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ABSTRACT

This report, representing the culmination of the first phase of an Organisation for Economic Cooperation and Development (OECD) project, analyzes the various concepts of human resource development in relationship to structural and technological change. Part I, "The Knowledge Base of an Industrial Economy" (Gunnar Eliasson), begins with a chapter on conflicting political and social concerns in the industrial economy. The nature and development of industrial knowledge, based on published economic historical materials, are then considered in Chapter II. Chapter III focuses on the emerging knowledge requirements of the modern firm, and Chapter IV discusses how the human capital and industrial knowledge needed may be most efficiently produced in modern society. The first part concludes with a 133-item bibliography; some of the titles are in Swedish. In part II, "New Technology and Human Resources" (Paul Ryan), Chapter V addresses the effects of information technology on job content and skills. Chapter VI considers the implications of information technology for human resource development. A 231-item bibliography concludes the second part. (MES)

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THE HUMAN FACTOR IN ECONOMIC AND TECHNOLOGICAL CHANGE

by Gunnar Eliasson and Paul Ryan

November 1987

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CO-OPERATION AND DEVELOPMENT

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Paris, November 1987

This report marks the culmination of Phase I of the OECD/CERI project of enquiry into the implications for human resources and education policies deriving from the momentous changes now going on in the world of work under the impulse of the new technologies.

The project, which began in 1982, had four components: i) Case studies of five automobile enterprises (in as many countries) conducted in duplicate by internal (company) and external (academic) teams of examiners; ii) Country reports on national policies for human resources development as it relates to education and training; iii) A study of the impact of the new technologies on the work patterns, qualifications and education of the white-collar section of the labour force; and iv) An analysis of the various concepts of human resource development in their relationship to structural and, in particular, technological change.

It is to the last of these topics that the present review addresses itself, drawing not only on the findings of the other studies but on the whole of the relevant literature from the major industrialised countries undergoing these changes.

Part I, by Dr. Gunnar Eliasson, Director of the Swedish Industrial Institute for Economic and Social Research, analyses from the perspective of different economics theories the relationship between economic growth and human capital. It presents important new insights into the increasing significance of human resources in relation to the modern manufacturing firm and raises fundamental issues for the formal and informal education system.

Part II is by Dr. Paul Ryan of the Department of Applied Economics, Cambridge University. This focuses on the new information technology and its impact on the organisation and content of work and upon human skills. In particular, it presents empirical findings on information technology's consequences for both de-skilling and up-skilling.

This document completes the publicly available literature for the "Changes in Work Patterns" project.

8562

CONTENTS

Part I

THE KNOWLEDGE BASE OF AN INDUSTRIAL ECONOMY
by Gunnar Eliasson

PART II

NEW TECHNOLOGY AND HUMAN RESOURCES
by Paul Ryan

LIST OF TABLES

FIGURES IN THE TEXT

Part I

THE KNOWLEDGE BASE OF AN INDUSTRIAL ECONOMY

by Gunnar Eliasson

> The true method of discovery is like a flight of an aeroplane. It starts from the ground of particular observation; it makes a flight in the thin air of imaginative generalisation; and it again lands for renewed observation rendered acute by rational interpretation.
>
> Alfred North Whitehead

Chapter I

A CONFLICT OF CONCERNS

> Central economic theory has to incorporate the four fundamental ideas of interdependency, value, process and institutions.
>
> Johan Akerman (1950)

Two items dominate the agenda of political leaders in the old, industrial world: a mounting open unemployment and an ominous loss of industrial competitiveness and hence, in the longer term, a decreased economic well-being and more unemployment. Many are worried about the unemployment trap from which a large fraction of laid-off workers will never escape. In some political circles it is even argued that the tens of millions of open unemployment in the OECD world has been caused by the introduction of new electronics-based information technologies in industry. At the same time there is widespread belief that the electronics "revolution" in its various manifestations will kick the economies of the industrial world onto a new, long wave of economic expansion.

The two concerns are political and social and in apparent conflict. The problem is economic. One could summarise the dilemma as that between the competence to renew and the ability to adjust, together making up the economic and structural flexibility of industries. It is important for what follows that both these abilities relate to firms as well as individuals. The time dimension is critical since it determines conditions of welfare and equity during the transition. Are those who absorb the adjustment cost the same as those who will later benefit, or are those who gain from preventing or postponing the adjustment of industrial and human structures to new technologies the same as those persons who will later have to be satisfied with a relatively lower material standard?

Competitiveness -- as we will demonstrate in what follows -- depends importantly on two factors: the ability of the economy to adjust both relative prices and industrial structures, the latter through the scrapping of commercially obsolete activities and the development of new, viable businesses. Scrapping releases labour. New development often requires more skilled or educated labour. If it is not available, new recruitment takes much longer than normal, and unemployment may follow.

Higher quality labour -- as we shall also argue -- promotes flexibility and adjustment and hence competitiveness, and consequently contributes to the solving of the unemployment problem.

Most of us would instantly agree that knowledge and human skills are what matter for economic welfare. Such a general proposition is trivial until we have defined empirically what we are talking about. Few of us would, however, venture a more exact hypothesis about the properties of the relationship between industrial knowledge and industrial output. And no attempts of the latter kind would be right since we simply do not possess, by any scientific standards, the necessary empirical knowledge.

This paper attempts to bring explicit awareness of the significance of human capital to bear on, and to develop a conceptual framework for, economic reasoning. This sounds pretentious, and it may be, but the implications are of a different kind. The removal and addition of small, seemingly innocent assumptions traditionally made in economic analysis simply destroy or change standard results on how (in economic terms) things work and what should be done. The modifications we will make relate to the nature of microeconomic processes (dynamics) and the fundamental instability of institutional and organisational forms as a consequence of economic processes. This makes the analysis of economic efficiency a comparison of new and old organisational forms, and welfare analysis the study of the adjustment process.

1. <u>A Working Hypothesis for Policy Making</u>

Lacking a concept of the whole of a dynamic economic system, the policy debate has focused on easily observed details and taken some of its participants into sometimes extreme or absurd positions. Unfortunately, we have got, as a consequence, a debate on robotics in process automation and what to do about chips manufacturing rather than a discussion of the educational needs to cope with emerging, unknown industrial technologies and adjustment problems. The quality of labour and its selection for various tasks in working life is an unavoidable problem in a study of how human resources are used in production.

The task before us is, of course, much too large for the compass at our disposal. We intend, therefore, to outline the policy problem as a whole rather than present a collection of separate pieces of evidence. And we offer the paper as a <u>working hypothesis for policy makers</u> for later checking and careful testing.

The observations and systematic evidence here presented are predominantly centred around the industrial firm in a broad sense -- an important restriction to keep in mind since manufacturing and private industry are rapidly becoming statistically blurred concepts. Even though private industrial firms represent only a limited part of the whole economy, it is there that technological transformation is initiated and where the demands on (and for) human resources will first be felt. Even within that limited sector, however, evidence is very fragmentary, so any conclusions drawn are necessarily a synthesis of fact and assumption. This is of course the traditional method in formulating a set of working hypotheses, and we will be explicit where particular assumptions are critical for the conclusions and where more evidence is needed if decisions of any importance are to be carried out.

Within our area of inquiry most facts brought together concern the use of information technologies in factory production and how they affect workers. The reason for this is the great concern voiced in the 70s about automation, robotics, jobs and competitiveness. (For reasons of balance, this report is presented in two parts, the wealth of literature on automation and factory production being dealt with by Paul Ryan in Part II.)

Part I gives emphasis to the accumulation of high-level industrial competence needed to co-ordinate, control and transform entire business organisations. We focus in particular on the nature of the transformation process and its consequences for the inhabitants of the organisation at all activity levels and work stations. We highlight the growing service content of industrial production and the growing looseness of institutional forms. Non-process activities in the large, sophisticated manufacturing firms already use up more than half of the labour resources, measured by hours of work. Most of these non-processing activities concern the collection, analysis and use of information. In the Swedish economy, for instance, these firms dominate the manufacturing sector and export trade. It is, therefore, interesting for our purposes to study them as indicators of future structural development.

In this a lot of important guesswork has to be done before we can generalise from the fragmentary evidence available from these very sophisticated firms. To what extent, and when, will these patterns be typical for industry at large?

Our emphasis on the industrial firm can also be justified on other grounds. In our reasoning, it is the engine of the economic growth process. This assumption is in part a reflection of the industrial firm as being the initiator and carrier of new technologies. We also conclude that the generalisation to the entire private sector from sophisticated manufacturing firms will probably be reinforced if more evidence on the provision of information services is gathered. This assumption about the engine of economic growth is traditional in economic growth analysis. It is, however, based on some specific notions about the nature and relative efficiency of protected domestic production activities. In those it is implicit that protection per se, notably from competitive, innovative entry and market-forced exit, deprives the protected sector of qualities that are crucial for the macroeconomic growth process to occur. With free competitive entry and free pricing, for instance in the public sector (privatisation), the approach of this paper would have to be modified. In applying the conventional framework of discussion we can, however, keep our problem reasonably narrow, and deal with government as an infrastructure builder that supports (or blocks) the free market forces in the private sector.

However, a major part of our concern in this paper is a typical public, and regulated, activity in most western countries, namely schooling. It is tempting to ask what would be the result on educational output and economic performance if free competitive entry into schooling was permitted and encouraged, allowing private enterprises to engage in previously public teaching, in competition with public schools, but retaining public financing of the schooling system.

We are asking this question bluntly and provocatively because two indications of this study are: first, that the most important human capital accumulation occurs before school (upbringing) and after school (on the job); second, new knowledge and skill requirements in emerging new industries make on-the-job accumulation of knowledge through varied professional careers relatively more important for productivity performance and personal job success. We are discussing aspects of learning that cannot efficiently be performed at school. Hence, privatisation of important elements of the educational process may be taking place endogenously, as part of the reorganisation of production towards structures that incorporate a constant upgrading of human skills on the job as a necessary cost of efficient production (see Chapters III and IV). It is therefore appropriate to ask to what extent this development is explained by the nature of knowledge requirements on the job, or as a result of an inefficient organisation of knowledge production in the schooling system.

This finally, leads on to an obvious restriction of our analysis: we are discussing the relationship between human resources and economic performance, meaning essentially economic growth. For reasons of time and practicality we have not, however, been able to concern ourselves with other important matters such as equity, fairness of income distribution or intergenerational problems, except for the financing of certain forms of education.

