singapore	12,346	3,471	23,557	12,154
Taiwan	10,014	1,094	19,912	10,866
Brazil	4,600	5,150	12,791	14,511
South Korea	4,212	2,617	29,162	17,898
Thailand	2,648	1,156	7,227	5,473
Malaysia	2,607	776	16,384	7,337
Hong Kong	2,264	1,323	8,835	6,786
China	2,100	2,549	17,663	18,903
Mexico	1,380	2,150	7,496	7,491
Israel	500	874	3,279	3,438
India	428	545	3,633	4,119
Russia	360	765	3,015	4,684
Indonesia	300	337	2,751	3,403
Philippines	260	450	2,599	1,693
South Africa	209	922	1,192	3,113
Venezuela	176	370	546	1,459
Turkey	160	622	2,117	3,601
Saudi Arabia	86	318	433	1,711
Egypt	33	125	156	582
Other Emerging Economies	604	1,644	4,054	7,119
Emerging Economies	45,287	27,263	166,802	136,341
Major and Emerging Economies	200,546	195,599	776,501	745,985

Source: Yearbook of World Electronics Data, Vol. 4, 1995

Table 3.
Production and Apparent Consumption of Data Processing Equipment and Total Electronic Equipment in Selected Developed Countries, 1993 (US\$ million)

	Data	Processing	Total	Electronics
	Production	Market	Production	Market
Japan	58,757	39,135	212,180	137,018
USA ¹	53,809	60,186	224,429	251,993
United Kingdom	7,993	10,570	26,127	32,094
Germany	6,861	13,487	42,061	49,130
France	6,431	9,236	27,579	31,697
Italy	6,148	6,758	18,609	22,881
Sweden	488	1,842	4,703	6,018
Other OECD Countries	14,775	27,122	53,911	78,813
Developed World	155,259	168,336	609,699	609,644
Major and Emerging Economies	200,546	195,599	776,501	745,985

Source: *Yearbook of World Electronics Data, Vol. 1, 1995*

¹ Including Puerto Rico

What are the Contributions of ICTs to Economic Growth?

The claim that ICTs are important tools for economic growth in the present epoch involve a projection from a small number of relatively undisputed trends. The first trend is that economies throughout the developed world have in the last two centuries been able to achieve higher levels of sustained, or long term, economic growth by transferring agricultural to industrial labour through the use of fossil fuels for motive power, the improvement of mechanically based technologies of mass production, and the establishment of new forms of social organisation such as the factory. The basis for this sustained growth was the realisation of much higher productivity in industry than had been possible in agriculture. Higher productivity made it possible to sustain economic growth rates in excess of the rates of growth of either labour or invested capital and, in turn, made it worthwhile to steadily raise the amount of employed capital per worker. Correspondingly, agriculture itself was transformed beginning in the 19th century through the use of fossil fuels, originally for transportation, and then, later for uses such as motive power in the field, irrigation, and chemical fertilizer. Mechanical technologies used in agriculture further displaced agricultural labour into the industrial sector. These transformations relied upon the availability of productive opportunities in the industrial sector; otherwise the displacement of agricultural workers would have created massive structural unemployment and impeded the growth of demand for industrial output.³ Nonetheless, the extent of gains available from the transformation of agricultural into industrial labour were finite. In industrial nations, most of these gains had been realised by the first half of the 20th century. During the second half of the 20th century, the industrial growth of developing nations may have been constrained by the existence of the productive capacity of already industrialised nations.⁴ By the first

³ In practice, problems of structural unemployment and underemployment have only materialised relatively recently, and are most pronounced either in developing countries where industrialisation has proceeded slowly or in advanced economies where substantial welfare state provision has limited employment at lower wages.

⁴ Economic theory appears to explain away this problem through the doctrine of comparative advantage which concludes that gains from trade can always be made based upon the relative productivity of nations. One problem with the application of this theory is that the speed of transition in agriculture has the potential to displace labour at a faster rate than it can be absorbed into the industrial sector, i.e. as new productive

half of this century, most of the possible gains from this transformation had been realised in industrialised nations while developing nations, for many reasons, have experienced difficulties in fully entering this process.

The promise of ICTs for addressing manufacturing productivity in developing nations is that substantial productivity advances would allow a substantial expansion of industrial output. Such output expansion, if large enough, could substantially influence the creation of employment and the creation of wealth. Because ICTs are often labour-saving, a large increase in output is necessary to raise the derived demand for labour, net of the labour released through productivity improvement. Otherwise the impact of ICTs may be to reduce labour inputs, an undesirable outcome if there are not satisfactory alternative employment alternatives which is common in developing nations. The promise is partially supported by observed technical progress in the performance of ICTs. Much of this progress has been the direct result of the application of materials science to the production of modern ICTs. The earliest, and still the most important of these applications, is the use of semiconductors for the production of computers, telecommunications equipment, and related electronic devices.

Technological improvement in semiconductor technology, as measured by the cost and speed of performing narrowly defined functions, has advanced at rates that were unprecedented for other manufacturing technologies such as power generation using fossil fuels or improvements in machine operating speeds through improvement in mechanical technology. The rapid advance in *technical characteristics*, which have also led to dramatic falls in price per unit of performance, have generated optimistic expectations about the contributions of information technology to manufacturing productivity growth. Unfortunately, there is a "slip between cup and lip" in the translation of technical characteristics improvement to productivity growth, the role of organisational change in translating technical performance

opportunities can be developed in industry for domestic and foreign demand. Another is that the terms of trade are determined by the relative productivity of trading partners. If developed nations productivity advances substantially outstrip those in developing nations, the consequence is slow growth or even a decline in real wages offered in developing nations, a development that reinforces adjustment problems of absorbing agricultural labour.

of inputs into productivity and growth. The issue of organisational change has implications for the contributions of ICT use to both economic growth and competitiveness. In this section we focus on how ICTs influence economic growth while in the next we return to the organisational issues as a determinant of competitiveness.

