OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

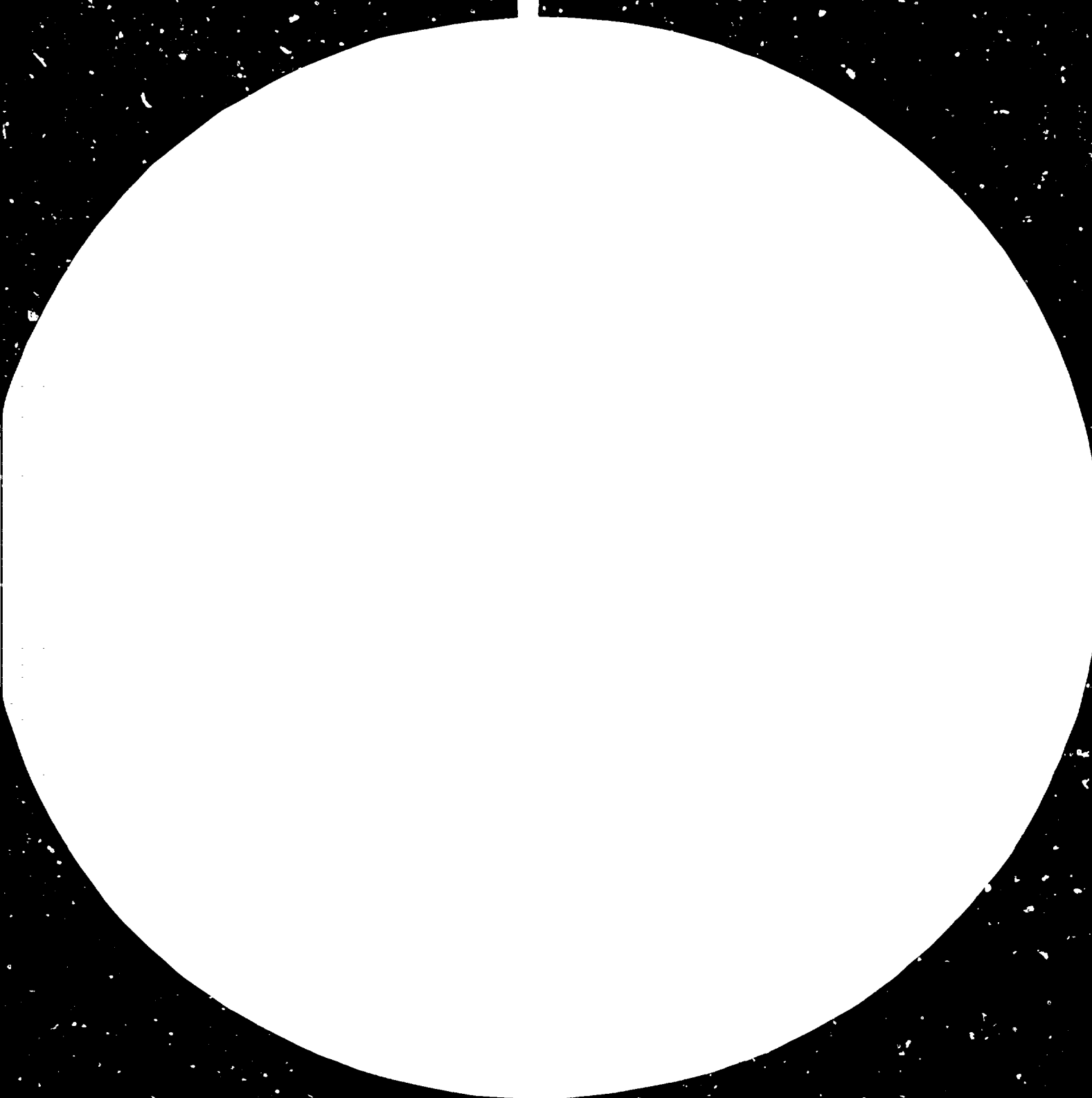
FAIR USE POLICY

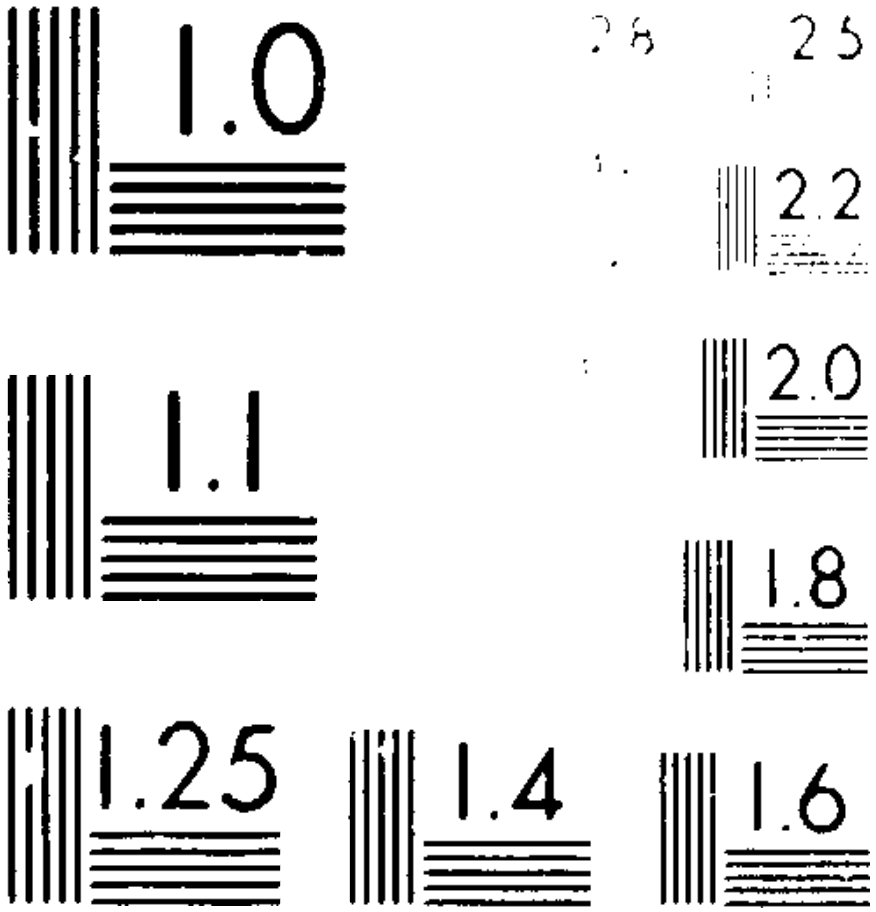
CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org




1.0
2.2
1.1
2.0
1.8
1.25
1.4
1.6

EXCHANGE OF VIEWS WITH EXPERTS ON THE IMPLICATIONS OF TECHNOLOGICAL ADVANCES IN MICRO-ELECTRONICS FOR DEVELOPING COUNTRIES

Vienna, 10-12 June 1981

B.P.12

11295

FUTURES WITH MICRO-ELECTRONICS

by

Ernest Braun
University of Aston
Birmingham

* The views expressed do not necessarily represent the views of UNIDO. The document has been reproduced without formal editing.

V.81-26244

FUTURES WITH MICROELECTRONICS

Ernest Braun
Technology Policy Unit,
University of Aston in Birmingham.

The Employment and Skills Debate

The debate about the impact of microelectronics on employment is not new; it is a modified re-run of the debate on the impact of automation which raged in the late fifties and early sixties. That debate was not truly new either; it was simply a new chapter in the continuing controversy about the impact of technology on economic activity in general and on employment in particular. That debate - on the impact of technology on employment and, equally important, on skills - can easily be traced to the industrial revolution; it is likely, however, that it raged fiercely as soon as stone technology was displaced by bronze techniques. It may be fanciful but not widely off the mark to imagine the stone-age flint sharpener shaking his flint axe in anger and despair at the young upstarts claiming superiority for their metal implements.