We do, however, bring in the notion of economic and political stability. Large shifts in wealth and income distributions, opportunities provided, and the like may cause instabilities in the political system that are detrimental to economic performance. If such shifts depend on the way schooling is carried out in an industrial society, the results of our analysis become even more important.

2. What Kind of Capital Matters?

Capital and labour have long been thought of as separate factors of production in economic conflict. Traditional economic analysis views higher capital intensity (machine and construction capital) in industry as the vehicle for economic growth. Hence, much economic planning has been based on the notion that more machine capital (or even cheaper financing of machine capital) is enough to trigger economic growth. As labour, enriched by skills and knowledge, i growing in importance as a productivity-enhancing factor, while pure capital inputs in the form of machinery and constructions are increasingly associated with negative economic signals, the relevant question is to what extent human capital confers productivity on both hardware capital and man-hours.

A notion present in much policy discussion about labour market problems is to what extent the economic value of the human capital endowment of an individual depends on what task he happens to be allocated to. A standard theoretical assumption is to make the productivity of labour independent of the task (the homogeneity assumption). Our study indicates that this assumption is false and leads to misleading conclusions. Hence, in our conceptual framework, an employee behaving as a passive agent waiting for a well defined job to approach him, or for a labour market agency to take care of him, is going to experience a reduction in the value of his personal human capital compared to the potential open to him in alternative occupations. Three theoretical notions that are standard in much modern labour market analysis should therefore be mentioned here. The first is again that of the individual as the sole, active search agent in the labour market, regarding search time as an investment that will eventually yield a higher life income. Representatives of this view often argue that a higher open unemployment signifies longer search and, hence, may even be a positive welfare signal, a theoretical result that has not even been recognised in the political debate.

The second theoretical notion is that human beings have a well defined skill endowment that produces the same output and fetches the same price wherever it is employed.

The third notion is that the price paid for a unit of labour input measures the value of its marginal product.

All three notions are empirically suspect in their extreme versions and, while this may not matter in some contexts, it certainly does when we attempt to understand what goes on in a labour market. However, the fact that such assumptions are frequently present in theory and reasoning, and hence often in policy advice, means that any relevant discussion of human capital in the production process has to be theoretically and empirically explicit in distinguishing between schooling and the labour market process as a filter on the one hand, and as an investment activity on the other.

If selection rather than skill improvement and knowledge accumulation is what matters for individual and macro-labour market performance, then the standard post-war views on labour market policies and/or on the nature of unemployment are wrong.

The supply and demand situation in the job market is characterised by extreme diversity, both as regards demand for talent and skills, and as regards supply of talent and skills. In addition, the structure of skills demanded is constantly changing. This means that a tremendous matching problem exists in the labour market and that this may be as important a problem for individual welfare as the investment in human capital. The selection mechanisms matter and active search in the labour market is what effectuates efficient matching. The potential welfare gains from a reallocation of labour on jobs may be potentially very large.

We even venture to propose that the educational process at home, at school and on the job may be the major vehicle for search, partly because it shapes the attitudes to the job market and partly because it enhances the efficiency of search and of evaluating and capturing diverse job opportunities.

With this approach both human capital and economic search theory broadly defined carry an explanatory power to individual labour market performance. And their respective explanatory power has to be ascertained before we can say anything sensible about policies. In addition, what links the two extreme versions of theory together is the organisation of the labour market process. This, then, with ... ...s of the process, becomes a critical, welfare-determining facto[illegible]

We have also inquired into the relationships between the educational process, knowledge creation, the ... technical change and macroeconomic growth. We observe that techn... ...nge, as conventionally measured in macroeconomic production function analysis, is really related directly to the rate of (market-guided) structural adjustment of the economy.

On this score we have concluded that fast and stable macroeconomic growth requires two things:

-- A steady increase in the knowledge base of industry;

-- The acceptance of significant micro instability and diversity.

We will demonstrate in the next chapter that the second "item", being a side effect of the dynamic market resource allocation process, is a necessary condition for knowledge and technical change to be transformed into macroeconomic growth.

Educational policies have traditionally focused on the first, investment-oriented conclusion. The second, however, has become a pressing reality during the 80s. There is a positive and a negative side. Diversity is created through active innovative behaviour in existing firms and innovative entry of new firms. The exit function, on the other hand, can be a very destabilising experience for the individual affected. As a rule the skills required on existing jobs and on new job openings differ significantly.

There has been heated discussion in some circles on "deskilling" as a consequence of new technologies; the standard example is that handicraft jobs disappear and robots take over. What remains -- it is argued -- are simple supervisory jobs. So it is possible that, if simple menial tasks or menial craft jobs disappear, middle-aged job holders who have done nothing else in their lives are pushed down the job quality scale, because going the other way requires too much in the way of reschooling. We may have to face a generational problem here, but it is not a new one. We know, however, that there is no upper limit to the demand for skilled and educated labour. The evidence to be presented here is rather that lack of skills, knowledge and flexibility on the job is what holds back investment and production growth.

The conclusion, then, is that the educational and the labour market processes are critical for macroeconomic growth. They create and allocate knowledge and talent, and they help to reallocate and recreate talent and knowledge wherever these have become obsolete. It remains, however, to identify what "the knowledge base of an industrial society" is and what the educational process that creates it looks like.

To say anything with empirical content about these matters, we have to demonstrate how the modern industrial firm functions as a vehicle for national industrial growth and general economic wealth creation. This can be done with some ease, since most of us tend to accept this as a fact without argument. Nevertheless, it is a pedagogical oversimplification which in some organisational contexts is simply wrong, and in others, misleading -- if not elaborated with care.

The next step is to explain the nature of the modern industrial firm, its knowledge base and its implications for the human beings. This is more difficult.

A first notion to bring home is the continuing development toward a more abstract job environment and more abstract work tasks, removing the workers more and more from direct manual operation. This is nothing new: it has been going on since prehistoric times. But many observers are worried that an accelerated change will accompany the so-called electronics revolution and that an increasing fraction of people will be unable to cope with this new environment and will be forced into low level jobs (deskilling). We conclude that this prediction is wrong.

In support of our objection, it is illustrative to compare the so-called electronics revolution of today with the invention of the printing process. The printing process presented mankind with a new technique of communication that speeded up scientific development, which in turn preceded the industrial revolution. The use of this new means of communication, however, did not disseminate faster than the development of a parallel skill, namely, literacy. Communication is the essence of an innovative, industrial market economy. Electronics-based information technologies provide an enormous future communications potential. However, it will not be exploited faster than the complementary literacy requirements grow. The benefits will accrue first and fastest in those societies that develop this complementary human capital first. This is a typical educational problem. While the learning process has already started at the micro level as a response to demands felt in the market, educators and policy makers have begun to discuss "computer literacy" (see Moonen and Wuite-Harmsun, 1984). It is illustrative again to observe that this is often taken to mean the same thing as the "rote learning" of how to use a terminal. So the educational issue is as much a problem for the teachers, the educators and the politicians as it is for the young at school and the people at work.

A second aspect is the increasing professionalisation of the firm. It is both a matter of increased specialisation on difficult tasks and a matter of generalised operational knowledge. In both instances the career becomes the important educational vehicle and especially in the latter, where a varied career is the critical promotion path. The relative importance of education or career as an investment and a selection device is almost impossible to ass[illegible] but we can at least see that the higher in the management hierarchy a person climbs, the more compelling a varied career experience becomes in his selection. Experienced and successful executive people are a far scarcer resource at all levels than recently graduated electronics engineers, the difference lying in a combination of selection of the talented, and the learning experience acquired during one's career.

A good supply of such talent is what constitutes much of the industrial knowledge base of a society. It is not obvious what policy makers can and should do about this; but it is clearly beneficial if they never lose sight of the importance for an individual of education acquired through a varied job career experience.

An entirely different question is whether a development into a different "information society" is indeed desired. Are people ready for it? Such a question has, of course, no scientific answer; but we do know that a gradual transition into a different society has been an ongoing process at all times, that human preferences are very flexible and -- contrary to the postulates of economic tradition -- are in fact an endogenous part of the economic process.

Culture, or the cultural tradition of a nation, has often acquired a design that contributes to a particular economic system or philosophy. This "culture" is an integrated part of our thinking, reinforced through the public schooling system to the extent that even "objective" researchers cannot abstract their analysis from their own cultural heritage. This is a trivial observation. In that sense cultural change is an element in the important economic information and indoctrination process of a society that this paper is concerned with, and an integrated part of the steady change of individual preferences that takes place. This is indirectly obvious from the ways formal schooling is designed.

As we will suggest, it is impossible to discriminate between cultural indoctrination and human capital investment in the schooling process. The economy may change faster than the culture can accommodate. The culture may change to facilitate or disturb the economic process. Part of the changes may be exogenous, but there certainly is a great deal of mutual endogeneity involved. These may not be appealing conclusions for the scholarly and educational worlds, but for the policy maker it should be natural to use the working hypothesis proposed here, namely, to see education and human flexibility as a pair and a means of solving the political equity and stability problems that are always critically present in a growing economy.

3. Who Benefits and Who Pays?

A political, cultural and moral superstructure has always existed in all organised societies. It is designed to monitor and control the more basic economic processes, concerned with the production of goods and services. However, the earlier dominant hardware production processes based on unskilled labour are losing competitiveness in advanced industrial nations. The information economy is mixing with the traditional production economy, creating an unfamiliar institutional float. At the same time new types of jobs with high skill requirements are opening up.

As a consequence, the labour market in the old industrial world is facing a difficult transformation problem. The main social problem appears to be located among the middle-aged, semi-trained people who have been in the market for an extended period of time and have acquired little or no experience from more than one job.

The young people are in a considerably more favourable position. Their education is new and they are prepared to learn a job. However, the search or experimentation phase may lead them astray, especially when the economy is in trouble and cultural preferences and values run counter to the efficient functioning of an industrial market economy. After a while the new entrants into the labour market belong to the middle-aged, semi-trained and less flexible problem group. There is even some evidence that children growing up in "unemployment families" tend to acquire a particular attitude to working life that makes them more prone to become unemployed themselves than the normal youth.