Productivity gains from the use of information technologies involve improved control within individual production processes, smoother integration of individual production process, and better control in the acquisition of inputs and the disposition of outputs. Communication technologies play some of these same roles, but are also particularly important in coordination, e.g. relaying detailed information about inventories and scheduling throughout a distribution system. The productivity gains from ICT are realised through cost-reduction, with reduction in material inputs, labour, and capital. The relative shares of these reductions differ across industries and over time, but labour saving is a principle source of cost-reduction. In addition, ICT use may make it possible to produce more or higher quality with the *same levels* of inputs, i.e. productivity advances that are independent of changes in input use.

Growth in the use of ICTs in manufacturing appear to involve greater flexibility and changeover speeds as well as shortened and accelerated flows of materials for processing, work in process, and finished good inventories. These changes suggest a transformation in methods of organising production systems from traditional models of mass production. At the same time, however, ICTs can augment the centralisation of control and routine to reinforce systems of mass production based on the innovations of Ford and Taylor. The tradeoff between the creation of new organisational models and the augmenting of old is essential for evaluating the issue of competitiveness, and thus is developed more fully in the next section. Here, however, we note that the tradeoff in the use of ICTs appears to favour transformation rather than reinforcement of existing mass production methods. While ICTs do offer gains in improving traditional techniques, simpler control systems (such as the Japanese paper-based kanban system of work in process inventory) offer many of the gains of ICT-based manufacturing, without the complexity and overhead costs of full employment of ICTs. Moreover, much of the value of ICTs in reinforcing existing mass production

systems relies upon a high level of development of market institutions including advanced transportation, communication, and distribution infrastructures.

It is true in principle, however, that ICTs can play a role in compensating for particular deficiencies in market infrastructures. For example, deficiencies in the transport infrastructure can be ameliorated through the use of remote communication technologies. A lorry driver stranded in a traffic jam can notify the destination of the delay using a cellular phone and identify alternative routes using local radio communication, or, even better, all of this information can be coordinated through a sophisticated logistical control network that seeks the best set of decisions given the specific problems of the environment. As yet, however, the most advanced of these applications do not seem to be widespread. At the same time widespread deployment of ICTs, without organisational change, is unlikely to reproduce the sorts of historical productivity advances experienced in the last century of manufacturing improvement. It does little good for the lorry driver to notify the destination of delay unless this message can be transmitted to the "shop floor" in a way that alters the composition of work activities which presumes a high degree of flexibility and ease of "reconfiguration" of production processes and tasks.

Our simple example, the lorry driver, is only an illustration of a very large class of specific actions within the social and technological networks comprising modern manufacturing organisations. Most of these networks have evolved for several human generations and are not amenable to rapid alteration or reconfiguration. This is the essence of the problem of reforming manufacturing organisation to fully exploit the productivity potentials of ICT.

The second trend underlying the claim that ICTs are the tools for economic growth is that, beginning in the second half of the present century, improvements in the productivity of manufacturing labour in industrialised nations that have largely been independent of the use of ICTs, have made it possible to expand other economic activities, conventionally referred to as the "service sector." The service sector encompasses an enormous range of activities, ranging from professional services such as medicine to personal services such as hair stylists. Reproducing the historical gains in productivity experienced in manufacturing within the service sector has proven to be a much more intractable problem for which ICTs have been

seen as an important solution. The hope for ICTs in the service area begins with the observation that ICTs are a major component in the predominant form of physical capital that service industries employ. The statement that ICTs are the tools for productivity improvement in the postindustrial or information society age is based on the premise that ICTs will produce productivity gains that match or exceed those that have been historically experienced in manufacturing technologies. With such productivity gains it would be possible to indefinitely sustain the growth of economic output and productivity despite the trend toward a growing share of this output being produced in service sectors.

The possibility of indefinite growth in the production and consumption of services is encouraging for both developed and developing economies. For developed nations, an increasing share of output in services is consistent with increasing investments in human capital or the dispersal of industrial activities domestically and internationally to reduce localised environmental problems. For developing nations, the growth of services provide domestic growth opportunities that can absorb labour displaced by productivity improvements in agriculture and industry and that are less challenged by imports from developed or other developing nations.⁵ The corresponding problem for developing countries is to find ways to upgrade the value and quality of services so that service sector employees experience increasing wages over time. Doing this, of course, requires improvements in the productivity of the service sector. Thus, both developed and developing nations face a common challenge in finding ways to improve service sector productivity.

Again, however, it is the issue of organisational change that provides a fundamental barrier to translating the rapid technological advance of ICTs into productivity gains. Developing and implementing the organisational changes that would permit ICT use to have the same productivity impact in services as previous organisational changes had in manufacturing has proven a very difficult task for several reasons. First, in the service sector, mass production is the exception rather than the rule. The absence of mass production makes it difficult to

⁵ For example, the use of ICTs can create a domestic demand for software and system engineering services, creating jobs that offer a higher value added than many other service occupations.

engineer ICT solutions that can be applied across a range of service activities, a problem that is often reflected in the costs of software development.⁶ Second, ICTs are often used in the service sector to further differentiate products, removing them even further from the mass production and consumption model. For example, in financial services, where the ICTs do support economies of scale in transactions processing they also permit the creation of many new services.⁷ Third, none of the available models for organising ICT-intensive organisations has achieved the dominance or prevalence of the Fordist model. Indeed, referring to the variety of models for restructuring production using ICTs as post-Fordist models conveys a much greater degree of unity among them than in fact exists.

