

Diffusion and the employment effects of information and communication technology

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New technologies: Job creation and destruction

Ever since Ricardo's famous remarks in 1821 and the ensuing debate, economists have recognized the two-edged nature of technical change: that it both destroys old jobs and creates new ones. In general, economists have argued that the job creation effects have, in the long run, outstripped the job destruction effects, albeit accompanied by a steady reduction in working hours throughout the nineteenth and twentieth centuries. However, nobody has claimed that such "compensation" is automatic, painless or instantaneous. As Ricardo pointed out, the new jobs may not match the old ones with respect either to skill or to location. Where the mismatch is severe and/or prolonged, economists speak of "structural unemployment" and the problems of "structural adjustment". Though the precise borderline between "structural" and the more usual "frictional" unemployment is not always easy to define, the existence of some fairly severe problems of structural unemployment from the 1970s to the 1990s is now universally recognized. In fact, it has become obvious from the rapid increase in, and presently high rates of, "long-term" unemployment or male "non-employment" in most developed countries.¹

Schumpeter (1939) gave a new twist to the whole debate with his conception of "successive industrial revolutions" occurring when new technologies diffuse through the productive system. In his long-cycle theory, such new technologies can give rise to major waves of investment and employment in new industries and services which, in turn, stimulate expansion throughout the economy. When these expansionary effects begin to diminish, a period of relative stagnation or depression follows until a new

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¹ Male non-employment is less subject to definitional differences in the measurement of unemployment between countries and therefore is, to some extent, a more correct measure of the "unused" labour potential in an economy.

impulse develops from a fresh set of technologies. Neo-Schumpeterian economists (like Perez, 1983) have developed these ideas in greater depth, stressing the role of new infrastructural investment and the falling costs and reliable quality of abundant new inputs, such as cheap steel in the latter part of the nineteenth century, cheap oil in the twentieth century or cheap microelectronics today.

Irrespective of whether they accept Schumpeter's long-wave ideas, few economists or engineers today would deny the enormous global impact of information and communication technology (ICT). In fact, many commentators go even further to suggest that ICT is ushering in an entirely new era or a "post-industrial" society. Today, everyone would accept that the extraordinary reduction in costs associated with microelectronics in successive generations of integrated circuits, telecommunications and electronic computers (table 1) is having an enormous effect on almost every branch of the economy, whether in the primary, secondary or tertiary sectors. While previous technologies like steam power and electricity have had similar pervasive effects, ICT is unique in affecting every function within the firm as well as every industry and service. Scientific and market research, design and development, machinery, instruments and process plant, production systems and delivery systems, marketing, distribution and general administration are all deeply affected by this revolutionary technology. Moreover, the counter-inflationary effects of falling costs and prices in microelectronics, computers and telecommunications affect an increasing range of products and services.

Table 1. Estimates of increase in ICT capacity

Area of change	Late 1940s to early 1970s	Early 1970s to mid-1990s	Mid-1990s onwards ("optimistic" scenario)
OECD installed computer base (No. of machines)	30,000 (1965)	Millions (1985)	Hundred millions (2005)
OECD full-time software personnel	>200,000 (1965)	>2,000,000 (1985)	>10,000,000 (2005)
Components per microelectronic circuit	32 (1965)	1 mega-bit (1987)	256 mega-bit (late 1990s)
Leading representative computer: instructions per second	10^3 (1955)	10^7 (1989)	10^9 (2000)
Cost: computer thousand operations per US\$	10^5 (1960s)	10^8 (1980s)	10^{10} (2005)

Source: Freeman and Soete, 1994.

In attempting to assess the employment creation and destruction effects of ICT it is important, at least conceptually, to distinguish the direct from the

indirect effects. The direct effects include the creation of new jobs for producing and delivering new products and services, while the indirect effects are the consequences elsewhere. The computer industry, for instance, provided machines which displaced earlier types of electro-mechanical office equipment, whilst the microelectronic industry largely displaced the old valve (tube) industry. With the new digital telephone exchanges which require far less labour to manufacture and to maintain than the old electro-mechanical exchanges, the number of people working in the telephone switch industry has fallen in most industrial countries. Competitive restructuring of the old monopolistic networks has also resulted in a reduction in the number of employees, even though the number of firms and the number of lines and calls has increased. At the same time, however, the new telecommunication infrastructure provides the basis for many new information-service industries and equipment, such as e-mail, fax, data banks and the multi-media services of the future.

Given such diverse effects, comparing the balance of gains and losses is a difficult undertaking, as numerous empirical studies of the 1970s and 1980s confirm. The naive view of ICT as simply a process of automation and job destruction has its counterpart in the equally naive view of ICT as a purely positive source of new employment. Any sophisticated attempt to assess the employment effects must take both job destruction and job creation into account. Thus, while computer terminals are everywhere, it is not always clear whether they are displacing workers or adding new services and employment.

