Editorial

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Adam Smith, writing in the latter half of the nineteenth century, attempted to explain the growth in labour productivity which was occurring round him largely in terms of human dexterity and organisational changes which, for him, were the significant factors underlying the division of labour. It was Marx, however, writing one hundred years later, who grasped the significance of machines. These machines, he argued, were not merely characterised by the form of power used, but also by the mechanisation of the tools which were being used, and in some cases, the automation of the control of these tools.

The development of this machine-power, continually subject to technical change, underlies the quite unprecedented growth of the world economy over the past two centuries. Over this period not only have the control of tool-devices and the quality of materials used grown in sophistication, but there has been a continual improvement in the physical power used to drive machines. The power source has moved from humans to animals, to water, to steam (wood and coal based) to the internal combustion engine, the electric motor and, possibly in the future, even to the atom.

But, some observers argue, in the same way as this growth in the control of *energy* underlay the 'first' industrial revolution of the past centuries, so the 'second' industrial revolution in the future will depend upon the control of *information.* And the key to this ability to manipulate and transmit information lies in the rapidly emerging technology of microelectronics.

This issue of the *Bulletin,* whilst less ambitious in scope than the grandiose recasting of industrial history described above, attempts to explore some of the possible impacts which microelectronics technology might have on the problems of underdevelopment. Its particular focus is an examination of its impact on international trade. A simple-minded explanation of its significance might be as follows: the existing international division of labour depends upon developed countries supplying technology and developing economies providing labour; but when there is no longer a need for labour, where lies the future comparative advantage of developing countries? But before we move on to a brief discussion of some of the issues involved in this subject area, it is appropriate to begin with a description of the technology.

Microelectronics technology: a brief description

To understand the significance of the new technology it is essential to comprehend the explanatory power of binary logic. Basically this enables one to count or manipulate ideas in an either/or (ie binary) framework. For example, consider counting: if we specify three switches, the first representing the number '1', the second '2' and the third '4', then we can count up to '7' by switching on all of the switches and to '6' by only taking into account the values of the second and third switches. In this way, by making a suitable number of switches available, we are able to count as high a number as we like via a series of either/or decisions. Similarly, logical systems can also be broken down into a series of binary decision-points.

What microelectronics does is to provide the capability to operate these binary systems cheaply within very confined spaces and without any moving parts. The key to this capability was the invention of the solid-state (ie no moving parts) transistor in 1947 which provided the basic either/or building block. In 1959 the integrated circuit, which allowed for the incorporation of more than one binary gate on each 'chip' (as these tiny pieces of silicon have come to be called) was developed and in 1971 a new programmable capability was provided by the invention of the microprocessor (often called 'the computer on a chip'). Progress over the years has been startling and sustained. For example, since 1959 the number of binary gates on each chip has doubled every year with an annual average reduction in costs of 30 per cent. At the same time reliability has increased and power consumption has declined.

As these chips have cheapened so has the range of uses. Beginning in the US in the military and space sector, the technology was initially associated with the introduction of new products such as computers and television. It was consequently a technology associated with expansion of production, trade and employment. However from the mid 1970s microelectronics came to be used as a substitute for mechanical control devices (eg watches, machine controls) and counting systems (eg cash registers). In this most recent era it has begun to penetrate into a vast number of existing products (from cars to children's toys) and processes (from driverless tractors to monitors of animal health) and serves the function of making these processes and products more efficient. So from an optimistic image of 'engine to growth', microelectronics has begun to make the transition to 'destroyer of jobs' (even though its labour-saving characteristics are only one feature of the advantages it offers to users).

Microelectronics technology cannot possibly offer something for nothing. Thus while the 'hardware' (that is the chips themselves) might be effectively costless the ability to get them to operate usefully through the medium of software (written instructions) is costly in terms of human intellectual effort, and requires skills which are currently in short supply. But the compensating benefits which the technology offers are impressive. Without suggesting that all uses provide the same benefits, or the same degree, or benefits in the same relative order of importance, it is possible to distinguish three different sets of benefits which can be, and have been, realised. These are:

a) *in product.* This includes new products (eg televisions), products with improved performance (eg watches), better quality products and products produced with a considerably shortened lead time;

b) *in materials utilisation.* Through optimisation procedures, this includes the very important category of energy-saving devices. It also includes a wide range of uses in which shapes are cut out of a sheet which is a characteristic of nearly all assembly industries;

c) *in process.* Here microelectronics related process innovations can be both capital or labour saving or both. Moreover they can also conserve on particular types of each of these factors (such as skilled labour, or space). Finally it offers [as we can see from Jacobsson's article] the very important capability of enhanced flexibility.