If there is a growing risk for certain, exposed groups of people to get caught in an unemployment trap for the rest of their working life, if they lose their job, what can be done about it? Is it an economic proposition for society to get these people back into work, or shall society accept the problem and bribe the unemployed into accepting their new role? Most of the jobs disappearing are low-skill jobs, heavy and not particularly healthy jobs. Helping these people over to new, educationally demanding jobs is very costly. There is ample evidence that the productivity of many industrial activities coud be greatly increased if work could be freely reorganised in such a way that total labour input would be reduced, but only unskilled labour laid off. There is also some evidence from Sweden that workers laid off from heavy, uninteresting routine jobs, when given a choice between a new, similar job and a generous early retirement arrangement, prefer the latter (Björklund, 1985a). Economic analysis often suggests that society pays people generously rather than attempting to solve an impossible adjustment problem and concentrates on avoiding a continuous repetition of the same problem. There is no comprehensive knowledge base to evaluate the social side of such policies and hence the whole spectrum of policy positions is represented. Whatever the position taken, job allocation is still a major problem and the task for the labour market must be:

-- To prevent (young) new entrants from getting stuck in low-skill, routine jobs (the labour market problem);

-- To provide for the development of new skills and necessary human capital (the educational problem).

It is unclear who is in charge of this undefined task beyond the individual himself, and we will develop that issue later. It is also unclear where and how the important investment in new skills takes place -- in the family, in the formal schooling process or on the job. That matter, too, will be given due consideration below.

4. What Can Politicians Do?

A concluding argument of this paper is that, together with basic societal services (legal system, defence, healthcare, etc.), attention to the educational infrastructure is probably the most important task of Government. The educational infrastructure also includes the rules of the labour market process. The scientific community, however, does not yet know enough to develop detailed policies related to the educational function. Perhaps this is the way it should be and the important public task is to attend to the orderliness of certain functions in an economic process, rather than guiding, monitoring and controlling them.

For one thing, the nature of human skills and knowledge that matters in the production process is extremely fragmented and for most practical purposes not known at any central level above the work place. Hence, the schooling or educational system as a whole cannot be deliberately redesigned as an automobile to improve economic efficiency. It can only be improved through gradual experimentation. Centrally imposed standardization of the schooling process is more likely to harm efficiency. This is especially so if local experimentation with teaching methods is prohibited, the schooling system centrally controlled, and reforms hastily implemented, as has been the case in many countries.

Let me take a couple of examples. Suppose one can believe in education as an investment and that it takes place at school. Then one type of policy becomes natural.

However, if one believes, rather, that education is mostly a filter and that the most important educational experience occurs on the job in the form of varied job career, then one would opt for entirely different policy conclusions.

If one believes that both the filter and the investment in learning matter significantly, together with upbringing and useful indoctrination at home, at school and on the job, then the policy issue becomes overwhelming if it is going to be run through a central authority. This is perhaps the most appropriate starting point for policy-making in the educational field.

A second observation to make is that most educational activities can be placed in the market. A free market schooling process as a rule, however, will present individuals with unequal opportunities. But there is a host of intermediate solutions between a centrally run, standardized educational system and a completely free market solution, and a number of them will both allow and stimulate micro-based experimentation that will eventually develop into a better system, at least from the point of view of economic performance.

One observation of this paper is that industrial technologies and skill requirements have always been changing. It is an open question whether they are changing faster now than they used to. However, information technologies may be opening up the opportunities to create a fundamentally different industrial environment, the details of which we cannot predict. We can nevertheless infer that the new work environment will be scientifically and educationally more demanding, requiring both the ability to work with abstractions -- in contrast to manual jobs and craftmanship -- and be flexible in performing diverse tasks. In addition to this, the ability to be creative and innovative will command a premium on future jobs, especially if the job development for talented people goes in the direction that we believe, away from wage- and salary-paying jobs in large organisations towards smaller-scale activities and self-employment.

Our conclusion is that this development will not be faster than the people affected will accommodate. Human capital and talent will be limiting factors. However, the speed of development will differ enormously between countries. And the major impact of new technologies will not come directly through indigenous investments in new technologies -- which rarely cause problems -- but indirectly in the form of competition from those firms at home or abroad that do it better than you. So whatever is done, the future work environment will be characterised by significant and unpredictable change when it comes to all those important details. The ability to improvise, to initiate change and to cope with change caused by others will be well compensated in the labour market.

This observation raises a third question: how do we prevent the formal schooling system from inhibiting initiative and destroying creativity among the pupils? It seems a safe conclusion that the experimentation aspect, and search in the job market, will become an important characteristic of the future. The schooling system does nothing to facilitate that; rather the opposite, since it instructs you to be good at those things you are being taught, which is the knowledge base of the schooling system, and what teachers happen to know.

This introduction suggests the outline of the next few chapters. We begin in Chapter II with a well-rounded and quite speculative discussion of the nature and development of industrial knowledge based on published economic historical material. This allows us to focus in Chapter III on the emerging knowledge requirements of the modern firm, and to continue in Chapter IV with a discussion on how the human capital and industrial knowledge needed may be most efficiently created (produced) in modern society.

Innovative competitive entry in the form of new firms or new activities in old firms is the main vehicle for progress in industry, and for an education system that has gone stale from too much protection, repetition and subsidisation. Our conclusion is that if industrial policies are at all needed to help economic growth along, they should take the form of new labour market and revised educational policies.

Chapter II

HUMAN RESOURCES AND ECONOMIC PERFORMANCE: THE PROBLEM

1. A Few Observations

Recorded experience of initiating and operating "best practice" production establishments has inevitably been fragmentary and internationally dispersed. Ambitious nations have often believed that a faster transmission of those frontier technologies to their economies will speed up production growth. Literature, however, is rarely explicit about the complementarity between technology and requisite human knowledge. In the past some nations have gone quite far in encouraging the import of know-how and the immigration of entrepreneurs. It has also been common to send people to foreign advanced countries to learn about what is going on. Thus, the Swedish economist Westerman (1768) observed that Swedish shipyard performance in the mid-18th century was only half that in England and in Holland. He attributed it to the slower work process in Sweden, to lack of industrial knowledge, inferior methods of organising work and lack of "these new machines". What is interesting is Westerman's early emphasis on the importance of specialised industrial knowledge to know what to do with the machines and with labour. The literature has always recognised the critical importance of knowledge, but has rarely attempted to define what it is. It has been too difficult and, hence, has been passed over in economic analyses.

Statistics brought together by the United Nations and other international agencies offer a both interesting and frustrating picture of the current economic state of the world.

A not insignificant part of the world population still lives under technological and industrial conditions resembling those prevailing at the early stages of the industrial revolution in Europe some 200 years ago (Boserup, 1981).

While practically everybody can read and write in the industrially advanced nations, in countries of poor literacy the level of industrial technology is correspondingly low. In 80 out of the 130 non-communist countries in the world, encompassing the bulk of the population of the free world, literacy is below 50 percent (Boserup, op. cit., p. 13 ff.).

Table II:1

DISTRIBUTION OF COUNTRIES AND LITERACY AT
VARIOUS TECHNOLOGICAL LEVELS CA. 1970

	Technology levels				
	I	II	III	IV	V
Percentage of literates 15 years old and over	12	29	46	80	89
Number of countries (per cent)	26	26	26	26	26
Percentage[a] of world population 1980	8	26	9	10	25
Dominant region	Africa excluding North Africa	Same	Arab region	America excluding North America	Europe and North America

V Highly industrialised

IV, III } Median technology

II Low or very low technology

I Pre-industrial or close

a A residual of 22 very small nations and China, making up 23 per cent of the world population, has not been classified by technological level.

Source: United Nations: Developing Countries and Level of Development, E/Ac 54/L81 Annex II (New York, 1975).

A high verbal literacy is of course not a good measure of the educational skill requirements to run an advanced industrial society, but it is a minimal requirement. And the simple numbers in Table II:1 illustrate what a basic, general education may mean for economic performance.

The percentage of a population qualified for higher education may shed some more light on the educational side of human capital requirements. Data put together by the OECD demonstrate for the industrialised countries that the wealthy industrial nations have a higher proportion of their age groups qualified for higher education. However, the correlation between economic wealth and higher educational achievements is not particularly high. The definitions of "education" are very diverse, and higher education is only indirectly linked to production. In wealthy nations education may even include a significant element of personal consumption.

What the relationships are between various forms of education and the economic performance of a nation is an extremely difficult question to answer. We will attempt later to add some precision to the concept of educational requirements and the content of human capital needed for industrial growth and to run a prosperous economy. In this chapter the discourse will be more general, attempting a frame for the later analysis. We will argue that the economic wealth of a nation is closely related to the private firm and particularly so to the modern manufacturing firm and we will proceed in the following two chapters to detail the nature of activities going on in such a firm and to outline the knowledge base and the skills required. It will, however, be useful to distinguish already here between the "functional literacy" that comes with a general education and training in a vocational school with the knowlege accumulated from, and the skills acquired through, on-the-job learning. We are already beginning to hear the term "computer literacy" referred to as a required endowment for careers in future labour markets. A study like this requires that we discuss what such a term may mean in the new "information society" that some social science philosophers claim they can see on the horizon. In the historic analysis of engineering education to follow, it will be very appropriate to discuss the need for "functional literacy" in the information society. It is illustrative to set this discussion against the perceived economic effects of "the printing press" over the last 500 years.

Before entering upon this, a few additional observations are appropriate.

The bulk of industrial (manufacturing) process techniques in mainstream engineering industries are based on metal-shaping machine tools, the principles and designs of which took form some 150 years ago (Hicks, 1977, p. 147). Around these tools a formidable capital structure of hardware installations and human skills has been built. At the same time, new combinations of new materials, shaped and fitted together with new tools and requiring new skills, seem to be developing. This has already made old traditional skills obsolete and forced them to exit where they have not been protected by government regulation or union practices. Since the growing, money-making firms are more frequently in industries using new materials and new tools, the old machine tool-making industries have lapsed into a situation of economic distress. The outstanding feature of recent advances in manufacturing technology, however, seems to be a shift from <u>process</u> towards <u>product technologies</u>, rapidly increasing skill and human capital requirements and, as a consequence, significant increases of the service content of output (Eliasson, 1981, 1984a; Lindberg and Pousette, 1985).

A small delay in adapting to, or the inability of an (earlier) advanced nation to seize upon, this new combination of industrial techniques may rapidly throw its lagging economic structures into a situation of economic distress (Eliasson, 1979).