The change of "techno-economic paradigm" approach adopted in this article stresses both the direct and indirect effects of ICT. It points to the rise of new industries such as software, electronic computers, microelectronics, video cassette recorder and television industries in the second half of this century. Each of these industries employs millions of people today but barely existed before 1950. More importantly, following Schumpeter's analysis of the bandwagon effects generated by new markets and new opportunities for investment, this approach also stresses the indirect effects of the ICT revolution. This Schumpeterian concept of new technology as the most potent stimulus to waves of new investment was also unreservedly accepted by Keynes (1930), subject only to the complaisance of the monetary authorities.

The job destruction and job creation effects of ICT are well illustrated by the case of robotics in the automobile industry and of computers in financial services. Whether the net balance in a given economy is positive or negative cannot be assessed simply by counting the new jobs gained and the old ones destroyed. In fact, the expansionary effects on any national economy or on the world economy depend, paradoxically, on rapid increases in labour productivity. Therefore, a revolutionary new technology can create the basis for a virtuous circle of growth in which investment is high, labour productivity grows fast but output grows even faster, so that there is a net growth of employment. Whether this virtuous circle can be

sustained depends on macroeconomic policies, employment policy and trade as well as on the new technologies. A good match between technologies, policies and institutions can result in prolonged periods of full employment.

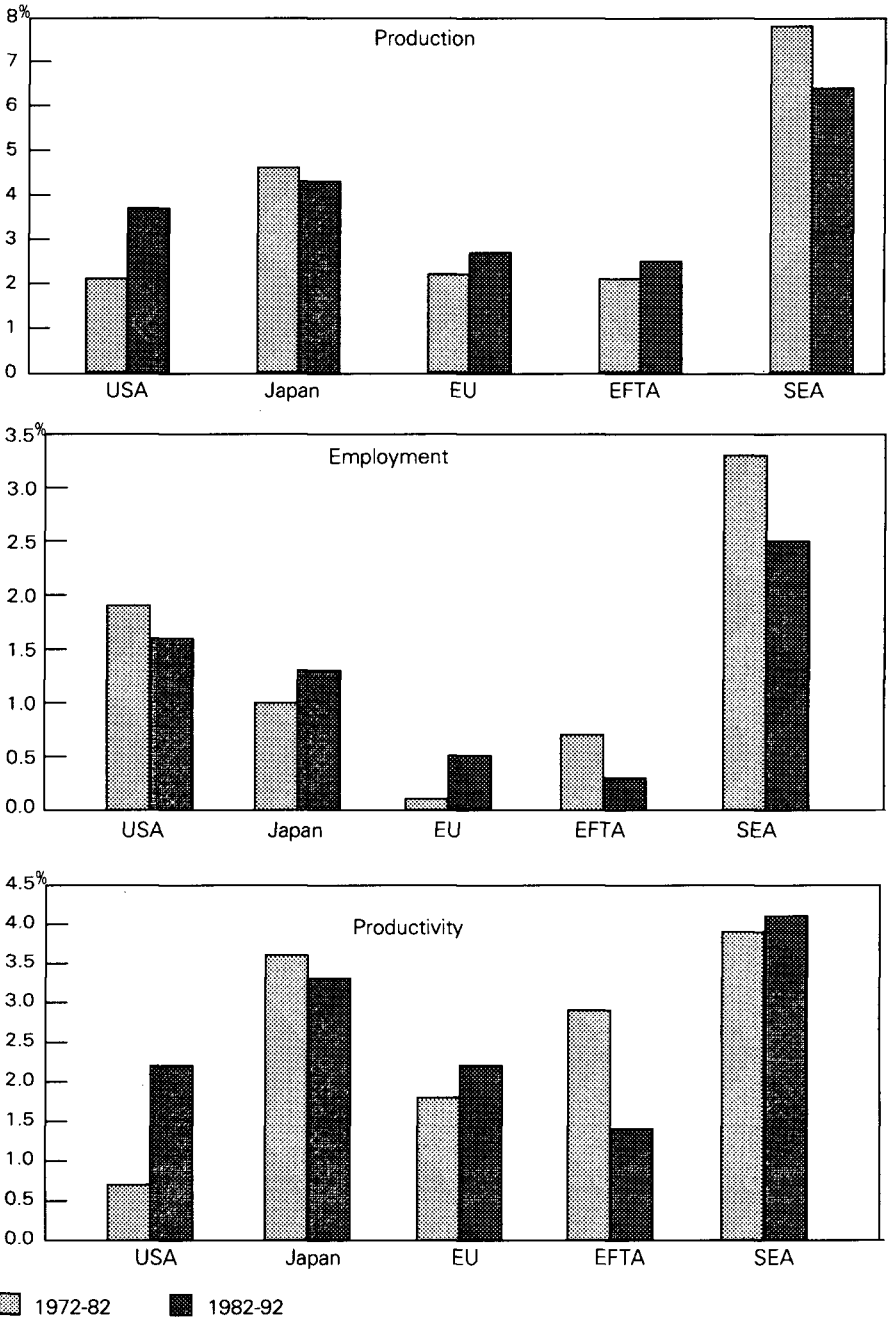
This was the happy situation in Europe, Japan and North America in the 1950s and 1960s. It was based on cheap oil and the rapid expansion of the automobile and consumer durable industries as well as of steel, plastics and many related services. Productivity growth was high but output grew even faster, so that there was also considerable growth of employment (the “Verdoorn” effect). See figure 1. This virtuous circle has since been achieved in Asia with the aid of new technologies. The “four tigers” of eastern Asia together, more recently, with some other economies of south-east Asia, have achieved remarkably high rates of growth of output, productivity and employment, an achievement that has been described as the “East Asian Miracle” by the World Bank (1993).