The links between microelectronics and comparative advantage

Of course, by itself, little can be held against the chip. It provides the potential to relieve humans from dull, repetitive jobs as well as to assist in the execution of intellectually challenging tasks. As such it offers the advantage of producing more and better products with less material and human input. Rather it is the form of social organisation within which it will be introduced that determines the nature and extent of benefits which will be reaped. Each of the various contributions in this *Bulletin* explores the likely impact of this technology with specific relevance to this social context, rather than in relation to an alternative, more 'appropriate' nexus of innovation. So, if the overall conclusion is that the introduction of the new technology (as it has come to be called) will have negative impacts, then it is essential to keep in mind the social context within which it is introduced.

Before we proceed to list some of the major issues involved in this subject area we ought briefly to remind ourselves of some of the developments which have taken place in the world economy over the past two decades. From an established division of labour whereby the developing countries seemed consigned to be processors of raw materials and suppliers of agricultural commodities, we have seen the entry in recent years of some newly industrialising countries (NICs) as major suppliers of manufactured goods and even of technology. South Korea's exports of manufactures, for example, grew at an annual rate of 36 per cent between 1965 and 1975; aggregate developing country manufactured exports grew from $4.6 bn in 1965 to $55 bn in 1975; and the share of developing countries in global manufacturing value added grew from around 7 per cent in 1965 to nearly 10 per cent in 1979. Not surprisingly, on the basis of this performance, the 1978 UNIDO Lima Conference set a target for the developing countries of 25 per cent of global value added in manufacturing by the year 2,000.

But both the achievements and projections occurred within the context of an expanding world economy in which there appeared to be space for a large number of producers and in which (particularly given near full employment in the developed countries) the benefits resulting from specialisation and comparative advantage appeared to be beneficial to most (powerful) trading countries. But now, as we enter the 1980s, the rising levels of unemployment in most industrial economies, associated with fierce competition in most sectors, suggests a different scenario. Moreover the potential productivity benefits offered by microelectronics—particularly in relation to the saving of labour—leads one to wonder whether comparative advantage can still be drawn on the same lines.

In exploring the specific links between the new technology and the changing pattern of comparative advantage, it is possible to establish four broadly different lines of argument. Whilst each of these can be justified on a macro- or sectoral-plane, it is an unfortunate fact that few sectoral studies have yet been undertaken to assess the detailed interrelationship between the new technology and trade. Thus the various contributions to this *Bulletin* [see also Ernst forthcoming] represent the first wave of studies which are being undertaken in this subject area. The results which are emerging are as yet largely suggestive and only time will tell whether they offer a realistic portrayal of the future. In discussing the four alternative scenarios, we will try to merge these two sets of micro- and macrostudies.

a) Microelectronics will have a positive impact on developing countries comparative advantage

Here it is argued that there is no reason to believe that the new technology will diffuse more unevenly through the world economy than have previous technologies. On the contrary, by saving on specialised skills [see Jacobsson in this *Bulletin*] it is particularly suited to developing economies and consequently it will have a disproportionately positive impact on Third World comparative advantage. Moreover since the new technology is inherently a systems technology [see Rada and Kaplinsky in this issue] it may well be that it is easier to introduce in expanding developing economies in which there are fewer impediments to change, than in rationalising industrialised economies which have a long history of established work patterns.

b) Microelectronics will have little impact on comparative advantage

In this scenario microelectronics is essentially seen as one in a long series of incremental technologies. It has no major impact on economic activity (and therefore leaves the macro-world unchanged) and it diffuses through the world economy at the same rate as other types of technology. None of the contributions to this *Bulletin* would appear to support this view, but that may only represent the obvious fact that no-one who is unconcerned about the problem would bother to do research on the subject!

c) The diffusion of microelectronics technologies will be associated with a reduction in developing country advantage

There is a wide variety of different 'schools' in this scenario. One of them is represented by a form of 'long wave' theory. This builds upon the recognition of 50 year long wave cycles in the world economy which are associated with the introduction of major 'heartland' technologies. Each of these cycles is considered to have an expansionary upswing in which the new heartland technology is predominantly used for the introduction of new products, and a rationalising downswing in which the technology is used to enhance competitiveness in the context of growing competition.