The service sector may seem to be of secondary importance for the developing nations, where it is often the case that a first priority is to develop manufacturing because of the "leverage" that manufacturing offers in stimulating the development of other economic activities. Moreover, ICTs' contribution to productivity advance in services are to reduce the number of workers, something that is seen as undesirable in developing economies dealing with the labour displacement effects of productivity improvements in agriculture and the rapid growth of populations through improvements in sanitation and public health. Industrialised nations face a productivity "drag" from the growing share of labour in services where they have lower productivity than in manufacturing. Developing countries often have an inadequate overall level of personal income and development of markets to support a high value-added service sector. In these countries, most services are personal services, and even so, too few opportunities exist to absorb the available labour. While there is some truth in these arguments, they are also misleading.

There are several reasons to believe that developing nations could benefit from productivity improvements in services. First, in developing nations, governments often absorb relatively large shares of national output and most government activities are involved in the delivery

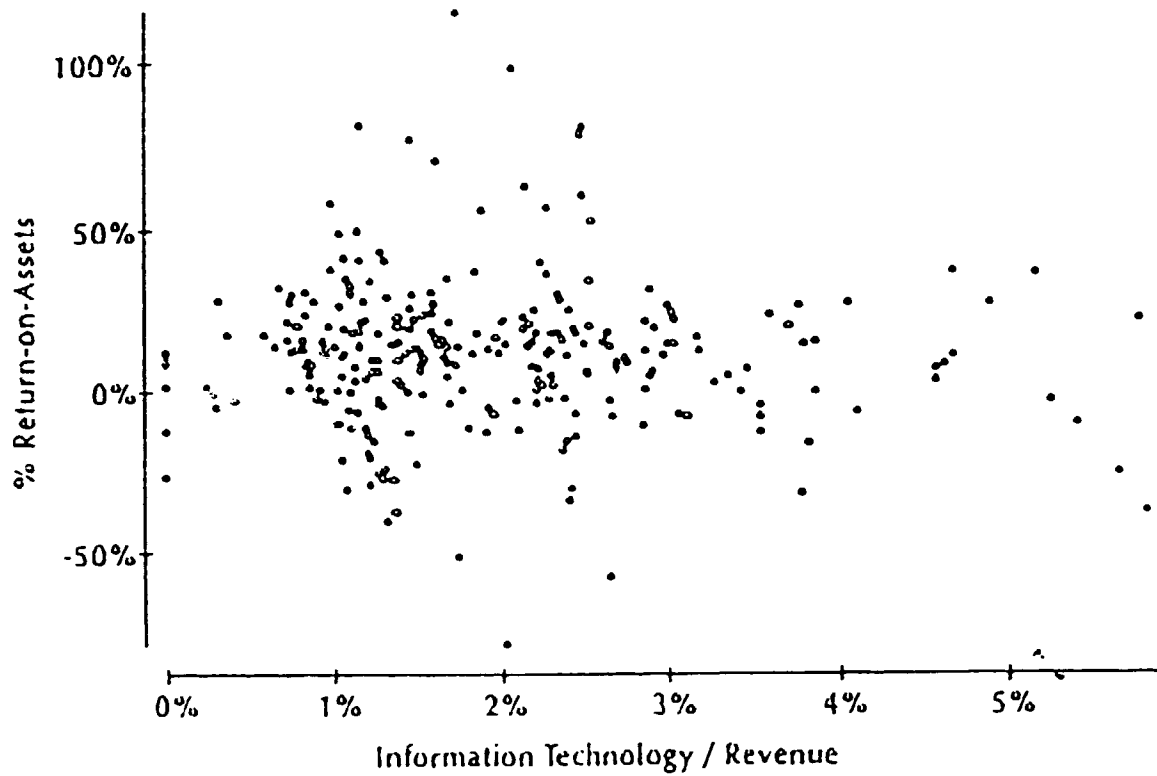
⁶ See Steinmueller [1995].

⁷ Of course the proliferation of new services does not tell us about expected gains or losses in productivity. Factors other than ICT productivity that influence productivity in this area include the costs of complements such as the input of skilled labour to explain and sell these services.

of services. Hence, improvements in productivity in government services could free resources for private investment. Second, services are often close complements to manufacturing. For example, the effectiveness of the retail and distribution sector of an economy influences the growth of manufacturing by providing more efficient market outlets for manufactured output. Third, developing nations are increasingly faced with the problems of harmonising their production systems with the use of ICTs in developed nations so that they can serve as suppliers and sub-contractors in an increasingly global division of labour. This process of harmonisation requires adoption of ICTs not only at the "service" level of the firm, e.g. the front office and the communication links to developed nation suppliers, but also within the production process to control quality and scheduling in ways that are consistent with customer demands. Many of these harmonisation problems, nonetheless, are reflected in demands for services that, without the extensive use of ICTs, serve as barriers rather than complements to improvement in international trade and that absorb resources that could otherwise be used directly for production. Fourth, and finally, productivity improvements in both services and manufacturing are worthwhile wherever they may be achieved. Having more output using the same amount of inputs is of benefit in whichever sector it is achieved. To the extent that ICT use achieves greater productivity through releasing labour, the problem is to develop other opportunities for their employment (or remove barriers to this adjustment) rather than to lock them into employment patterns where they have low productivity.

The results of ICT use in manufacturing and services are realised at the level of the organisation and the economy. Given the substantial organisational requirements of employing ICTs and the uneven pattern of diffusion these technologies, it should come as little surprise that, at the level of the organisation, that there are substantial uncertainties about the returns to investments in ICT technologies. In particular, the intensity of investment in ICTs is not likely to be a good short run predictor of profitability or revenue growth. Moreover, available evidence does not support the argument that such investments are likely to yield a large positive present value. Figure 1 shows one of the classic results from the literature on the returns from IT investment for a developed economy, the United States. It arrays the extent of investment in ITs on the profitability of enterprises. Care is

Figure 1.