Whilst many commentators, including the World Bank, have pointed to the role of exports and of education and training in achieving the “East Asian Miracle”, few have analysed the role played by new technologies or by the changing commodity composition of east Asian exports. The next section of this article considers the extraordinarily high rate of diffusion of ICT in east Asia and the crucial role that this has played in their export success, in their output and productivity growth and in their related success in generating new employment through virtuous circle effects.

The role of ICT in the success of the dynamic Asian economies

It has now become a commonplace to note that the countries of the South are overtaking those of the North in terms of total output, manufacturing output and shares of manufacturing exports. *The Economist* (1994) for instance, in a special supplement entitled “War of the worlds”, presented numerous graphs and tables to illustrate its predictions that by 2020 the South could account for nearly two-thirds of world output. While such predictions may be quite accurate in the aggregate sense, they do not take into account the extreme differentiation between various regions and countries of the South. In fact, they are almost entirely a result of the success of the Asian economies and especially the east Asian countries in the 1980s and 1990s, while the experiences of the rest of the South – Africa and Latin America – were quite different. While per capita incomes in the 1980s fell in both Africa and Latin America they rose by record amounts in east Asia. The east Asian share in total world exports of manufactures increased 6 or 7 fold between 1965 and 1990, whilst that of the African countries actually fell. This success of the Asian economies in industrialization and in output and export growth can certainly not be explained by an earlier industrial “start” than Latin America. As late as the 1950s, the levels of industrialization in the

Figure 1. Average annual growth in production, employment and productivity, 1972-82 and 1982-92



Source: ILO, 1992; OECD, CRONOS database.

Asian countries were actually much lower than in the major countries of Latin America (table 2). Since then, however, their progress has been based on a remarkable structural transformation, on high levels of infrastructural investment and, increasingly in the 1980s and 1990s, on the scale and efficiency of their ICT industries, services and exports.

Table 2. Starting levels (1955) for industry in Latin America and Asia.

	Ratio of manufacturing to agricultural net product	Net value of manufacturing per capita (US\$)
Argentina	1.32	145
Brazil	0.72	50
Colombia	0.42	45
India	0.30	7
Indonesia	0.20	10
Republic of Korea	0.20	8
Mexico	1.00	60
Thailand	0.28	10
Venezuela	1.43	95