The road of economic history is littered with business ventures, national economies and economic policies that have not made it. Lack of appropriate knowledge, know-how or skills is the explanation usually offered. For the social scientist, however, to define human capital and relate it to economic performance, is not only a formidable task. It takes us far beyond available standard economic methods into fields like engineering, economic history, business administration and education. To arrive at a conclusion, the content of human capital has to be specified and measured. Reasoning will have to be quite speculative at critical places, and based on important prior elements of pure assumption. The conclusion of this chapter will be a working hypothesis for policy makers, the assumptions of which we will proceed to elaborate and to test in the following three chapters.

2. Breakdown of Total Factor Productivity

Students of economic growth using macro-production function analysis have consistently observed that -- during the postwar period -- most output growth in manufacturing, or the whole economy, could not be explained by measured inputs of hardware capital (machinery and buildings) and labour in the production process. This total productivity factor was puzzling in itself, and the riddle doubled when total factor productivity growth suddenly disappeared after 1973, in the wake of the first oil price crisis (Denison, 1962, 1979; Griliches and Jorgenson, 1967, etc.). Numerous scientific articles and books have been published on this subject. A relevant question to ask is whether the macroeconomic production function technique, applied generally, is distorting understanding of the macroeconomic growth process. Essentially, this will be my argument. The economic growth process is a micro-economic phenomenon, with the dynamics of resource allocation in focus. Understanding economic growth requires an appropriate dynamic theory that has to be explicit about the ways the market processes co-ordinate economic activities. We will illustrate this by breaking down total factor productivity growth in Swedish manufacturing, 1950-76, into a number of well identified elements.

The traditional (production function) approach is illustrated in Table II:2a. It demonstrates how an increasing fraction of total output growth in manufacturing cannot be explained by increasing inputs of machinery and capital and of labour in the production process. By the mid-70s, more than 90 per cent had to be explained by some mystic technical residual. Then all of a sudden, after 1976, this "mystic" residual disappeared throughout the industrial world (see Table II:2b). To answer the question of why it disappeared, one has to know why it was there in the first place, and this is no easy task.

Denison (1962) in a much discussed study approached the residual in terms of factor qualities that are not measured properly in available

Table II:2a

PRODUCTION FACTOR INPUTS AND TOTAL FACTOR PRODUCTIVITY
IN SWEDISH MANUFACTURING, 1950-76

Period	Annual Percentage				Percentage of output growth attributable to total factor productivity growth
	Production	No. of hours worked	Capital stock	Total factor productivity	
	(1)	(2)	(3)	(4)	(5)
1950-55	2.5	0	5.5	0.9	36
1955-60	4.8	-0.2	4.6	3.6	75
1960-65	6.9	0	5.4	5.3	77
1965-70	5.1	-1.8	4.8	4.9	96
1970-75	2.4	-1.8	4.6	2.2	92
1950-76	4.2	-0.8	5.0	3.2	76
1976-80	-	-	-	0.9	-
United States non-residential business sector					
1948-73	3.6	1.0	2.9	2.2	61

Source: Carlsson: "The Content of Productivity Growth in Swedish Manufacturing", The Firm in the Market Economy, IUI 40 years 1939-79, Stockholm 1980, and Aberg (1984).

Table II:2b

TOTAL FACTOR PRODUCTIVITY GROWTH IN MANUFACTURING
IN VARIOUS OECD COUNTRIES 1953-80

Country	Output growth (per cent per annum)	Change in labour input (hours worked, per cent per annum)	Total factor productivity growth, per cent per annum	
			1976-1980	1953-1980
Canada	4.2	0.8	0.5	1.3
U.S.A.	3.3	0.6	0.8	1.3
Japan	10.1	2.7	1.7	3.1
Denmark	3.9	-0.7	1.5	2.9
France	5.2	0.4	2.1	2.7
West Germany	5.5	0.5	2.5	3.1
Italy	5.6	0.4	0.3	2.9
Netherlands	4.8	-1.1	1.3	3.1
Sweden	4.3	-0.5	0.9	2.6
United Kingdom	2.3	-1.1	1.4	2.0

Source: Åberg, Y., Produktivitetsutvecklingen i industrin i olika OECD-länder, 1953-80, IUI Research Report No. 25, Stockholm 1984, Tables 5:4 and 6:2.

statistics. By correcting labour input for educational levels and similarly for other factors, larger inputs in the production process are registered, and the residual factor is correspondingly reduced, but not eliminated. Furthermore, the problem is that quality correction is more or less arbitrary guesswork. The extreme version of this kind of corrections is found in Griliches and Jorgenson (1967). They correct for quality by imputing prices to factors that derive from a profit-optimising model in a static market environment. If factors are appropriately priced, factor prices should reflect quality differences. If factor prices are imputed backwards from data on measured output, factors will be given values that roughly correspond to their contributions to measured output. The residual factor more or less disappears in Griliches and Jorgenson's study. Under the equilibrium conditions, assumed quantities are mirrored by prices and vice versa (duality), and productivity change can be measured by prices. However, the problem remains. Quality corrections are still there more or less through guesswork and prior, unexplained, assumption. But the approach underscores one important element of the problem: prices and markets matter for the productivity performance of an economy. The problem is how!

We will start from this observation. The above calculations neglect the importance of the dynamics of resource allocation when the economy is operating out of equilibrium and the duality property does not hold (Eliasson, 1985b). More or less efficient institutional arrangements, skill applications and flexibility in adjustment characterise the various countries. The use of information and the actual process of change are resource-using activities, and our explanation of total factor productivity growth has to take the effects of the market adjustment process into account. We have attempted that on Swedish data in two ways. The first is illustrated in Figure II:1. Simulation experiments on the Swedish micro-to-macro model developed at the Industrial Institute for Economic and Social Research (IUI) make up the other illustration.

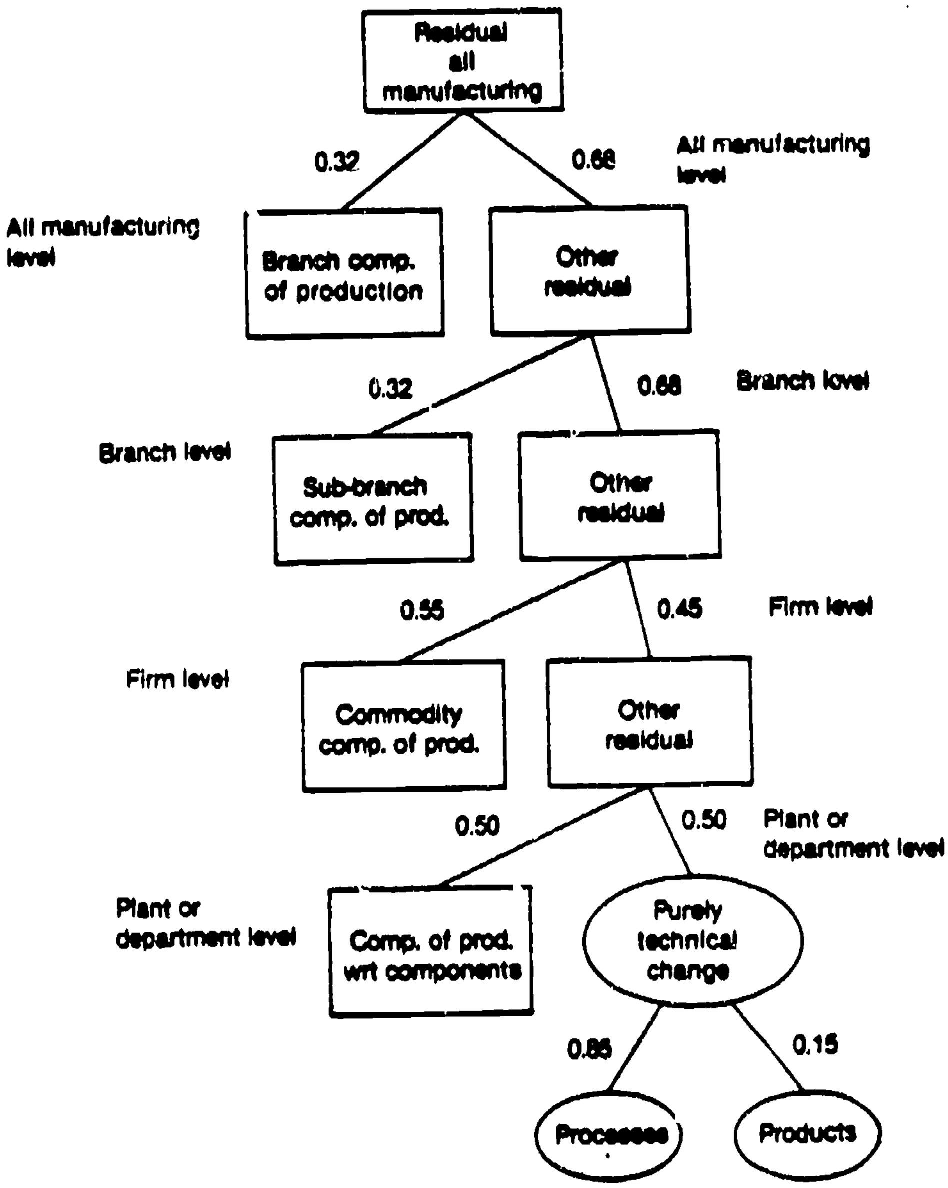
In the standard reweighing approach, traditional production function estimates were made on eleven individual sectors of manufacturing. We then found -- when comparing with the aggregate, industry total estimate -- that some 30 per cent of the total depended on structural adjustment in the allocation of resources between sectors, resources being shifted from the low-performing to the high-performing sectors. Taking one further step down to the plant level, in one industry sector we again found that 30 per cent of the sector's total factor productivity change depended on resource re-allocation between plants in that sector (see Figure II:1).

Similarly, when attempting to measure labour productivity change in new investment vintages ("best practice plants") we found that the average annual change over the 1955-75 period was around 2.5 per cent, compared to a corresponding aggregate industry figure of some 6 per cent. This was also the figure generated by the IUI micro-to-macro model (Carlsson 1980; Eliasson, 1979, 1980, p. 230 ff, 1981).