Source: Paul A. Strassmann, The Business Value of Computers, New Canaan, Connecticut: The Information Economics Press, 1990.

necessary in making conclusions based on this sort of diagram since we would expect that economic competition would eventually eliminate high profit levels in any area of investment. It might therefore be more interesting to compare investment in ICTs with the growth in revenue or, more precisely, value added over time. Brynjofsson and Hitt [1995] provide such an estimate for 300 large U.S. firms in 1988-1992, concluding that the marginal product (value added) associated with investments in information technology was positive and yielded a relatively high financial return.⁸ Earlier firm and sector studies, however, have found that over earlier (and longer) periods less positive results.⁹ It is uncertain whether the positive results for the more recent period are the consequence of a "turning point" in productivity contributions of ICT or reflect the short run effects of business restructuring.

These studies use disaggregated data from the U.S., i.e. the country where ICTs have been most extensively deployed over the longest period of time. They are also based on a mixture of service and manufacturing enterprises. We have, however, suggested that ICTs had a particular significance for the service sector where they are seen as the tools for reproducing the productivity-improving performance of manufacturing technologies. While it may appear that this trend is of most interest in developed nations where the growth of the service sector is the most important source of employment and revenue growth, it is also significant for the reasons suggested above, in developing nations.

In considering the service industry alone, the available evidence suggests that productivity improvements from the use of ICTs have been insufficient to slow the advance of costs from the addition of labour. In other words, the growth of service sector output in the service

⁸ Also see Lichtenberg [1995] and Jorgenson and Stiroh [1995] for similar conclusions using related methods.

⁹ The results of Loveman [1994] were that the marginal product of IT was indistinguishable from zero. For sector studies, see Morrison and Berndt [1990] who analysed two digit U.S. SICs for the period 1968-1982 and found a value added yield of eighty cents on a dollar of IT investment.

industry is closely paralleled by a growth in labour inputs, and therefore labour costs.¹⁰ This trend means that opportunities for economic growth in developed nations are becoming linked to the ability to move labour to higher value added service activities. Thus, higher levels of economic output can be achieved by developing higher value added service activities such as engineering, finance, and logistics rather than lower value added service activities such as personal services (e.g. hair stylists, retail clerks, and food and lodging service workers). This transformation is problematic for two reasons. First, lower value added service activities are often strong complements to higher valued added service activities. Thus, retail service clerks are often required for the generation of value added from product design engineers. Moreover, while the latter services can be exported to developed nations and are one market in which developing nations can compete, the former cannot be imported by developed nations.¹¹ From a developing country viewpoint, the inability to export the services that are complementary to the delivery of goods and services is a substantial market barrier. Second, most higher value-added service activities require a high level of educational attainment within the labour force. Thus, the ability to generate these activities requires time, significant inputs of public funds, and a social and cultural framework that supports the development of these kinds of skills. These reasons suggest caution in expecting rapid growth or productivity advance through the movement of activities within the service sector.

Our conclusions about ICTs' contribution to economic growth and productivity are based on empirical results from advanced industrial countries and on first principles arguments about the consequences of these developments for developing countries. The results from U.S. experience (which appears to parallel the experience of Europe and Japan where fewer empirical studies are available¹²) suggest that reproducing the enormous gains in

¹⁰ Baumol, Blackman, and Wolff [1989].

¹¹ It may be possible, however, to import labour to perform some of these services. This strategy is falling into general disfavour in developed nations.

¹² See Cane [1992] for an overview for OECD countries. For related work see Kwon and Stoneman [1995] and Wyckoff [1995].

productivity that were achieved in manufacturing over the past century, or even in the last half century since the end of World War II will require far more than the rapid technological progress that has come in the performance characteristics of ICTs. Large productivity advances will require fundamental organisational changes that have only begun to be made and are proceeding at very different speeds and in many different ways among the service and manufacturing industries that intensively use ICTs. This same pattern of heterogeneous and uneven development appears to characterise developing nations use of ICTs. Thus, there is substantial risk in seeking consistent positive contributions to economic growth or productivity from the use of information technology. If the promise of ICTs for economic growth is ambiguous, it is still possible that ICTs are necessary for improving, or at least maintaining, the competitive position of companies. This issue is the first theme of the next section.

While broad utilisation of domestically produced ICTs in domestic economies would be a complementary mechanism for producing economic growth, the extent of internationalisation of ICT production suggests the additional possibility of further entry in these industries as a means of fostering economic growth or raising productivity due to the generally higher productivity in ICT industries. The strategy of domestic ICT production is the second theme of the next section.

ICTs, Organisational Change, and International Competitiveness

On the shop floors and in the offices of modern enterprises of both developed and developing nations, ICT use implies forms of organisation that are antagonistic to the traditional hierarchical division of labour. Achieving the productivity gains from ICTs most often requires restructuring both the organisation and the content of labour's contribution to economic output. A persistent and incorrect view of the role of ICTs is that they could be productively employed as direct substitutes for unskilled labour in production activities and that the managers and designers of industrial work processes would be able to employ a more pliant and reliable labour force of automated machines rather than workers. Experience in the use of ICTs has demonstrated that the information acquisition, filtering, and transmitting operations performed by *middle managers* are often the ones that are bypassed through the

use of ICTs, making these managers redundant at a faster rate than labour employed directly in production. Moreover, implementing the new production technologies requires a skilled and flexible labour force that can solve problems on the shop floor independently of the guidance of the industrial designers. Precisely because of these tendencies, the adoption of ICTs in industrial applications is often resisted by the hierarchical structures created by earlier stages of the industrialisation process.