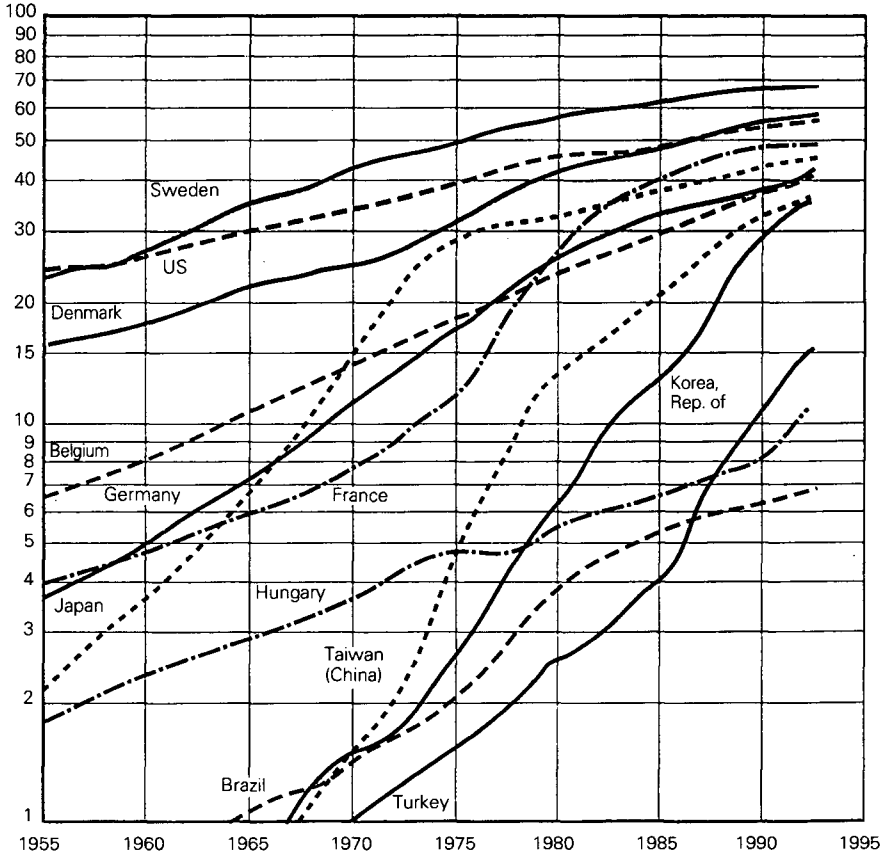
Source: Maizels, 1963.

An essential condition for export success today is an efficient telecommunication infrastructure. This can be seen from the priority given to the modernization of the network throughout the world, especially in eastern Europe and China. This infrastructure is not only essential for the conduct of everyday business, it is also the basis for a rapidly expanding network of new services which can be traded internationally and which can greatly enhance the efficiency of many other services, especially education and health. This accounts for its importance and for the priority given to "information highways" (and by-ways) in the United States and most other OECD countries in the 1990s.

It is therefore notable that the world telecommunication statistics demonstrate very clearly the great success of the dynamic Asian economies in overtaking Europe in the diffusion of telecommunication networks and services. As figure 2 shows, over the past 20 years the Republic of Korea and Taiwan (China) have almost closed the gap with many European economies with respect to the number of telephone lines per 100 inhabitants. Singapore and Hong Kong are already ahead of many European countries in this respect. Being entrepôt economies as well as major manufacturing centres and providers of trading services, they depend heavily on their telecommunication infrastructures. In addition, they have taken extraordinary measures to accelerate investment, to link traders with the network through computerization and to provide new services to the business and academic communities (Mansell and Jenkins, 1992). There is, of

Figure 2. Main telephone lines per 100 inhabitants, 1955-95¹:
Selected countries

Lines per 100 inhabitants



¹ 31 December of each year.

Source: Siemens, 1994, p. 40. (Reproduced by permission.)

course, a clear inverse correlation between the density of the existing network and the rate of growth of new main lines.

Other countries in the South, like Brazil, have achieved moderately high rates of growth in their networks. However, as figure 2 shows, although they were once ahead, they now lag well behind the east Asian and the OECD countries. Another feature of Asian development is the growth rate of new networks such as cellular mobile phones and new services.

Closely related to, but even more impressive than, the infrastructural development has been the export success of the dynamic Asian economies. The enormous increase in their share of world manufacturing exports has been universally acclaimed, but the change in the commodity composition of

their exports has gone relatively unnoticed. There are very wide differences in the relative growth rates of various commodity groups in world trade, ranging from 2 per cent for primary commodities to 13 per cent for ICT goods (table 3). This means that countries which have a higher proportion of exports in the rapidly expanding sectors of the world market also have a built-in expansionary advantage, especially as compared with those countries of the South which are still geared to the traditional pattern of primary commodity exports or semi-processed manufactures and low value-added commodities. The success of the four tigers is clear (table 4).

Table 3. Rates of growth of exports, 1980-89

All primary commodities	2
<i>of which</i>	
fuels	-5
food	3
raw materials	4
ores, minerals	4
All manufactures	8
<i>of which</i>	
iron and steel	4
textiles	6
chemicals	7
clothing	10
Machinery and transport	8
<i>of which</i>	
automobiles	9
ICT goods	13

Source: GATT, 1990.

Table 4. Share of office machinery and telecommunications equipment in total merchandise exports (ranked by value of 1989 exports)

	1980	1989
Japan	14	24
United States	8	13
Germany, Fed. Rep. of	5	6
United Kingdom	5	9
Singapore	14	34
Republic of Korea	10	22
Taiwan (China)	14	25
Hong Kong	12	16
France	4	7
Netherlands	5	7
Sweden	6	8

Source: GATT, 1990, p. 58, table IV.40.