Hence, by these independent estimates, more than 50 per cent of productivity change as measured at the aggregate level appears to have been generated through a re-allocation of resources between firms and plants at the micro level. Simulation experiments also suggest (Eliasson and Lindberg, 1981, p. 381 ff.) that investment misallocations *per se* may not matter that much, as long as mistaken (non-profitable) investments are properly and

Figure II:1

COMPOSITION OF THE RESIDUAL TOTAL FACTOR PRODUCTIVITY GROWTH AT VARIOUS LEVELS OF AGGREGATION IN SWEDISH MANUFACTURING



Source: Carlsson, "The Content of Productivity Growth in Swedish Manufacturing", p. 37 in The Firm in the Market Economy - IUI 40 Years, Stockholm, 1980.

rapidly scrapped. What matters is that you otherwise tie up labour in low-productivity plants, depriving high-productivity activities of labour input and raising the real wage level in industry above where it would otherwise be, especially in marginal expansion phases, thus holding back expansion in the high-performance firms. In fact, it has been possible to demonstrate in the micro-(firm)-based simulation model that, holding technology in new investment vintages constant, differences in long-term output growth rates as large as those observed between countries over the last 100 years (see Figure II:2) can be generated by simply varying types of market regime, that is, the parameters that set entry and exit frequencies and the speeds of new resource applications in response to prices and profit opportunities: in other words, the speeds at which old resources disappear and new resources come in.

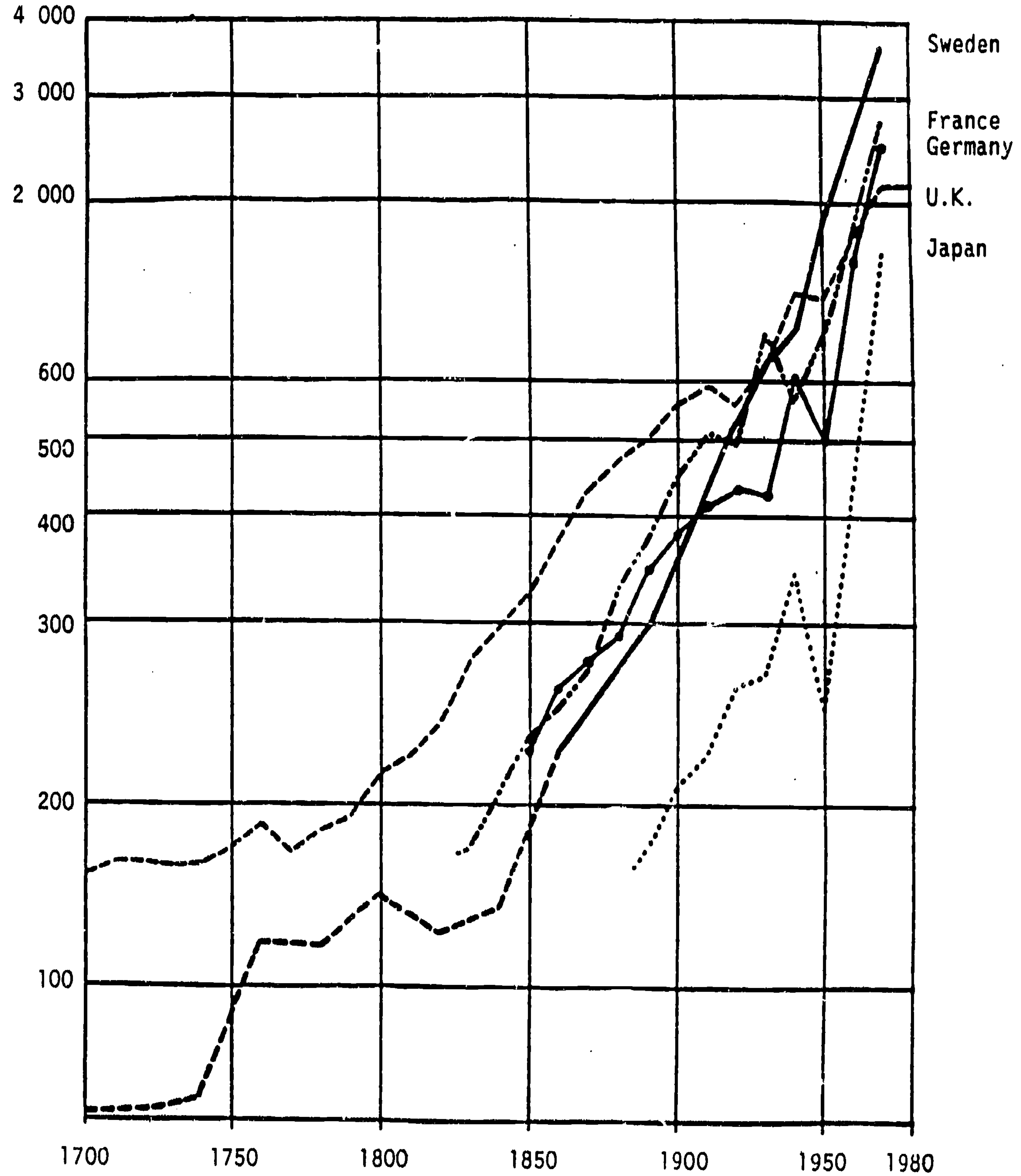
A survey of the literature of economic growth suggests that existing theories and thoughts can more or less be fitted into four categories (Eliasson, 1980b). We take Ashton (1948) and Solow (1957) as the representatives of the first (classical) macro-production function proposal. Ashton argues that new innovations in the credit market made capital cheaper. Thus, new and more productive capital was invested and the growth process, called the industrial revolution, started up in England. The main feature of this growth story is that improved productivity is embodied in the new hardware. What is needed to speed up growth is more saving to finance more and better hardware investments. It is an understatement to say that much policy making during the post-war period has been based on this notion of the economic growth process. This study will also raise and answer the question of to what extent an analogous theory of massive investments in human capital through more schooling can be successful.

The second type of explanation, the socio-economic, covers a variety of approaches, all placing major emphasis on the social, non-economic or semi-economic sides to economic growth. Weber, Schumpeter, Marshall and recently Olson (1982) belong here. In a stimulating but daring article, Wax and Wax (1955) place the cradle of capitalist thought and action in the Scandinavian Viking culture, well before the year 1 000. Recent archeological research is also proving the point that the Vikings, though armed and brutal, were more often traders and industrialists than robbers, and very much exhibited the individualist and democratic spirit that many researchers, among them Schumpeter, want to associate with a capitalistically organised market economy. Parker (1984) tells a similar story, but his begins with the Renaissance. The socio-economic explanation of economic growth emphasizes the economic-cultural-political environment as a factor in the growth process. One particular aspect of this is how the cultural climate influences attitudes towards "change" and "economic experimentation".

The third explanation we call the bureaucracy or (in modern terms) the industrial policy model. Here also the roots can be traced in history, European mercantilism being an example. It emphasizes the role of a central non-market body, like the Government or the King when it comes to organising an optimal growth process. It was commonplace in 17th-century Europe for the "dictator kings" of small and large empires to regulate the competitive entry process of the economy. Normally the ruler regarded the national economy as part of his private economy, a role adopted by some governments of today. The modern theory of economic planning, dating all the way back to the discussions of Taylor (1929), Lange (1936-37) and von Hayek (1940, 1945), is the core body

Figure II:2

GNP PER CAPITA IN DIFFERENT COUNTRIES, 1700-1980
(IN U.S.$ 1967, FIVE-YEAR AVERAGES)



Sources: Rostow (1980) and OECD statistics.

of thought that emphasizes, or rejects, the potential of a central overview of the allocation of resources, beautifully worked out within a static Walrasian framework. The traditional versions of this theory all presume that full information is feasible, at least at a cost, and hence directly contradicts the socio-economic explanation (1). The paradox that has to be recognised is that central economic doctrine (Keynesian and Walrasian general equilibrium theories) as taught throughout Western universities, lacks a theory of the dynamic market economy. Its assumption of a given number of agents or a given organisational structure confers upon it a strong "implicit bias" in favour of a centralistic planning solution, a fact that was not recognised in the Taylor-Lange-von Hayek discussion (see Pelikan, 1985).

A case for a market solution cannot be made within the framework of these theories without allowing competitive entry and exit and changing some fundamental assumptions about the availability of, and the costs of, gathering and using information. There are, of course, numerous soft versions of the bureaucracy model, all of them being manifested in the current ambitions of many Governments to develop a rational modus vivendi for a centrally-run industrial policy.

The fourth explanation we have attempted ourselves. We bring in a little from all three propositions, together with some elements of evolutionary economic theorising about technological regimes associated with Nelson-Winter (1982). We emphasize the initiative, and competence, of individual actors in the market, in this context notably the firms, and we set them up against each other (market competition), individuals and the political institutions. The notion of dynamic market allocation is that developed in modern micro-macro market theory (2). We talk about "market regimes" signifying their different efficiency features when it comes to handling resource allocation through factor markets. The individuals, through the latter, set a limit on the efficiency of the allocation process, forcing it to operate continually somewhere below its potential.

This explanation recognises the importance of know-how, but emphasizes both technical know-how and commercial know-how in a broader sense, thus removing the rigid connection between hardware capital and productivity improvements associated with the production function of the first hypothesis. It also emphasizes the importance of free trade and free competitive entry. We note that dynamic micro-macro market theory tallies nicely with the above decomposition of productivity (Figure II:1). It makes human knowledge, rather than machines and plants, the moving factor behind productivity change. When the requisite knowledge is missing, it does not help output, however much finance and hardware are supplied. With this approach the nature of the accumulation of human capital, and the allocation of labour become natural ingredients of the growth model; we need a micro-macro market theory. If special "elements" of human capital are important -- as we will find later -- we have also incorporated some of the socio-economic explanations.

In what follows, we will go through a number of issues related to the creation and dissemination of new techniques in an economy from a historical perspective with the fourth micro-to-macro growth explanation in mind. One purpose is to identify the institutions that carry the growth process, and to describe the roles of other institutional players. We will view the organisation of the market process and the use of information as two related, complementary technologies.

3. Why Industrialisation and Fast Economic Growth Started Earlier in Some Countries than in Others

A number of academic studies have been devoted to the question of why industrialisation started earlier in some countries than in others; and there are some historical indications as to an answer.

A commonly advocated theory has been that the sudden provision of physical (capital) resources in developing countries causes their economies to shift into higher growth gear and to take off. This theory has not worked well in practice. Resources have been wasted, the "bureaucratic" explanation of which would be lack of planning and coordination. The socio-economic explanation would be lack of proper infrastructure, or the wrong cultural environment.

With the exception of small, thinly populated countries that derive their wealth from an abundant, long-lasting raw material resource, one can observe that all wealthy industrial nations have been through a period of free capitalist organisation of their economies, prior to and during the industrialisation process. This can also be said to be true of countries currently experiencing very rapid growth in output.