The contradiction between ICT use and hierarchical organisational models is, however, a relatively recent development. ICTs have also been part of the continuous development of the factory and the related organisational innovations of Fordism and Taylorism. These earlier developments involve a distinctive pattern of information use that Beniger has called the "control revolution."¹³ The "control revolution" extends and regularises the hierarchical system by making the division of labour more systematic and by structuring production activities in ways that multiply the productivity of individual productive operations (problems that have created new disciplines such as operations research and production management). These advances have allowed productivity improvements well beyond those that would be available solely as the result of the improvements of individual machines or the application of fossil fuel-based motive power to production and have created a distinctive pattern of economic organisation involving mass production and consumption in which the large enterprise has played a central role.¹⁴

Thus, there is a competition or trade-off between uses of ICTs in developing new forms of organisation that are antagonistic to the existing mass production and consumption system and uses of ICTs that extend and regularise the mass production system. While the outcome of this competition is still uncertain, it now appears that ICTs have a greater impact in fostering new forms of organisation than they have in reinforcing the traditional forms. Throughout the developed nations, larger organisations are engaged in a process of re-examining their

¹³ Beniger [1986]. See Hughes [1989] and Hounshell [1984] for more complete histories of these developments.

¹⁴ See Chandler [1990] and Porter [1990] for the basis of this conclusion.

internal structure to identify their "core competences" and have broadly adopted policies of outsourcing component and sub-assembly operations to smaller and more specialised suppliers, distribution to independent agents, and so forth. The role of ICTs in this process is consistent with the theory of the firm offered by Ronald Coase who observed that the competition between internal or managerial organisation of economic activities and market organisation was determined by the relative efficiencies of managerial and market coordination. ICTs play an important role in reducing the transaction costs of externalising economic activities and thus contribute to a movement toward outsourcing.¹⁵

Developing nations face many of the same basic problems as developed nations in the use of ICTs to improve manufacturing productivity. They, too, face the tradeoff between the use of ICTs to augment hierarchical organisational models and the possibilities of new organisational forms. Developing nations are, however, further influenced by the pattern of ICT use in developed nations. As developed nations use ICTs to move toward greater levels of outsourcing, developing nations experience reduced market barriers and are more likely to be able to become suppliers. To participate in these markets, however, developing nation enterprises find it necessary to develop the ICT links to integrate themselves into the supply chains being created for such activities. Moreover, as developed nations utilise ICTs to improve the level of their manufacturing flexibility and the variety of products, enterprises in developing nations face competition that is more difficult to meet using traditional mass production methods and are forced to consider also adopting organisational models that reduce hierarchies and that more closely link production activities with market demand.

Thus, developing nations do not have the option of ignoring ICTs because industrialised countries are in the midst of organisational transitions that involve higher ICT use. To the extent that developing nations hope to develop export markets for their manufactured outputs, particularly those that are intermediate goods or that are linked to increasingly ICT-intensive retailing activities, the systems that manufacturers employ must increasingly be compatible with the emerging new industrial models based on more intense ICT use. Examples of these

¹⁵ Coase used the specific example of a communications technology, the telephone, to illustrate his argument.

developments include the growing emphasis on international quality standards with high levels of information content, the specification of product design using computer aided design and manufacturing, and the coordination of product delivery (including "just in time" and "sales driven" production) using high levels of ICT. Developing countries thus have an "offensive" strategic interest in adopting ICTs to maintain their competitiveness in export markets.

Moreover, the liberal international trade environment that has characterised the "new world order" offers developing nations access to new markets (although developed countries maintain substantial import barriers in some areas) provided that they open their own markets to import competition. Imports from nations that employ ICTs to augment the flexibility and tighten control of the production process can offer formidable competition even with large differences in wage rates. Competition for domestic markets from exports in developing nations makes it necessary for developing country enterprises to adopt similar tools for achieving flexibility and variety that their competitors in developed and other developing nations are coming to employ. Thus, the adoption of ICTs involves a "defensive" strategy for developing country enterprises to maintain their own domestic market position.

"Offensive" and "defensive" strategies in the use of information technology in production processes influence a growing share of output in developing nations and account for much of the growth in the use of ICTs. ICTs also may be consumer products, however. In Table 1, we examine the size of EDP and consumer electronics markets (apparent consumption) in various regions. Several interesting results emerge from this Table. First, in the U.S. and Western Europe, the ratio of EDP markets to consumer electronics is approximately three to one, while in Japan consumer electronics markets are slightly larger in relation to EDP reflecting the lower penetration of computers, especially personal computers. In the emerging economies, it is particularly notable that the NIEs (along with Eastern Europe, China, the Middle East, and India) have a much lower ratio of EDP to consumer electronics than in the developed countries. This is not the case, however, with South Africa, the ASEAN countries, and Latin America, indicating these countries or regions are using ICTs as part of their defensive and offensive strategies for maintaining competitiveness. To see this, one needs to hypothesise that some proportion of data processing demand is actually

demand for consumer electronics (the consumer use of personal computers). The relatively smaller size of consumer electronics markets in South Africa, the ASEAN countries, and Latin America suggests these countries are using EDP equipment in production and service activities more intensively than the NIEs *or*, less believably, that the former countries have a much higher share of data processing equipment demand for consumer use than the latter. Further research is needed to examine how the NIEs have been able to be as successful as they have been in export led strategies with such a modest level of EDP use.¹⁶

These findings suggest that a number of the developing nations are finding increasing applications of computers as intermediate inputs in manufacturing and services. In other words, they are adopting some mix of the "offensive" and "defensive" strategies in the use of ICTs. A particularly interesting question that we are unable to answer is what the mix is between the strategies in ICT adoption. Of course this is not a black and white sort of issue. Firms that are principally oriented toward international markets may also have important domestic market positions while strong domestic firms may also seek export opportunities. Nonetheless, evaluating the impetus of export competitiveness against the impetus of domestic competitiveness in the adoption of ICTs is very important. When, for example, it is possible to maintain domestic competitiveness with a more modest (or no) use of ICTs while export activity requires a high level of use of ICTs then a much more focussed policy regarding ICTs may be employed. Considerable research remains to be done on how and where ICTs are employed in developing economies. At present, much of the evidence about the relative significance of these two strategies is anecdotal and there are major questions about how the balance between them is developing over time.¹⁷

The rise of ICTs, and particularly computer and data communication technologies, over the past half century has encouraged a variety of strategic responses from nations that found themselves lagging the pace of advance. The most common response has been one of

¹⁶ Hobday [1995] has provided some important insights into this issue.