In addition to the four tigers, Thailand, Malaysia and China are rapidly increasing their output and their exports of ICT goods and services (with electronic products accounting for nearly 20 per cent of Thailand's exports in 1992). At the same time, the high imports of ICT products into these and other countries in east Asia indicate that the region has now become a zone of highly interdependent production and trade in electronic components and in the ICT industries. Japan is the main source of technology imports into the region and is (especially since the appreciation of the yen) also the main source of new investment. In addition, however, the four tigers have also become major suppliers of new capital for other countries in the region, especially China and south-east Asia. At the micro level, this can be illustrated by the Samsung Trading Company which, until the late 1960s, was not even in the electronics industry. Pressure from the Government of the Republic of Korea induced it to enter the industry and it was so successful that, by the 1980s, it was itself investing in new plants not only in Asia but also in the United States, in Europe and in Russia.

Rapidly growing exports in the most dynamic sectors of world trade have generated a lot of new employment both directly in the export industries and indirectly by multiplier effects in the rest of the economy. This phenomenon was identified by Alfred Maizels (1963) in his classic book on industrial growth and world trade. From his thorough study of world production and trade over 60 years (1899-1959), he concluded:

Since exports are also an important part of total demand for final output in most industrial countries, a change in competitive power – which implies a change in export sales – will itself affect the rate of growth in industrial production. Thus, exports interact in a dynamic way with the growth of the whole economy.

There has, in fact, been a remarkably close relationship over the past 60 years in the relative growth rates of the main industrial countries and their shares of the world export market in manufactures (Maizels, 1963, p. 17).

The virtuous circle of rapidly increasing output, slightly slower increases in labour productivity, rising employment and steeply rising exports can be seen most clearly in the case of Singapore. Employment in electronic products and components (ISIC 384) rose from 65,837 or about 24 per cent of manufacturing employment in 1983 to 121,336 or more than a third of total employment in manufacturing in 1993. While total manufacturing output almost doubled between 1986 and 1993, the output of electronics nearly trebled (table 5). The slower increases in output, employment and productivity in traditional electrical machinery and equipment (ISIC 383) is noteworthy since many countries still group these two industries together in their industrial statistics. The statistics for Republic of Korea also reflect this extraordinary dynamism of the ICT industries, with the output of office machinery, television and communication equipment increasing at more than double the rate of growth of total manufacturing or of traditional electrical equipment.

Table 5. Singapore: Manufacturing output and employment

	Output (1992=100)			Employment ('000)		
	1983	1986	1993 *	1983	1986	1993 *
Total	—	55	110	273	248	355
Electronic products and components (ISIC 384)	—	44	123	66	69	121
Electrical machinery, apparatus, appliances and supplies (ISIC 383)	—	55	103	16	16	19