If this is the nature of a successful capitalist, macroeconomic growth process, the outcome in terms of wealth creation between countries and between individuals will be highly varied. The important question, however, is to what extent prospective wealth creation moves the capitalist growth engine. On the basis of pure statistical records, it would be hazardous to bet on theories that propose that inequity in incomes and wealth creation do not matter as key factors behind fast industrial performance. It is obvious that supergrowth in the new industrial nations is closely correlated with very high rates of return, and profits reinvested in industry (see Chen, 1979). But it is also obvious that both high rates of return and fast growth depend on the <u>ability of firms</u> and nations to compete efficiently in world markets. This is all a matter of the created human capital endowment.

From all this, the explanation of the fourth market theory would be the commonsense one: if the requisite profit incentives and the necessary competence to use resources profitably do not exist, resources that flow in too easily or at a subsidised cost will be wasted. The answer, then, lies in the nature of industrial knowledge and how it is accumulated. On that problem economic theory has close on nothing to tell. What we know from historical studies is that if knowledge is to be accumulated from scratch at home, it is an extremely long-winded process. Strongly felt needs of survival may have forced (induced) new technological solutions. To speed up the process by "economic policies", however, operational knowledge has somehow to be imported, and in some countries military ambitions may have been the moving force behind fast technological progress. The following evidence would seem to support this explanation.

Raw material resources that can be profitably exploited have undoubtedly been a help in the growth process when a matching industrial knowledge has been present to make profitable reinvestment of the resource flow possible -- as in Sweden for the last 150 years, up to the early 70s. If the industrial knowledge is not present, or the resource flow cannot be channelled back to new investments, much or most of it winds up as public and private consumption. This is a typical problem of the oil-rich countries including Norway, and to some extent Holland.

It is still a debated issue among economic historians whether the liberalisation of trade and production (the market argument) or technical innovations (the Schumpeterian view) or foreign demand (the Keynesian view) propelled industrialisation. A composite proposition is that when trade and production were formally and legally liberalised, the thrust of technological change had already in practice broken down the regulatory framework erected in the past. In that interpretation trade liberalisation was an endogenous outcome of economic development.

Those nations that deliberately or by chance have begun to accumulate the necessary human capital infrastructures and organised themselves on a capitalistic mode, have also, eventually experienced industrialisation and economic growth. A study of industrial policy making should look back into the economic history of today's industrial economies to see how early the groundwork for infrastructure and knowledge accumulation really began.

Heckscher (1953) is very categorical in arguing that the existence of an efficient central, administrative control system, dating back to Richelieu's days, prevented early industrialisation from taking off spontaneously in France. In England it was much less elaborate controls (and in particular the absence of an efficient monitoring and control system) that made early industrialisation possible. It is interesting to observe from Figure II:2 that the Swedish industrialisation phase took off later, at about the time domestic trade and new competitive entry in industry were liberated around the mid-19th Century. It is also interesting to note that a foundation of industrial knowledge for industrial take-off had been deliberately encouraged by the Swedish kings since the mid-17th century, through imports and immigration of industrial know-how (Heckscher, 1935, 1941).

Much, or perhaps most, of human capital accumulation is part of a learning process engaging the entire labour force. It has been very time-consuming. Above all, human capital cannot easily be brought in readymade from abroad and injected into the local population through a crash schooling programme.

From the Printed Word to the Computer

One reason for this study has been the concern that industrial technologies of the Western world may be suddenly and rapidly reaching a higher stage of sophistication that will compete laggard economies into stagnation and cause severe adjustment problems in the labour market. The emotive words have been "electronics", "computers" and the "information economy". This is not the first time in history that worries of this kind have been voiced. National authorities have been worried about the international competitiveness of domestic industries. Labour has been worried about jobs. A first and very similar round of debates on computers had already occurred in the 60s.

It is illustrative in this context to look at a technological innovation of 500 years ago: printing. Studies of historic, long-run growth processes have generally neglected the factor of production knowledge and concentrated on the diffusion of technological innovations. The diffusion of information for hundreds of years through the printed word allows us to discriminate between these two factors. Printing technique was a pathbreaking production technology. It made it possible to pass on large volumes of knowledge in the abstract form of written information, which is a technology in itself. The use of that information required, however, a knowledge base in the receiver. He had to be literate. Eisenstein (1979, Chapter I) calls printing "the unacknowledged revolution". She goes on to point out that the contribution of the printed word to the development of an industrial society has been a matter of many centuries and it may never be possible to realise the full extent of society's debt to this information technique.

Parker (1984), on the other hand, passes over "printing" in the traditional way: the importance of communications techniques before 1850 has to do with physical transport of people and goods. In the second half of his section on communication, the economic "effects of the telegraph and the telephone" are discussed. Economic growth is typically propelled by physical innovations. He fails to observe, however, that none of the innovations he mentions would have been discovered or applied with success were it not for the ability to pass on information through the printed word. In fact, a money-based market economy cannot be conceived of without a complementary, extensive use of information techniques based upon this fundamental discovery.

Braudel (1972, p. 764) emphasizes that "one of the great borrowings of Mediterranean civilisation was undoubtedly the printing press which German master-printers introduced to Italy, Spain, Portugal and as far away as Goa". Later (1981, p. 3197) he refers to its contribution to the development of more efficient techniques of warfare ("artillery") and ocean navigation -- the printed word as a vehicle for transforming and transmitting the mathematical revolution of the 17th Century into practical applications. These two techniques helped Europe to achieve military and commercial dominance in the world for a long time.

But the capitalist market economies that began to develop in stages used information techniques -- and since the 16th Century the printed word -- as an integral part of innovative, productive and distributive activities. Eisenstein (1979, p. 8) also notes how the abundance of written records "affected" ways of learning, thinking and perceiving among literate élites. It affected the ways tradition was passed on from generation to generation. Barriers to the spread of information and knowledge were efficiently broken down and the way was paved for the age of enlightenment. Eisenstein also underlines that "standardization was a consequence of printing". Standardization and improved taxonomies are requisites for improved measurement techniques and, hence, an integrated part of scientific and industrial development. It is a first stage in the development of theory, measurement and quantification techniques. The development of mathematics certainly depended on the technique of printing, as is still the case for the diffusion and transfer of sophisticated skills of industrial society.

On the other side of the coin, the potential importance (indeed danger) of this was officially recognised as long ago as the early 1600s when the Vatican attempted to suppress all printed references to the unwelcome conclusions of Copernicus and Galileo (de Santillana, 1958).

Generalised and efficient taxonomies, standardization and mathematical thinking are key notions in the new, digitally-based information and communication technologies with which this study is concerned. For purposes of our further analysis of the commercial implications of information techniques, we will reformulate a distinction that Eisenstin carefully makes. The spread of printing first profoundly affected and altered the nature of communications within the already literate élite. Second, however, the advent of printing also encouraged the spread of literacy, although the latter, as can be seen from Table II:1, has been a fairly drawn-out process. In both cases the reason was that printing lowered the costs of communication, including teaching, and increased opportunities. If we generalise this observation to information technology in general, and modern computer technology in particular, we can say that the change in the nature of communication among those already "literate" corresponds to improvements in productivity experienced in already existing firms while the spread of literacy corresponds to the widening of the base of such improvements.

The latter is probably what matters in the longer run. It explains why nations and individuals have experienced a tremendous variation in success, and why the economic effects can be profoundly negative if a "nation is unobservant" and negligent.

The Knowledge Endowment of a Nation

This example also indicates the enormous size of the human skill endowment of an advanced industrial society -- something that its inhabitants normally take for granted, or may not even realise. Not even the devastation of the Second World War destroyed the industrial human capital endowment of Germany, only physical capital. But in a historic perspective the human capital of a country, by degrees and through political and institutional arrangements, can be made both to deteriorate and improve in quality and quantity.

It is difficult to be more explicit about the ways in which information ...plied to generate economic growth. Almost all economic historians have ...rated their attention on the invention and use of physical means of ...o. These are of course important, and we will sift through the e... what follows. Our argument, however, is that the means of upgra... and co-ordinating the physical resources is really what matters, and that ...ormation and communiation techniques then become supreme techniques of industry. The capitalistic market system, the planning system or any administrative or management system are different "technologies" of using information to co-ordinate production. A few remarks are appropriate on the question of which of these is the most efficent mode of organising resources.

How to Release the Technological Potential of an Economy

Some authors (among them Boserup, 1965 and 1981) have emphasized social pressures as driving forces that have induced technical innovations. Throughout observed economic history and, notably, in the industrial age, they observe the occurrence of combinations of positive factors, like closeness to mass markets (Europe), immigration of a skilled work force (notably the United States), etc. Cohen (1977) argues that overpopulation in prehistoric times forced a hunting and food-gathering population to leave a pleasant living style for a better organised food production (i.e. agriculture), harder and longer working hours and "civilisation". Ashton (already mentioned) suggested that credit market innovations released the tremendous industrial technology potential that already existed, and started the industrial revolution in England. Heckscher (1953), on the other hand, emphasizes the productive forces released when barriers to trade and new competitive entry were removed.

Major exogenous technological advances can pull the natural innovative process along by making it easier to solve pressing social problems. While some believe that the technological advances within the defense establishment have fuelled industrial growth, others point out that freely available technologies have been no blessing to the underdeveloped world. Some, like Vogel (1979), argue even that the large fraction of US economic resources devoted to defence and space-oriented R&D has significantly lowered its efficiency, compared to R&D investment in Japan, where practically all industrial R&D spending has passed the market test.

However, policies or more resources will do nothing to promote economic growth if the requisite knowledge base is not present. On this we know that ambitious and imperially minded kings of 17th-Century Sweden needed an upgraded manufacturing base to boost military might (Heckscher, 1941). The only way of doing that with some success in recent times was to import the knowledge. The kings of 17th-Century Sweden encouraged immigration of entrepreneurs and industrialists. It is interesting to note that the corresponding way today of introducing industrial knowledge fast and to obtain a skilled labour force is to encourage multinational firms to establish subsidiaries. The links between states and organisations like firms are, however, much looser than was the case as regards the immigrants who invested both their knowledge and their money on the basis of a "privilege", or a monopoly contract. They eventually became Swedes. However, manufacturing was slow to get started (3), but the knowledge base was there when demand for manufacturing products began to increase and resources started to flow from Swedish basic industry exports.

The steady improvement in heavy transport efficiency since the 18th Century "suddenly" moved producers and markets very close to one another. Competition intensified, old producers were forced out of business, and international specialisation to a degree not seen before became possible.