¹⁷ Statistics on the internal production and the distribution of ICTs in developing countries are notoriously difficult to acquire and either a little or a lot might be happening behind this curtain.

indifference, treating these technologies as similar to other advanced producer goods that must be imported and utilised according to the choices of business enterprises. While this may have been the most common strategic response, several other strategic models have been adopted, all of which are related to strategies of promoting domestic production of ICTs, the second theme of this section.

First, beginning the 1960s larger European nations became concerned about gaps between their national capabilities and those of the United States and adopted policy often called the "national champions" strategy of encouraging, through procurement and subsidy policies, of strengthening a single large firm in the computer industry, e.g. Bull in France or ICL in the United Kingdom, and, similarly, a system of national preferences for telecommunications equipment. These policies had a significant impact because of the rapid growth and absolute scale of government-related demand for mainframe computers and telecommunications equipment in those nations.

Second, beginning in roughly the same period, Japan started moving its domestic manufacturing of electronic products to higher value added products with the object of strengthening its export capabilities. While these cases differ in the weight assigned to export performance, they were similar in being an attractive direction for industrial policies that were dominated by structural readjustments in traditional industries such as steel, textiles, and, shipbuilding. The idea of "sunrise" industries and the need to participate in these rapidly growing industries was consistent with the effort to achieve higher rates of long term economic growth by assuring that a share of such growth would come from industries that had higher than average expansion. The Japanese strategy, in turn, became a basis for "export led" expansion in several other Asian economies including South Korea, Hong Kong, Taiwan, and Singapore. Initially, these economies chose industries other than those based on ICTs, but by the 1970s, ICTs became an important part of their portfolio.

During this period a third strategy emerged in some of the developing countries, particularly in Brazil and Mexico which was based on the simultaneous arguments of improving domestic supply capabilities and "sunrise" industry growth as a contributor to raising national output. Given that these nations lagged behind the technological level at which ICT-based goods were

available on the international market and had accumulated large trade deficits in the sector, they elected a policy of market closure and "import substitution" to provide the incentives for the development of domestic production capability.

A full assessment of "import substitution" ICT policies is beyond the scope of this paper. There are, however, two outcomes worth noticing. First, import substitution did create significant domestic production capabilities in ICTs, and some of these capabilities seems to be surviving the reversal of these policies in the past decade. Import substitution policies also created capabilities that have been unable to sustain competition from imports and the elimination of import barriers in these areas, particularly in telecommunications as suggested by the Mexican experience (although Mexico has fared increasingly well as an exporter of electronic products generally), have most often led to a collapse of the domestic industry. The second outcome is that import substitution has proven rather ineffective in creating domestic production capabilities that support exports to any other market. In principal, it is plausible that developing nations might share common needs for ICTs that differ from those in industrialised nations. In practice, however, it seems that either problems in inter-country trade within the developing world or the modest value of product differentiation prevented the establishment of substantial export markets among developing nations.

Protectionist policies are not always based on the logic of import substitution. Historically, many of the newly industrialising economies that have built significant ICT industries have employed protectionist policies. These nations have adopted an "infant industry" growth strategy in which incentives for domestic ICT production capabilities were focussed from the outset in achieving international competitiveness. We are not suggesting that this outcome was ignored or was undesired for those countries adopting "import substitution" policies. The difference was in the incentive structure. While the nations that adopted "infant industry" policies protected domestic industries, they did so with a credible and closely monitored policy that such protection would be temporary and would only be continued if definite progress was made in export performance. Under this structure of incentives, protected domestic industries in several nations did succeed in reaching an international

standard in a decade or less and were able to survive, and indeed prosper when such protection was removed.¹⁸

Having achieved success, infant industry policies are relabeled the "export led" growth strategy, in the process, shedding the recognition that most of the nations that are now identified as successful implementers of "export led" growth strategies once had protectionist import policies. The historical opportunity to exercise protectionist policies may not be available at present since a parallel development of the last decade has been a much closer attention to all forms of protectionism with the consequence that nations adopting protectionist policies, regardless of motive, face more rapid and intense pressure to eliminate such policies. Moreover, it is unclear how many more nations can be admitted to the "club" of export-led growth economies given the turbulence caused by rapid displacement of industrial labour forces in other developing and developed nations or the absolute capacity of the world economy to absorb a more rapid rate of growth in the supply of ICTs.

It is ironic that, while the effective use of ICTs often involves the dismantling of mass production systems, the production of ICTs is heavily reliant on mass production techniques and is therefore already highly efficient in terms of labour inputs. Thus, moving employment toward ICT production will often improve productivity but will not contribute very much to employment growth. It is, nonetheless, true that the leading countries in ICT production, Japan and the U.S., have high employment in this sector because of their very high level of output in this sector. Moreover, the newly industrialised economies of the Pacific Rim including Singapore, Taiwan, South Korea and Hong Kong as well as two industrialising economies in the region Thailand and Malaysia have generated substantial output (see Table 2) and employment through "export led" growth based on ICTs, again through the development of large outputs. Thus, there are real potentials for economic growth in the production of ICTs. It remains an open question, however, how far this strategy can be employed by developing countries since the "export" led strategy depends upon international competitiveness in a manufacturing industry where economies of scale are often important

¹⁸ Even in these nations the problem of administering protectionist policies created distortions in the use of imported components.

and the increase in output of ICTs is growing at an enormous pace, perhaps one that will challenge the absorptive capacity of the world economy relatively soon. Again, the issue is whether new members can be added to the "club" of ICT-based export-led economies. Evidence about the length of time required to develop a significant export capacity in ICTs is mixed.