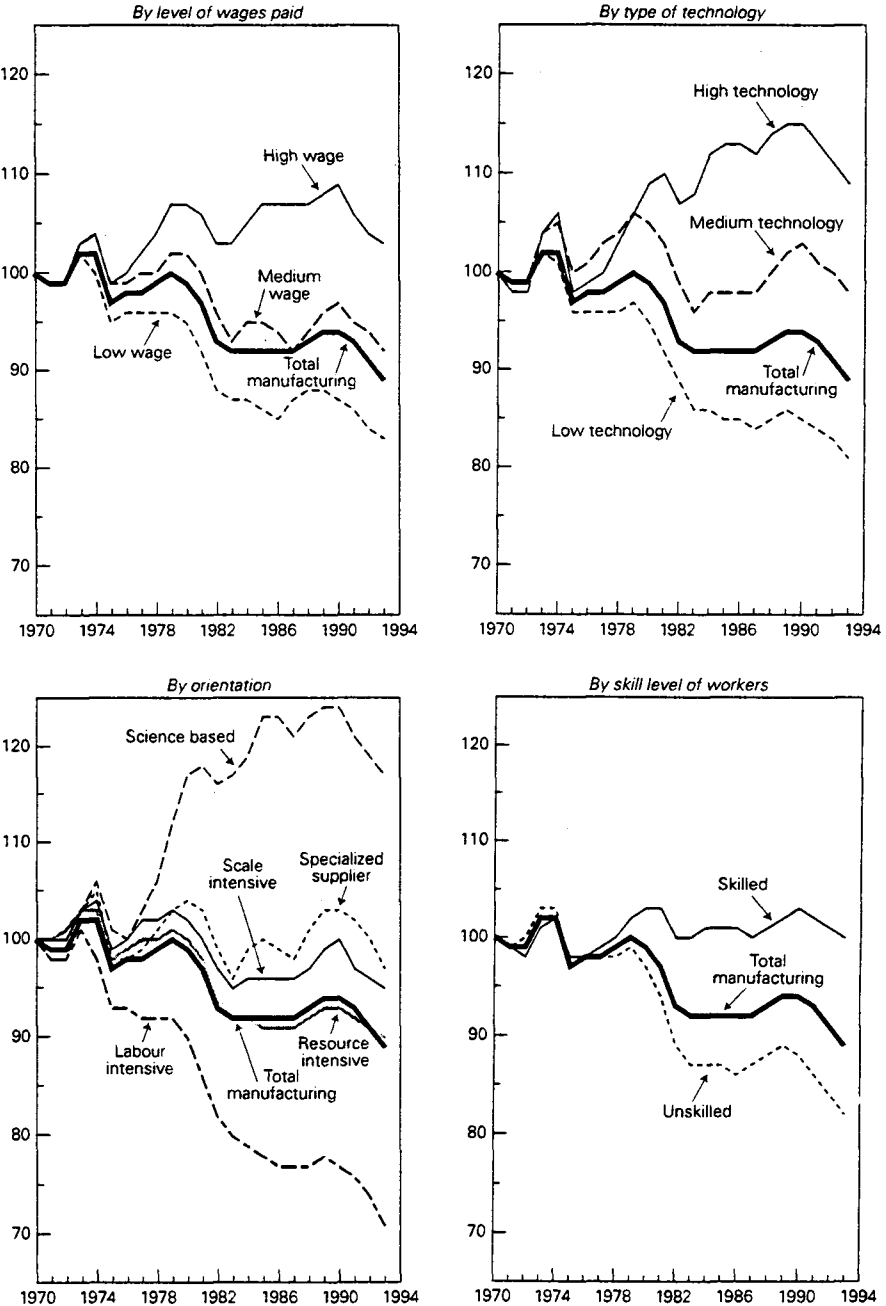
* Preliminary figures.
Source: Singapore, 1993.

The shift of investment and employment towards countries like China, in response to lower labour costs has further complicated the picture in Hong Kong and Taiwan (China). Thus, though total manufacturing output in Hong Kong has continued to increase, the rate of growth (including that of electronics) has slowed down dramatically and there has been a substantial fall in employment in electrical equipment and electronics in the 1990s. While employment in the electronics industries in Hong Kong increased from 49,000 in 1970 to 114,000 in 1980, it fell from 114,000 to 84,000 between 1989 and 1993. In Taiwan (China) too, manufacturing employment has been declining since 1987. However, in both these countries, the decline in industrial employment has been more than offset by the rise in tertiary (service) employment, resulting in low, overall levels of unemployment (2.1 per cent in Hong Kong in 1992 and 2.4 per cent in Taiwan (China)). Amongst the services, business services and software employment have been especially dynamic. Business services employment in Taiwan (China), excluding financial services, rose from 79,000 in 1983 to 205,000 in 1993, whilst in Hong Kong it increased from 79,000 in 1987 to 125,000 in 1993. Employment in financial services increased even more in both countries.

Employment in business and financial services has been one of the most dynamic sources of employment growth, both in the South and the North. In Japan and the United States, as also in Brazil and India, such employment doubled between 1976 and 1992. In Hong Kong and Republic of Korea, too, it grew at an extraordinarily high rate. Much of the employment growth in business services in all these countries has been in consultancy and design, especially in software and data-processing services.

Thus, in considering the overall stimulus to output and employment in the four tigers over the past 20 years, one has to consider both the effects on employment in all industries and services and the effects on the competitive performance of these economies as well as of the entire region, including China. In fact, the direct employment generating effects are still strong in China, Malaysia and Thailand. In the four tigers the direct effects in the ICT

Figure 3. Manufacturing employment by type of industry: Averages for 19 OECD countries, 1970-93 (1970 = 100)



Source: OECD, STAN database, March 1995. (Reproduced by permission of the OECD.)

industries were greatest from the 1960s to the early 1980s. During this period, the share of these industries in the rapidly expanding total manufacturing employment grew to nearly 15 per cent in Hong Kong and about 20 per cent in Taiwan (China) and the Republic of Korea and even more in Singapore. As has been seen, the share of ICT equipment in total manufacturing exports rose to a similarly high level (table 4). In the late 1980s and 1990s, though the direct employment effects are still important, they are primarily in the financial- and telecommunication-based services. More important, however, are the indirect effects on the competitive performance of the entire region. Technical changes (summarized in table 1) have resulted in very high increases in labour productivity in the ICT manufacturing sector. This, together with the falling costs of the ICT producers themselves facilitates diffusion of ICT throughout the area.