Governments could support this process or slow it down. Railroads were perhaps the most significant early infrastructure improvement. There was an economic rationale behind having the Government as a partner and even initiator in railroad building. Countries with an early start in this transport business today belong to the most advanced industrialised countries in the world.

Before Europe leapt ahead industrially during the second half of the second millenium, China probably had the most advanced economy in the world (Needham, 1961). The vast territory in China (and in India) was connected through a system of canals, built at enormous cost. The very existence of this canal system seems to have worked as a deterrent to modernisation of land transport through railroads, and hence, perhaps also took the steam out of industrialisation (Boserup, 1981, p. 160 ff.). Japan, on the other hand, already at this time had a Government that positively interacted with the private sector to help and push industrialisation along.

It has been argued (Eliasson, 1980c) that the very steady, fast and long industrialisation phase of the Swedish economy was essentially due to the right, delicate interaction between private industry and Government. Until the late 60s, Government in Sweden predominantly meant local government, and it was here that most resources were devoted to the upgrading of an industrial labour force (health, education, insurance and, in the post-war period, moving labour to the jobs). The remaining resources were largely spent on building a transport infrastructure. Decisions on how to run businesses were completely separated from the political system.

Until the late 60s, public aspirations to take a part in the division of the output pie increased. By the late 60s, ambitions to regulate the decision process were growing. While the Swedish economic success story began just before the mid-19th Century when the economy was deregulated (see Figure II:2), it began to pale when the opposite happened in the early 1970s.

All countries that have successfully industrialised have relied on some domestic resource, the most important being a minimal amount of social discipline and economic abs 'nence. This has made it possible to abstain from consuming a significant pa‹c of the extra amount of consumption released by the industrialisation process, or abstaining from consuming an abundant raw material resource too fast (Eliasson, 1983, especially for the current Norwegian problem). A crude way of saying the same thing is that the social and political organisation is efficient in keeping the poor people from consuming the resources generated by the economy. Sweden is perhaps an outstanding example in this respect, where the rents of a fair amount of abundance of raw material resources were effectively shielded off from the consuming general public, and the public sector, until they had reproduced themselves through wage formation in industries built on the profits from raw material exploitation. The Government also restricted its ambitions, at least until the late 60s, to funneling resources into transport, health care and educational infrastructures and by degrees also into building a retirement insurance system. Altogether, the Government's main function appears to have been to provide a growing industry with disciplined, educated, healthy and insured workers and an efficient transport system. This was the tacit idea of the old Swedish policy model.

The historian has, however, for good reasons a professional inclination against overly simple explanations like the above for complex phenomena like the industrialisation process of a nation. The economist cultivates the opposite approach. It certainly is not difficult to compile long lists of pros and cons (from existing literature) in an attempt to explain the economics of the past one hundred years. There is always a strong wish to come up with something simple, a key notion or a variable that explains "it". A tempting such variable is "knowledge" or "education". Education by definition is the crucial investment element behind human capital. But this is simply passing over the issue by a verbal trick. What exactly is human capital? How do we measure it?

Literacy is a minimum, simple output of the educational process. And we have already observed from Table II:1 that you cannot run an advanced industrial economy with more than an insignificant fraction of illiterate people in the labour force. What is the nature of the "minimum literacy" needed to run the advanced industrial society of today and tomorrow? In an effort to reach a "simplistic" explanation, quite a few studies have focused on the extent of technical and engineering education.

4. The Possible Importance of Technical Training and Engineering Education

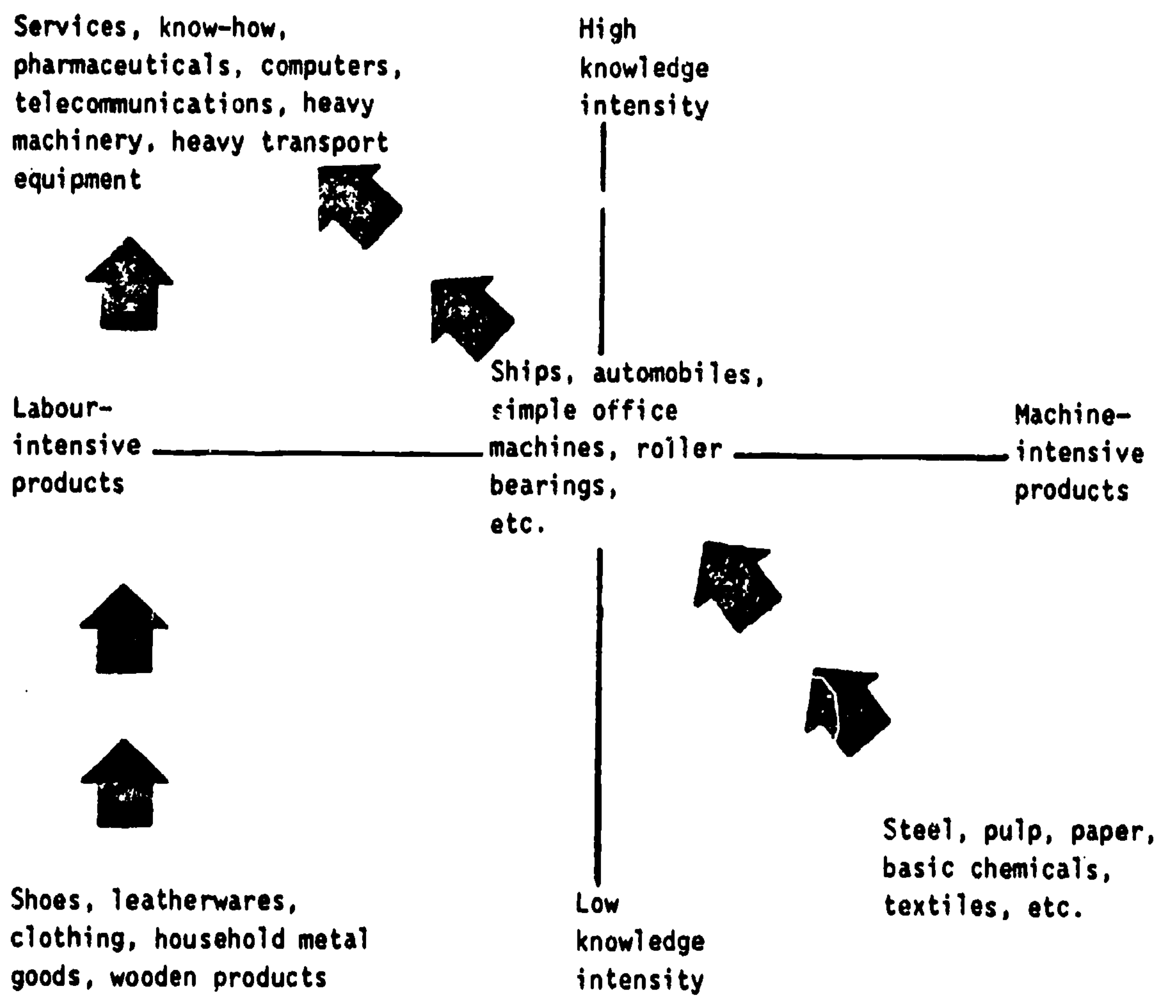
The competitive structures of manufacturing industries in advanced industrial nations have shifted considerably during the last couple of decades. Figure II:3 gives a summary overview of the Swedish situation based on a series of studies at the Industrial Institute for Economic and Social Research (IUI) in Sweden (see Eliasson, 1984a). It can probably be generalised to the other advanced industrial economies. The question is what forces have pushed this development, or made it possible. It is clear that the transformation of industrial knowledge and skills shown in Figure II:3 has been instrumental for Swedish industry in maintaining its technological lead position in European industry. This Figure well illustrates, too, the main theme of this book, namely, the nature and importance of human knowledge for economic performance and the nature of the investment process that generates human knowledge.

Immediately after the Second World War, Sweden was one of the few countries in Europe with a reasonably intact production system. Simple hardware capacity to produce and to deliver was enough to achieve high export growth rates in international markets. Hardware capital alone, however, soon ceased to be an indicator of competitiveness and rapid sales growth in international markets. By the middle of the 50s, it became increasingly important for export success to have a high hardware capital intensity of production combined with a high intensity of skilled workers. This signified the emergence of a fast-growing engineering industry in Sweden, and it is to be observed that a necessary condition for this to happen was the existence of a sufficient supply of not overpaid (in foreign currencies), skilled workers. Ever since the mid-50s, hardware-intensive basic industries that were low on human skills have been on a declining trend, drawing (at least in Sweden) a constant share of total capital and manpower resources, but generating a declining share of total profits and output.

By the mid-60s, a high fraction of skilled workers in the blue-collar labour force was no longer sufficient for success in export trade. Also, a higher fraction of engineers in the total labour force was needed, and hardware capital was becoming less and less of an indicator of competitiveness (Ohlson, 1980). By the early 70s, a high-skilled worker content of production was no longer necessary for export success. This could mean two things: either skilled workers had become overpriced in relation to their productivity and wages in other countries, or other factors had taken over. Evidence in favour of the former hypothesis is provided from an IUI study on foreign direct investments in Sweden (Samuelson, 1977) which indicates that US firms that had successfully invested in skilled worker-intensive production in Sweden for exports in the 60s, were curtailing such investments in the early 70s, or closing their plants. Wage overshooting (the "cost crisis") in the mid-70s meant a further competitive squeeze for process-based industries. Evidence in favour of the latter hypothesis has become increasingly obvious during recent years, notably in the ongoing shift from a process towards a product-based industrial technology (Eliasson, 1984b).

Figure II:3

FROM MACHINE CAPITAL TO KNOWLEDGE CAPITAL



Source: Translated from Figure in Ohlson, L., "Att utmönstra industrier med goda framtidsutsikter", supplement till Vägar till ökad välfärd, DsJn 1979:2.

Throughout the 70s, engineering-intensive production gained in importance as an export success signal and by the early 80s, the "three leg" nature of competitive Swedish firms was well established; high (1) R&D and (2) international marketing-intensive production carrying the competitiveness of (3) domestic hardware production for exports. Key competitive factors were clearly to be found now in product technologies rather than process technologies (Eliasson, Bergholm, Horwitc and Jagrén, 1984). There is even some evidence (Swedenborg, 1979) that the more R&D-intensive domestic production is, everything else being the same, the more inclined firms are to produce for export in Sweden rather than to supply foreign markets from factories outside Sweden.