The debate about technological unemployment and about the loss of skills has, at least in recent years, consisted of several major strands. It may be useful to tabulate the main arguments in much simplified form.

new technology	reduces the requirement for skills -	deskilling
	requires new skills -	change of skills
	takes over repetitive, arduous and dangerous tasks and thereby frees people for creative tasks -	humanisation
	replaces humans and thereby causes -	unemployment
	creates new economic opportunities and thereby increases wealth -	growth
	increased wealth may lead to -	more employment
	and/or to more -	leisure

The excessive simplification and schematic representation are deliberate devices to show the bare essence of much elegant and eloquent argument spread over many decades. There is no doubt about the veracity of many - or possibly all - of the arguments. Yet the debate continues unabated and the considerable accumulated experience has not given us the wisdom of hindsight to declare a definite winner. So much unresolved controversy must show something - it must mean that all the arguments are deficient in some way.

The most likely deficiency of all arguments attempting to relate employment to technology is the lack of simple causality linking a single cause - a specific technology - to a single effect - a given rate of unemployment.

Employment is related to a very large number of factors and technology is only one of them. Open or hidden unemployment are, in a society which seeks to achieve full employment, signs of every kind of inefficiency in the economy. Such inefficiencies arise because of too much or too little competition, and out of a variety of mismatches - skills to jobs, work places to local population, production capacity to demand. Inefficiencies also arise out of unsuccessful fiscal and monetary policies, excessive military spending, pressures of international trade, and many more causes.

There can be little or no doubt that the present economic recession, recent inflationary pressures, and current unemployment problems, have not been caused by microelectronics. Technology is clearly involved but only as one of many factors. Continuing technical change has increased the efficiency of production to a point where aggregate demand - (world demand adequately supported by means to purchase) - has become insufficient to make full use of productive capacity. There is no doubt also, that the only truly new sector of economic activity, computers, microelectronics and associated industries, have not provided sufficient outlets for surplus labour from other sectors.[1,2]

Conceding thus a role for technology in current and future unemployment, it must nevertheless be said again that the main causation of the present crisis lies in classical macroeconomic failures - inflation, maldistribution, inadequate aggregate demand - and not in current technology. In fact, curiously enough, very few people ascribe current economic problems to the introduction of computers or microelectronics - this particular causation is commonly reserved for future crises. Perhaps past and current crises have adequate and obvious explanations and only the explanation of the future needs to resort to phantasy.

We have said that unemployment, in a society seeking full employment, is a result of inefficiencies in the economic system. In principle therefore, any technology that raises efficiency should be welcomed as a boon to society. Unfortunately, things are not as simple. For the efficiency of the total technological system is only one aspect of the efficiency of the total economic system. It is perfectly possible for increased technical efficiency to cause decreased economic efficiency. We must now turn to the question of whether this is the situation in the case of microelectronics.

In principle it must be true that if a technology increases the efficiency of production and thus enables the economy to produce more goods or services with the same effort, this should increase the total disposable wealth of society. To make the principle a reality requires, inter alia, that there should be a match between production capacity and markets. This means that any surplus arising out of increased efficiency must be redeployed to supply new goods and services and thus meet either hitherto unsatisfied demands or altogether new demands.

That unsatisfied demands exist even in the richest countries cannot be doubted. What is in great doubt is the ability of economies to make the necessary adjustments and switches of resources to match capacity with effective demand, i.e. demand backed by purchasing power.

In the case of microelectronics, all arguments about the alleged catastrophic effects of the technology upon employment are based on three examples: watches, cash registers, and telephone exchanges. As these three products have been fundamentally changed by the replacement of mechanical or /electro-mechanical parts by pure electronics, the effort required to make them has been dramatically reduced. This has had several effects: a shift of production from old established industries and countries to new places, a large increase in demand, a change in skills required, probably an overall reduction in the numbers of skilled workers, and possibly an overall loss of jobs although detailed figures are obscured by international shifts. The overall demand for these products has increased dramatically and, in the case of the capital goods, would have increased even faster but for the shortage of available investment.[3]

From the fact that these three products have dramatically changed their labour content some observers have concluded that all products containing mechanical parts will change equally dramatically and equally rapidly. So far, however, there is no sign of this happening on a very large scale or such as the motor car, at very high speed and there certainly are many products where microelectronics will only provide additional features in essentially mechanical devices.