Within this framework, the period 1950-75 saw the expansionary upswing of the microelectronics based cycle with full employment and a growing international division of labour. Now that the world economy is in the rationalising downswing with growing unemployment at the centre (partly fuelled by labour-saving microelectronics technologies), the 'space' no longer exists for peripheral economies. Trade barriers and increased competitiveness of developed country producers using the new technology thus undermine the developing country comparative advantage which began to emerge in the 1960s and 1970s.

At a less grandiose level, a number of sectoral studies seem to confirm this trend towards comparative advantage reversal. The contributions by Rada, Braun, Hoffman and Rush, and Kaplinsky in this *Bulletin* would seem to confirm the hypothesis that the use of the new technology provides significant benefits to innovating firms and serves to undermine the potential comparative advantage of developing countries using cheap labour and pre-microelectronic technologies. In some cases (semiconductors and garments, for example) it is already possible to identify examples of trade reversal. Only Jacobsson's article suggests that the introduction of the new technology will be associated with enhanced developing country comparative advantage. And even in this case, it is argued that it is likely to be only a temporary phenomenon.

Finally, a third set of arguments sees the introduction of microelectronics technology as associated with growing centralising tendencies in the world economy [see Rada's contribution]. In the context of the growing crisis in the world economy, and with the undermining of developing country comparative advantage by the use of the next technology, these transnational companies will be less likely to locate production in the periphery. This is precisely what appears to be occurring now within the electronics industry itself [see Clarke and Cable, and Rada].

d) The impact will vary between countries

Most observers (Clarke and Cable, Rada, Hoffman and Rush and Jacobsson) recognise that developing countries are not a homogeneous group. Some of the NICs have by now established a level of industrial sophistication which probably means that they will already have made the transition to 'industrial development'. This group of countries, they argue, will almost certainly be less badly affected than the non-NIC developing countries.

Some policy implications

The contributions to this *Bulletin* reflect the embryonic stage of research in this area. Consequently it is difficult to offer more than tentative policy conclusions (although each of the relevant authors do so in their more extensive research reports). However three conclusions stand out in importance.

a) The use of microelectronics technology

Braun cautions against the conclusion that developing countries should move into the production of electronics components. However it is overwhelmingly clear that the new technology represents a quantum leap in efficiency and unless developing countries adopt it in products and processes, they will be forced to retreat from world markets (particularly with respect to exports to industrialised economies) and to increase protection to domestic producers. The signs are that the new technology is relatively easy to use and requires fewer and less skilled operators and less of some types of maintenance and repair skills (Jacobsson and Kaplinsky). But the danger is that even if developing countries do introduce the new technology, trade barriers partly resulting from job displacement in developed countries may well close off trade opportunities anyhow.

b) The development of software skills

The 'old' view that underdevelopment is caused by an absence of skills has by now been exploded in the context of high levels of unemployed graduates in many developing countries. The irony is that many of these countries (particularly India) are exceptionally rich in the very 'software' skills which constrain the introduction of microelectronics in developed countries. It is an open question, therefore, whether this software capability could be a source of developing country comparative advantage in the future, or whether the absence of an 'organic' link between this skilled cadre and indigenous industry undermines the feasibility of this policy option. The contribution by Bogod suggests a role for developed country technical assistance in this area in further encouraging the production of software skills in developing countries.

c) Appropriate technology

Hitherto the introduction of microelectronics has been associated with the military sector and in meeting the needs of developed country producers and consumers. Little attention has yet been given to meeting the requirements of groups within developing countries, to take advantage of the significant benefits which the technology offers. By this we do not mean the development of the solar-powered video recorders suggested by one agency to meet the basic needs of Indian villages, but rather technologies such as irrigation-control systems (eg in drip-feeds), meteorological forecasting for islands characterised by micro-climates and rural health care systems. The development of appropriate systems to meet developing country needs deserves far greater emphasis than it currently gets.

In conclusion, therefore, despite the 'under-development' of our awareness of the specific impact of microelectronics related innovations we cannot fail to recognise their significance. For a whole series of reasons, the coming decades are clearly going to differ from the previous ones and it is important to bear in mind the technological dimensions of the changing world if appropriate policy responses are to be fashioned. At the same time it would clearly be foolish to ignore the political-economic context in which these technological developments are occurring. Technology cannot be seen as an 'abstract good' since it takes particular forms which reflect the interests of the innovating parties. And in addition since transnational firms account for such a large share of world trade in manufactures, any set of policy responses should be acutely timed to the likely reaction of TNCs to these changing technological, political, economic and social climates.

Bibliography

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