For other industrial countries, the general evidence for the direct positive employment effects of advanced technologies was analysed by the OECD in its Technology/Economy Programme report and other studies. The case of manufacturing is illustrated in figure 3, which gives striking confirmation of the role of science, technology and skills in employment creation. However, the (relatively small) gains in high-technology and science-based employment were more than offset in these OECD countries by the decline in other manufacturing industries. This was especially serious because of the decline in demand for unskilled workers and it is this problem in the mature, industrial countries that will be considered in the next section.

Skills, technical change and the global economy

The simultaneous increase in unemployment in the developed countries and the high rates of growth in production and exports in a number of east Asian countries, together with the rapid diffusion of a pervasive technology like ICT across most of the developed countries, have led to a revival of academic and policy interest in the nature of the relationship between technology and employment.² However, this relationship is no longer discussed within the traditional "closed economy" framework of classical, neo-classical or Schumpeterian economic thinking. Instead, it is considered in the context of the rapid internationalization of production, liberalization of international trade and investment, and globalization of information and communication; developments that have led to fundamental changes in the world labour market (see for example, the highly original paper by Campbell (1994)).

As before, this debate tends to be dominated by policy concerns that the employment "compensation" following from the gains in efficiency caused by new technologies and the (international) relocation of factors of production will not be an immediate and instantaneous process. In contrast

² There now exists a substantial empirical literature on this subject. For a recent review see Vivarelli (1995).

to previous debates, these concerns have now been broadened to include the direct and indirect effects of international trade and relocation more explicitly. Two features have received particular attention in the recent literature.

At the employment level, the economic debate has focused on the possible "skill bias" in recent technical change, particularly in relation to ICT. The latter is now recognized as representing a pervasive, "general-purpose" technology, which could imply significant increases in the demand for skilled labour. ICT could also imply a time-consuming, large-scale process of structural adjustment as individuals, firms, industries, governments and all other institutions learn, largely by trial and error, to use the new information and communication technologies more efficiently.³

At the aggregate level, this concentration on the skill implications of ICT has led to a further shift away from issues relating to skill mismatches as a bottleneck to growth, and towards a growing concern in Europe, the United States and Japan about the skill distributional aspects of technical change, especially the decline in the demand for unskilled labour. The rate of unemployment for less educated, low-skilled workers has been much higher than the rate for the better educated. Also taking into account those who are out of employment, the non-employment rate for the less educated segments of the labour force in the United Kingdom and the United States has risen to more than 30 per cent.

Countries have differed very much in their responses to the decline in demand for unskilled labour over the past decade. In the United States, labour market adjustment has resulted in a substantial decline in real wages for the least educated and least skilled workers; in Europe, it has led to much higher levels of unemployment amongst the unskilled; in Canada, most of the adjustment has occurred through variations in working time. Whether this decline in demand for unskilled labour can be correlated with technical change in general, and ICT in particular, has become the major issue of debate. The limited evidence available on this issue pertains largely to the United States (Berman, Bound and Griliches, 1994), with only a few studies for other countries. Furthermore, many of these studies suffered from the lack of detailed data on skill and education, let alone the question of establishing clear links between educational or skill requirements and ICT use.

The present authors concur with David (1994) in rejecting the notion of "skill-biased" technical change. Instead, it is argued here that the diffusion of ICT is now characterized by an intangible-capital-deepening and tangible-capital-saving bias (see also Freeman and Soete, 1985). This process is typified by a gradual increase in the knowledge base of economic production (and consumption) rather than just by a skill bias. The result is a

³ Various authors have pointed to the historical analogy between the diffusion of electricity (notably the electric unit drive) and that of ICT (Freeman and Soete, 1985, 1987; David, 1991).

broader set of perverse effects than a decline in the demand for unskilled labour alone. What is indeed typical of the most recent set of ICT technologies is the substantial growth and employment potential of networking. At the same time, however, not being linked up to information networks necessarily implies being locked out of the efficiency gains associated with the use of ICT. Moreover, it implies being prevented from participating in the learning activities associated with new and more efficient uses of ICT.

In other words, the rapid diffusion of ICT has led – and continues to lead – to a substantial “exclusion” of large parts of the labour force, either unskilled or wrongly skilled and incapable of retraining. This bias in the demand for labour, which has only emerged over the past 10 to 15 years, is likely to become much more pronounced in the rest of the 1990s.

A particular feature of the increased demand for highly skilled labour, noted by many US economists, is the rapid increase in the wages paid to that segment of the labour force. That increase, in the 1970s and 1980s, is, from a traditional neo-classical perspective, difficult to square with a trend towards skill-biased technical change. The particularly strong trend towards cheaper unskilled labour should, of course, have led to a substitution of unskilled labour for skilled labour, inducing skill-saving technological change in the long run. The fact that it has not remains for those economists a major puzzle. For those who reject factor substitution as anything more than a neo-classical production function invention (Freeman and Soete, 1987), this is, of course, not surprising. Skills complement other forms of intangible and physical investment and therefore substituting them for more units of unskilled labour will generally make little sense.