Affected Sectors

We have reviewed some forecasts of likely impacts of microelectronics on the products of various industries and have concluded that the sectors most likely to be substantially affected over the next few years are the following[4].

1. Mechanical engineering.

   Numerically controlled machined tools are likely to spread further.
   Computer aided design will become more significant.
   Robots will be produced in greater numbers and for a greater variety of applications.
   Production control systems will become widespread.
   No significant impact on levels of employment are expected, except in the vehicle building and components industry.

2. Instrumentation

   Mechanical instruments will become partially robot assembled.
   Most instruments will become electronic and a large variety of new types will be developed.

Automated assembly will predominate.
Great changes in skill requirements are anticipated.
Total employment need not decrease and could even grow.

3. Electronics and Electrical Goods

Present trends to more sophisticated and automated methods of production of electronic components are likely to continue.
Electronics will spread into more and more products and provide additional facilities as well as replacement of electromechanical functions.
Growth of the industry may balance job losses, although the pattern of overcapacity in e.g. television sets may be repeated in some other sectors.
Considerable automation in electrical goods, with likely job losses.

4. Materials handling.

Considerable developments in robotics and automated warehousing, stock control, automated dispatch, etc.
Industry may expand and use more labour, but mainly with high qualifications. In operations considerable shedding of labour is anticipated.

5. Precision engineering.

Many changes from mechanical to electronic logic.
Automated assembly.
Significant loss of employment anticipated and very large changes in skills.

6. Telecommunications.

Large growth in total facilities and networks anticipated with many fundamental technical changes.
Doubts whether growth will balance potential job losses caused by simplified equipment such as electronic telephone exchanges.
Some new skill requirements, but overall loss of skilled work opportunities is feared.

7. The Office

Finally, the office sector, which is common to all manufacturing and service industries. So much has been written about the office of the future that it is hardly necessary to give any further descriptions here, be they based on technology or on phantasy.[5,6] The undoubted fact is that office efficiency can be greatly enhanced. Thus, other things being equal, office employment could radically decrease. Other things are not, however, equal. Two contradictory trends are in operation. The first is Parkinson's law. In the present context, this might be paraphrased as 'administrative and office work will expand to meet all available facilities'. If office work becomes more efficient, more office work shall be done. There is no natural limit to the amount of such work to be performed. Just as there is no upper limit to the services an office can provide, so the lower limit, the irreducible minimum

of services vital to the organisation, usually lies well below the current level of performance. The second trend therefore is to perceive the office as parasitic and to attempt to reduce it when economic pressures mount. Thus in a climate of economic crisis the tendency will be discernible to use the increased efficiency which modern office technology can provide not to increase the services provided, but to decrease the office staff.

Which of the two trends predominates is globally unpredictable. Two mighty pressures - Parkinson's empire building and the eternal dislike of bureaucrats - meet head on and only a punter would be willing to commit himself to any given outcome of the struggle.

The Spread of Microelectronics in Manufacture

Certainly the spread of microelectronics in manufacture is not nearly as rapid as one might be led to believe. We have studied manufacturing innovation in some branches of the West Midlands industry and were impressed by the slow rate at which microelectronics was being adopted.[7,8,9] Many firms do, of course, buy a variety of instruments containing a few chips and a few firms buy highly sophisticated numerically controlled machine tools and robots. But walking through the factories and talking to managers one certainly does not get the impression of a revolution sweeping through industry - currently the impression is that of a deluge of economic hardship.