To gain some insight into these issues, we have examined the pattern of international trade in two segments of the ICT sector, data processing equipment and their parts over the past decade which we will refer to as DPEC. The results are summarised in Tables 4 and 5 which regard current U.S. dollar imports and exports for 1983 and 1993. Table 4 reports the results for developing economies and Table 5 reports the results for industrialised nations. These tables should also be examined in relation to tables 2 and 3 which provide production and apparent consumption figures for the same countries. Tables 4 and 5 should be examined with substantial qualification, however, as the 1983 figures largely omit Computer Parts (SITC 759.95 Rev. 2 and SITC 759.97 in Rev. 3). This is true for both developed and developing countries. Nonetheless, the size of the growth of production is overstated in these tables.

First, despite the reservations about coverage, Tables 4 and 5 indicate the enormous growth in international trade in DPEC products over the decade. The significance of DPECs in international trade for the developed world was established in 1983 but was of minor significance in the developing world. In the intervening decade Singapore has achieved extraordinary gains in its exports, passing the United Kingdom and achieving export values greater than half of the value of the U.S. or Japan. While no other nation has achieved such a phenomenal record of growth, the performance of Korea, Thailand, and Hong Kong is also remarkable, particularly Thailand which grew a \$2.5 billion export industry from an insignificant base in 1983.

Second, Table 5 demonstrates that the developed nations are net importers of DPEC products. In the countries that we have selected for this table this is not, except for the case of Sweden, the result of export weakness, but rather the growth of domestic demand as can be seen by comparing the first two columns of Table 3 which reports domestic production

Table 4.

Imports and Exports of Data Processing Equipment (SITC 752) and Parts (SITC 759.95 in Rev. 2 and SITC 759.97 in Rev. 3) in 1983 and 1993. Ranked by 1993 (or most recently available year) exports.

	1983		1993	
	Imports US \$000	Exports US \$000	Imports US \$000	Exports US \$000
Singapore	188,990	301,469	6,978,455	15,876,116
Korea	204,069	116,262	1,698,019	3,296,984
Thailand	23,488	85	1,539,089	2,478,609
Hong Kong	161,832	84,438	3,797,366	1,799,968
Mexico	161,548 *	21,805 *	1,084,777	826,060
Philippines	27,978	0	239,415	214,952
Brazil	95,144	124,024	789,814	170,894
India	8,203	60	185,799	110,554
Indonesia	42,573	93	150,819	102,827
Argentina	105,848	70,106	550,993	74,097
S. Africa	355,965	6,594	803,143	50,117
Turkey	189,805 *	2,124 *	505,722	4,984
Chile	29,388	1,244	251,096	3,570
Venezuela	66,205	5	266,043	2,228
Morocco	8,564	0	68,408	816
Egypt	8,552	0	32,755 **	61 **
Pakistan	3,674	0	53,236	30
Algeria	13,611	0	55,532 **	20 **
Kenya	1,802	0	11,727 **	1 **

Source: United Nations Trade Flow Data.

** In 1992; * In 1987.

Table 5.
Imports and Exports of Data Processing Equipment (SITC 752) and Parts (SITC 759.95 in Rev. 2 and SITC 759.97 in Rev. 3) in 1983 and 1993. Ranked by 1993 exports.

	1983		1993	
	Imports US \$000	Exports US \$000	Imports US \$000	Exports US \$000
Japan	683,396	2,847,799	6,597,525	26,182,157
USA	1,981,963	5,599,496	38,664,000	25,397,033
U.K.	2,652,443	1,446,699	14,751,149	10,586,059
France	1,767,605	1,077,348	7,844,375	5,014,218
Germany	2,059,583	1,857,112	9,030,903 *	6,444,876 *
Italy	909,974	747,521	4,661,753	4,000,916
Sweden	1,043,775 *	711,054 *	2,011,077	658,900

Source: United Nations Trade Flow Data.

* In 1987.

and apparent consumption of data processing equipment (a portion of DPEC products reported in Table 5. The size of the domestic market simply outstrips domestic production.

Third, Tables 2 and 3 show that developing country demand for data processing equipment is modest compared to developed countries. Nonetheless, Table 4 indicates that developing countries are generally unable to achieve positive balance of trade in these industries. Even Mexico, which was one of the largest exporters among the developing countries recorded a large trade deficit in DPEC products. This confirms our general conclusion that it is relatively difficult to achieve the "export led" strategy. Moreover, the size of apparent domestic consumption in the EDP and components industries indicated in Table 1 for 1993 suggests the very strong position of the NIE's and ASEAN countries in electronics consumption compared to other nations. Their very large consumption of components is not only linked to their export performance in electronic and electronic-using products, but is also providing opportunities for enlargement of their components industry as already demonstrated by Korea and more recently, by Taiwan.

Fourth, and finally, these tables indicate mixed results from past policies of import substitution. On the one hand, as indicated by Table 4, countries like Brazil and Mexico which had significant import restrictions in 1983 have seen imports outstrip export growth after liberalisation. On the other hand, Mexico has made substantial progress in export and although Brazil's export performance has been modest, in the area of data processing equipment (Table 2) domestic production remains a significant portion of the domestic market. It is clear, however, that Argentina, Chile, and Venezuela have experienced large gains in trade deficits in DPEC products through liberalisation. One other example of note in Table is include India which has only liberalised relatively recently and still has modest trade deficits in DPECs.