The policy challenge behind the continuous decline in the demand for unskilled labour is formidable: the adaptation to what the European Union (EU) has now started to call the “information society” is not just likely to lead to substantial changes in the demand for various sorts of educational and skill requirements; it also implies that new forms of employment need to be found for large parts of the unskilled labour force who are becoming excluded.

Questions have been asked about the likely employment impact, particularly on unskilled labour, of the increased level of imports from the South. Wood (1994) suggests that the growth in such trade flows in the 1970s and 1980s has been an important factor behind the collapse in the demand for unskilled labour in the North. Wood’s calculations are, as he himself admits, largely “guesstimates” based on the assumed effects on more disaggregated product trade flows, including intermediaries; the induced effects of technical change on relocation; the assumed effects on various associated service activities, etc. His calculations have been strongly challenged by calculations of the import factor content for the United States. The United States has, of course, a relatively small but rapidly rising proportion of imports from developing countries. For the EU, on the other hand, few detailed analyses have been carried out so far. The share of the

South (identified here as countries with wage costs of under \$7 an hour in 1993) in total extra-EU imports appears to have risen substantially. The United Kingdom, with the lowest wage costs, also has the lowest share. Thus, despite the lack of detailed factor content calculations, one might assume that in the case of the EU, too, the significant increase in imports from the South could well have had a negative impact on the demand for unskilled labour.

However, as Wood argues, such independent analyses of trade ignore the crucial interaction between trade, technological change and relocation. From a trade-employment point of view, the significant issue is not the direct factor content of low-wage imports in the North. In many cases, that production no longer takes place in the North, so it will in fact be impossible to calculate such factor content. Rather, the crucial question is how increased imports have induced firms to introduce technological change more rapidly, thus exacerbating the reduction in demand for unskilled labour. Similarly, it is crucial to ask how new information and communication technologies have enabled the decentralization of routine parts of production and their relocation in low-wage regions or countries. Such routine production, while involving less skilled labour, is in no way limited to low-wage commodity production. This could explain why low-wage countries such as China, Thailand, the Philippines and Indonesia have been characterized by rapid growth in both imports and exports of "high-technology" commodities. Calculations of import factor content can shed little light on such intra-commodity trade.

Once again, the policy challenges of such international trade and investment trends are formidable. They point to a much more open world in which differences in labour costs between North and South (mainly Asia, particularly when they relate to unskilled or less skilled labour) are becoming increasingly transparent and are likely to lead to relocation pressure. Not surprisingly, that pressure is likely to be greatest for high value-added commodities which have low unit transport costs – often the new, high-technology commodities. From this perspective, the shortening of the product life-cycle and the erosion of some of the monopoly rents associated with the introduction of new products are a logical consequence of the liberalization and internationalization of trade, production and information. As argued above, the North is condemned to keep innovating to stay in the same place.

The policy implications for employment creation in the North – the continuous need for upgrading skills and the growing proportion of the excluded, unskilled part of the labour force – need to be recognized to a much greater extent.

Policy conclusions

The above discussion demonstrates the necessity of taking into account divergent trends in different parts of the global economy as well as social

equity within countries. Powerful new technologies are being diffused at varying rates in different parts of the world. In the most favoured regions, principally east Asia, they are part of a virtuous circle of high output growth, high productivity growth and full employment. In Europe, output growth has been too sluggish to take full advantage of the new employment potential of ICT, so that job destruction effects have outstripped job generation. In Africa and, to some extent, Latin America, exclusion effects tend to predominate and very high rates of unemployment and under-employment generally prevail.

The shift towards a knowledge-based economy has particularly adverse effects on the employment and wages of unskilled manual workers. Consequently, a world employment strategy must not only embrace intensive training programmes for long-term solutions but also job creation programmes for unskilled workers in community and personal services which have a high growth potential (for an elaboration of this point, see Freeman and Soete (1994)). Though ICT will be used in this non-traded sector of the economy, the criteria and imperatives of international competition will not exert the same pressures to conform to the needs of the international market. Within the traded sector of the economy, on the other hand, where international competitiveness will be the rule, rapid and efficient diffusion of ICT, combined with global expansion strategies, promoted by international economic organizations and agencies, could encourage a world wide boom and generate virtuous circles in many countries. The strong downward trends in costs and prices of ICT products and services will help to dampen any inflationary dangers.

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