The reasons for the slow spread of microelectronics into manufacturing industry must be sought in a general theory of manufacturing innovation. We have recently proposed that innovation in general and manufacturing innovation in particular should be seen as requiring specific constellations of circumstances to enable them to proceed. We thus propose a constellation theory of innovation.[10]

In essence, constellation theory seeks to identify clusters of circumstances under which an identified weakness in the manufacturing system can be remedied by an identified or developed solution. The innovation will proceed only if weakness, solution, and the necessary steps towards implementation of the solution are all related to each other in such a way as to favour the process. A manager may, for example, be aware of the fact that the

part produced by a series of machines requires too many operations, too much material and is too often outside specified tolerances. He may not be aware, however, of a readily available solution and may not have at his disposal the engineering skills and development facilities required to develop a solution. Alternatively a highly complex machine may be available on the market which would eliminate the problem, but the manager may be unable to muster the required capital, or the required maintenance and programming skills, or he may be unable to negotiate a suitable redundancy agreement.

The two key conclusions from our studies could be summed up as:

(i) Manufacturing innovation usually is undertaken in order to remedy a variety of weaknesses rather than for a single underlying cause.

(ii) The innovation can only proceed if the proposed solution is available and its implementation is within the capability of the firm and does not require unacceptable changes in the work organisation.

The net result of these facts is that innovation, and therefore the diffusion of microelectronics into manufacturing industry, is a very much slower process than some writers would have us believe. The shortage of capital, shortage of programming skills and many other difficulties of implementation militate against the overnight revolutionary change sometimes envisaged.

Although our findings suggest that only a few industrial sectors will be very seriously affected by microelectronics and that the effects are not spreading very rapidly, nevertheless the cumulative effect on employment can be very large. This is particularly so as some of the most affected industries, such as vehicle building and other sections of the engineering industry, are very large employers of unskilled or semi-skilled labour. We cannot therefore deny that a large number of jobs are at risk.

Similarly, our findings suggest that the danger of de-skilling many workers exists, although this is partially balanced by new requirements for new skills, such as electronic engineering, electronic maintenance and programming.

Why Introduce Microelectronics

If all these dangers exist one must ask oneself why the technology should

be introduced at all. Two answers spring to mind, neither particularly appealing but both rather compelling.

First there is international competition. The argument has been stated many times but needs to be re-stated here. If Britain, or any other technologically advanced country, wishes to retain or strengthen its position in world trade of manufactured goods, then it must manufacture the most competitive goods in the most competitive way. This means incorporating the best of the most recent technologies in the design of products and using the best available technology for efficient manufacture.

International competitive pressures cause a kind of technological determinism in the same way as international fears and mistrust cause a relentless march towards more and "better" arms. To control the advance of technology in traded goods is at least as hard as to control the arms race. The argument is an old one and militates against the wish to be in control, but it is very hard to see a way out of it except by radical changes in international trading arrangements. To suggest such changes or even to consider their desirability goes way beyond the scope of this paper.

The second answer to the question why we cannot halt the introduction of microelectronics is that the technology has become irresistible. If a technology offers such very great advantages compared to its predecessor technologies and has powerful backing by powerful companies and marketing organisations, it reaches a stage where nobody can truly resist it / and we have just about reached this stage now. Microelectronics has become rather like the mini-skirt; once it had become fashionable, no self-respecting young woman could possibly have been without it. Similarly, no self-respecting organisation can be without a micro-computer, word processor, electronic control, or some other miracle of microelectronic technology. The competitive advantage is too great to miss and the penalties of being labelled 'old fashioned' too great to accept.

Before turning our attention to issues of policies for microelectronics one point must be re-stated. Notwithstanding everything that has been said about employment effects of microelectronics, the main determinants of total

employment are macroeconomic factors which contain technology as only one facet of a complex constellation. Technology is undoubtedly a determinant of competitiveness and therefore of economic success. Technology is also a determinant of the efficiency and complexity of the economic system of a country. But factors such as interest rates, employment and educational policies, level and kind of public expenditure, tax structure, foreign exchange rates, state of the world economy, and a whole host of other economic factors are all of tremendous importance and between them probably predominate over technological factors alone.

Just as it takes more than economic policy to determine the level of success of manufacturing industry, so it takes a great deal more than technology to determine the level of employment in an economy.

Policy Issues

It has become very obvious that policies of "laisser faire" have turned into policies of "ne laisser faire rien". Current circumstances are such that passive government has come to mean passive, that is unemployed, people. In the current situation of international competition it is obvious that full employment, or at least low rates of unemployment, are best achieved in countries with highly active government employment policies.