We cannot conclude that an increase in DPEC trade imbalances is, in itself, a negative development. The gains from the use of data processing equipment may be reflected in spillovers to other industries. But these data do suggest that the possibilities for export led strategies are limited.

Policies

Several of the relevant policies have already been considered and we now present them in summary form.

1. Import substitution without explicit export goals is a failed policy.

Hindsight is acute compared to foresight, and it is, we believe, inappropriate to conclude that such policies were certain to fail given the available information at the time of their implementation. Moreover, given the historical experience with these policies, it is unclear that there is now a bright line separating import substitution policies from infant industry policies. In particular, policies that encourage technology transfer and domestic content in ICT production may still have value in building national productive capabilities. It is appropriate, however, to examine such policies critically for evidence that the productive capabilities that they foster have a real prospect of contributing to sustained growth. Moreover, such policies should not conflict with the promotion of the use of ICTs for strategies that we have called "offensive," i.e. competitiveness in export markets of non-ICT products, and "defensive," i.e. maintenance of domestic competitive capabilities.

2. Infant industry policies may work but are increasingly difficult to implement in the current international trade environment.

The pace of change is so rapid in the ICT industries that the construction of any particular capability must be viewed as a temporary source of competitive advantage that may not contribute much in the way of sustained growth or opportunities for incremental progress. In an industry where large numbers of firms are recurrently wiped out by competitive developments, risks are high and there are significant opportunity costs from the infant mortality of infant industries.

3. Export led policies for the promotion of ICT production, aside from requiring protectionism for initial development, collide with the problems of small domestic markets and the absence of a clear differentiation between world and domestic demand patterns.

Although the success of export led strategies in ICTs for several nations has been spectacular these nations have a very strong export orientation in many areas. For larger developing nations such as India, Brazil, China, or South Africa with substantial technological capabilities and large domestic markets it may be possible to develop domestic markets of sufficient scale to support domestic ICT industries. For other nations, even those that are large, the costs of developing domestic capabilities should be weighed against the very difficult problem shared with developed nations of making the organisational changes and skill improvements necessary to achieve the benefits from ICT use. We have little evidence to suggest that developing nations can produce highly differentiated ICT products that could provide a basis for export led growth outside of established pattern of relatively standardised products for which international competition is likely to be increasingly intense. On the contrary, most differentiation of ICT products occurs in developed nations in response to the size of the markets in these nations. This is a fundamental hurdle to the extension of export led strategies, they will most often lag behind market developments and it is therefore difficult for developing nations to gain a disproportionate share of these markets.

4. To date, there is little evidence that a pure domestic market development policy for ICT production can produce an industry that can meet the challenge of import competition. Policies supporting the creation of such industries are therefore risky.

This is the most uncertain of our conclusions. Here, risk means very fundamental uncertainty. In our view, there are a number of large developing economies that offer substantial opportunities for domestic ICT production including China, India, Brazil, Indonesia, South Africa, Mexico, and Egypt. Each of these economies have substantial technological capabilities and are approaching a "middle income" level standard of living at a time when the costs of many ICTs are falling into the upper end of the range of affordable goods. While import competition is a substantial challenge for the development of a

domestic industry in most of these economies, imports also serve as an indicator of market potential. Just as domestic production of television receivers or motor bikes is stimulated by the success of imports, we might expect entrepreneurs in these nations to seize opportunities offered by ICTs.

5. Whatever the prospects are for domestic production, we stress the importance of effective policies in the use of ICTs. Several policy areas seem worth considering:

a. The production and use of complementary knowledge

Effective use of ICTs requires knowledge from a range of disciplines and the solution of difficult problems of synthesising technological knowledge and managerial "know how." The absence of well-established models for effectively achieving this synthesis suggests that the creation of substantial variety of knowledge creating and using capabilities will improve the likelihood of adaptive success in realising the potentials from ICT use. Many of the problems of implementing the new models of organisation require a skilled and flexible labour force that can solve a variety of problems that do not arise in the older "Fordist" production systems. The range of such capabilities is sufficiently broad that they should be viewed as problems of social capabilities, i.e. spanning the range of educational, research, and commercial institutions constituting a society. Developing nations must find means of developing these capabilities with limited means, a task that is inherently paradoxical. Conserving on investments suggests making priorities and eliminating redundancies, yet there is little guide at present to what priorities should be assigned and even less about what areas are "redundant."

b. The problem of developing "links" to the infrastructure.

Fortunately, this area suggests a more focussed set of policies. Some of the issues that should be considered include the tradeoff between the society-wide level of infrastructural support and the creation of specific geographical "growth poles" where infrastructural features or pricing are particularly favourable. For example, the problem of telecommunications tariffs and quality of the telecommunication network has an important

impact on the ability to profitably employ ICTs. Faster progress may be achieved where it is possible to establish priorities in the allocation of these infrastructural resources. Similarly, the identification and augmentation of backward and forward linkages in the use of ICTs by domestic producers is a feasible area for policy intervention.

6. Opportunities may yet exist for the direct promotion of complementary technologies that are specialised to the circumstances of developing nations.

Policies of this sort are unfortunately part of the "appropriate technology" debate in which it is argued that adaptation of developed country technology to certain applications in developing nations is either very costly or simply ineffective. Despite the very uneven quality of this debate, it is still possible that the development of technologies differentiated to specific developing country needs has promise. Optimistically, some of these products may provide the basis for international trade between developing countries in ICTs, something that we find is, in general, absent from current patterns of international trade.

In summary, our view is not optimistic. ICTs do not offer an immediate solution to many of the problems that developing countries face. At the same time, developing countries cannot afford to ignore the role of ICTs in their plans for industrialisation or the improvement of public infrastructure.

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