There can be little doubt that current unemployment problems are related to macro-economic difficulties, but equally there can be no doubt that the eventual widespread use of labour saving technologies will make it all the more imperative for governments to use every available measure to ensure full employment.

If we accept that microelectronics must spread and that its widespread use will compound employment difficulties, we can see the kind of policies that need to be employed[11].

(i) First and foremost it is necessary to ease the transition of workers from those sectors of industry which are forced to contract their labour force into those sectors which can expand. These are all the sectors which are not under direct pressure from international competition - e.g. many urgently needed services - but also all those sectors whose expansion is made possible by the

use of new information technology. New and improved products will absorb some labour, more efficient services will expand demand for them, and a whole host of unsatiated demands might come nearer to being satisfied. There is no shortage of work to be done, only a dearth of mechanisms for the transfer of resources from declining to growing employment opportunities.

The encouragement of suitable technological innovations must be part and parcel of any policy which attempts to ease the transition of resources from declining to growing economic activities.

One of the many demands to be fulfilled is no doubt increased leisure and there is no reason why shorter working days, weeks, years or lives should not be considered. This does not, and must not, mean the disappearance of work; but it may easily mean a real shortening of the time spent at work. Clearly, the increase in leisure time can only be meaningful if suitable facilities and sufficient resources are available to make good use of such extra leisure.

(ii) Secondly, we must come to grips with the question of what constitutes acceptable work. Certainly microelectronics allows both de-skilling of work and requires new skills. We must fight the concept of technological determinism as there is definite evidence that the same technology can be used in different ways. There is no simple deterministic relationship between machines and human tasks - tasks can be made more satisfactory by policy measures within the constraints of a given technology.

Much research has been carried out in this area, but the questions are very far from being resolved. The only thing that is quite clear is that enlightened management, in cooperation and true consultation with the workforce, can achieve working conditions more acceptable to free and intelligent human beings than a first glance at the technology might suggest.

(iii) To achieve the objectives of both the above policies it is clearly necessary to provide training and educational facilities at both formal and informal levels. With goodwill and incentives, many skills can be acquired, often in only partially formalised manner, by sometimes surprising candidates.

Several other policy issues arise out of the use of microelectronics, such as the need to cope with security of and access to information, but this paper can obviously not deal with these.

Indeed the three policy issues briefly mentioned above are only a summary of the subject matter dealt with in the main text.

References:

1. C. Freeman: Unemployment and Government, in "The Microelectronics Revolution", ed. T. Forester, Blackwell, Oxford, 1980, pp.308-317.

2. R. Rothwell and W. Zegveld: Technical Change and Employment, Frances Pinter, London, 1979.

3. W. Dostal: Die Beschäftigungswirkungen von Mikroprozessoren, "Rationalisierung", vol. 2, pp. 34-38, 1979.

4. J. Bessant: The influence of microelectronics technology, in "Technology, domestic distribution and North-South relations", ed. S. Cole and G. Chichilinsky, UNITAR report, 1980.

5. APEX: Office Technology, the Trade Union Response, Association of Professional, Executive, Clerical and Computer Staff, London, 1979.

6. R. Bertrand: Büro-Rationalisierung, in "Mikroprozessoren - Die elektronische Revolution", Deutsches Institut für Fernstudien, Universität Tübingen, pp. 139-142.

7. E. Braun, R. Moseley, B. Wilkinson: Manufacturing Innovation in the West Midlands Materials Forming Industry, to be published.

8. J. Bessant: Influential Factors in Manufacturing Innovation, to be published.

9. J. Bessant, E. Braun, R. Moseley: Microelectronics in Manufacturing Industry, the Rate of Diffusion, in "The Microelectronics Revolution", ed. T. Forester, Blackwell, Oxford, 1980, pp.198-218.

10. E. Braun: Constellations for Manufacturing Innovation, Omega, forthcoming.

11. E. Braun: Government Policies for the Stimulation of Technological Innovation, working paper WP-80-10, International Institute for Applied Systems Analysis, Laxenburg, 1980.