Most of R&D spending in Sweden takes place in the large firms, that also account for the bulk of foreign investment. The bulk of R&D spending is devoted to new product development and the bulk of foreign activities (about half of the labour force in the 30 largest exporters, about 35 per cent of the total manufacturing labour force) concerns various forms of marketing or market-oriented production (Eliasson, 1984a). It is obvious that educational, or high-skill-intensive kinds of production, dominate successful production for exports in the large Swedish firms. The transition to this new industrial structure occurred during the 70s, pushing the traditional raw material, rent-dependent basic industries into the background. Since the mid-50s at least, skill-intensive production has dominated Swedish industry to a rapidly increasing extent. It is even more important to know what exactly -- in the form of industrial competence -- was required to engineer the highly successful transition from a crisis-loaded industrial structure in 1975 to a very competitive and advanced industrial base in 1986 -- a transition many other industrial countries have yet to achieve (4).

Before we come back to this difficult question, we must attend to a number of other items, beginning with the extent and importance of engineering education in economic growth in a historic perspective. There has been much speculation on this matter built on poorly systematised evidence. Gerschenkron (1966), for instance, believes that a fast economic payoff from systematic instruction in engineering schools after the middle of the 19th Century was critical for industrialisation. Landes (1969, p. 150) is much more sceptical about the short-term effects of such engineering instruction, but emphasizes the long-term effects as something self-evident.

Bergh, Hanisch, Lange and Pharo (1981) suggest that one of the factors behind the faster industrialisation of Sweden than of Norway was a much earlier (fifty-year) start of systematic engineering instruction. Petersson (1983) finds that machinery capital and engineers have been complementary factors in production. As is implicit in the title of Ahlström's (1982) book on German, French and Swedish engineering education, and fairly explicit in his summary of results, engineering has meant something, and probably a lot, for industrial growth. However, this does not mean that we can plot quantitative measures on the extent of engineering education over time in various countries on one axis and expect to see strong correlation patterns between the relative rates of growth in output.

A comparison of Figures II:2 and II:4 demonstrates that the relationship is much more complex -- even if it exists. The number of "comparable" engineers per unit of "comparable" GNP volume shows no relationship with GNP growth for the period 1870 to 1914. The stock of engineers is growing roughly parallel in Sweden and in France, while the rate of growth is considerably higher in Germany. The engineering intensity (in Figure II:4), however, remains constant in Sweden because of a faster growth rate in the denominator than in both France and Germany, both of which entered the 1870s with a higher and more rapidly growing engineer intensity for production.

Systematic engineering education started early, and grew fast -- like railroad building -- in those countries that later became advanced industrial nations. There is, however, the puzzling exception of Great Britain. The industrial revolution began in Great Britain and, obviously, without any prior systematic engineering instruction. Even more interesting is that no, or very little, institutionalised engineering instruction developed later to support the industrial revolution during the 18th and 19th centuries. Industrial growth continued anyhow and "British engineers, entrepreneurs, managers and scientists emerged from a striking variety of educational backgrounds" (Weiss, 1982, p. 9). The "unlettered, pre-scientific tinkerer" (Mussum and Robinson, 1969) appears as the image of the British entrepreneur and industrialist. Since then, higher engineering education has been absent, or on a small scale, in Great Britain. In a couple of hundred years, it did not seem to matter, then all of a sudden it seemed to do.

Was systematic engineering knowledge less important in the first phases of an industrialisation process, only to become significant later? Is the situation different nowadays, for instance, in the underdeveloped world? Is it rather that only recently a science-based industrial technology has begun to demand systematically trained academic engineers to achieve competitiveness in international markets from a high wage production base?

What does the quality, comprehensiveness and orientation of engineering instruction mean for growth performance of the macro economy?

French technical education started very early (late 18th Century), in fact before the industrial revolution in England, and it obviously did not initiate an industrial revolution of any consequence in France. When the Ecole Polytechnique was founded in 1794, the reason was not to cure French economic retardation and make France catch up with British industrialisation. The British were seen as "a traditional enemy" and the reason for starting the school was the need for military engineers to confront them (Weiss, 1982, p. 13).

Another aspect of engineering education is its relative emphasis on science and vocational training and, in addition, its degree of vocational comprehensiveness. German engineers compared to British engineers are said to have a larger vocational element in their training and also a broader educational experience, including, as a rule, business administration and economics.

Having accounted for these factors to the extent possible, the density of engineers graduated in recent years does not appear all that different among countries (see Table II:3) except in Germany and (especially) Japan with numbers much above the average. One is rather wondering about the low density of engineers reported for Sweden and the United States, two advanced industrial economies supposedly manning the technological frontiers together with Germany and Japan (see Pavitt and Soete, 1981).

Hutton and Lawrence (1981, Chapter 3) emphasizes the "quality" of engineering education from the point of view of the later application of that education as engineers. They find again that German, Scandinavian and French engineering education has an edge in that respect over British engineering education. The latter has a distinctly more scientific, theoretical orientation of instruction, closer to the natural sciences. The importance of practical training as part of engineering education is also illustrated by the fact that while engineers from the highly theoretical departments of graduate engineering schools in Sweden went to industry, graduates in similar fields from the natural science departments at universities stayed in academia or became teachers or bureaucrats.

However, before drawing fast inferences from this observation, one should note the differences in orientation of the two lines of seemingly similar education, and the different recruiting sources when it comes to teachers. Engineering schools place a high premium on practical industrial experience compared to academic writing in recruiting professors or teachers, and they are concerned with solving industry problems rather than theoretical ones. Interaction with firms is strong. Quite the opposite holds for physics departments at universities. More similar conditions may prevail in laboratory-oriented sciences like chemistry and microbiology and one also finds stronger ties with industry here. The point is that the content of teaching may not matter so much, but the orientation of students and teachers does.

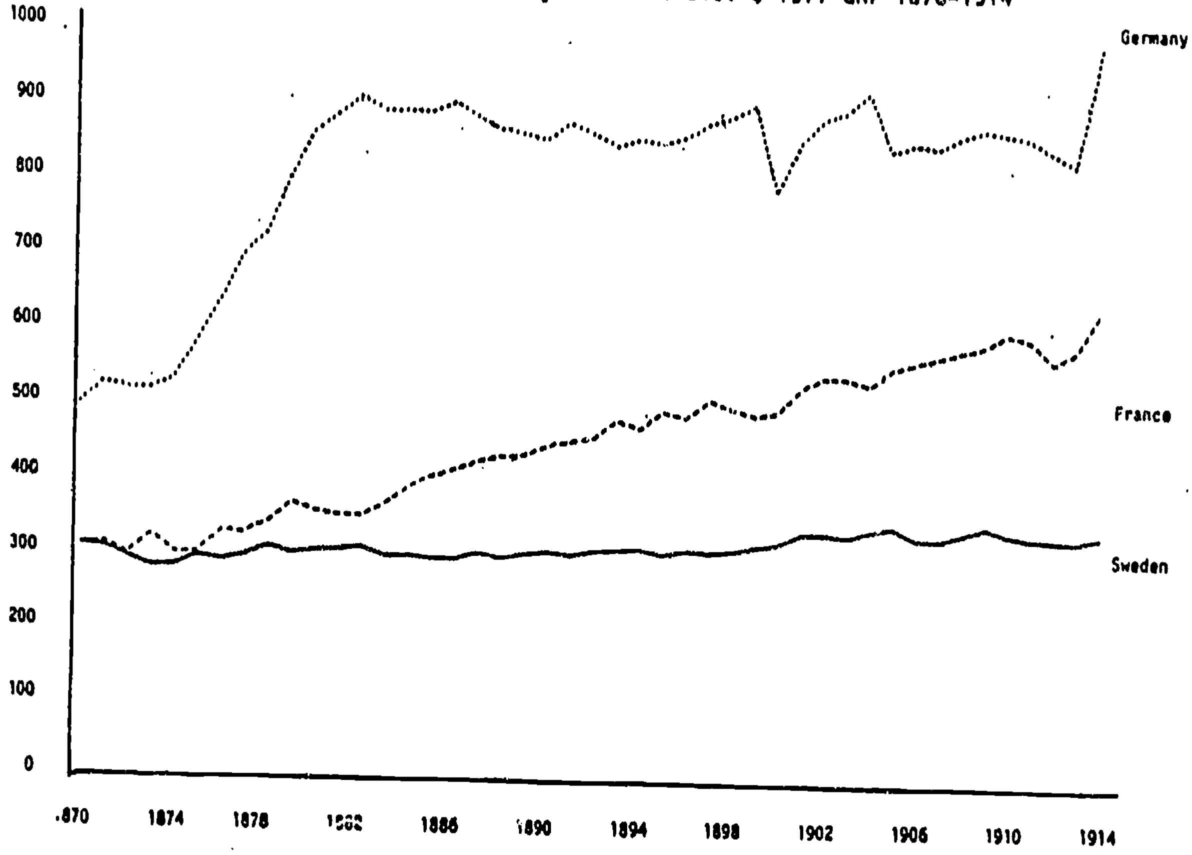
There is also the question of whether the practical qualities said to be observed in graduate engineers are a consequence of instruction per se, or are due to the filter provided by the admission rules to engineering schools.

In a study by Bartenverfer and Giesen, reported in Hutton and Lawrence (1981, Chapter 3), on German students intending to enroll in various graduate programmes, the would-be engineers were found to be very good students and interested in everything relevant to engineering, while they were not so proficient in languages, verbal fluency, and humanities in general. Their spheres of interest, furthermore, were narrowly practical. Other studies (see same reference) corroborate these findings and also label engineers as "convergers" rapidly focusing on practical solutions, while arts students tended more to act intellectually and critically as "divergers". Hence, again, the question remains unanswered, whether the engineering schools endow their students with a certain repertoire of useful vocational talent, or whether they filter out students with these other qualities through admission tests and other selection mechanisms.

A reliable answer to this question is certainly important for the formulation of good educational policies aimed at improving the industrial knowledge base of a society. And we still have not asked the question if industrial knowledge is taught at all at school. Perhaps what really matters is on-the-job learning, and the important task for schools is only to give a good pre-programming for self-instruction on the job. There is also the question of the kind of qualities that will be needed in the future compared with today. The human qualities desired for higher level non-production labour are vastly different from the skills demanded in factory workshops. As one climbs further up the career ladder, the ability to cope with complexity and variety to deal with people and, now and then, to reorganise your methods of work and business orientation gain in importance as elements in the

Figure II:4a

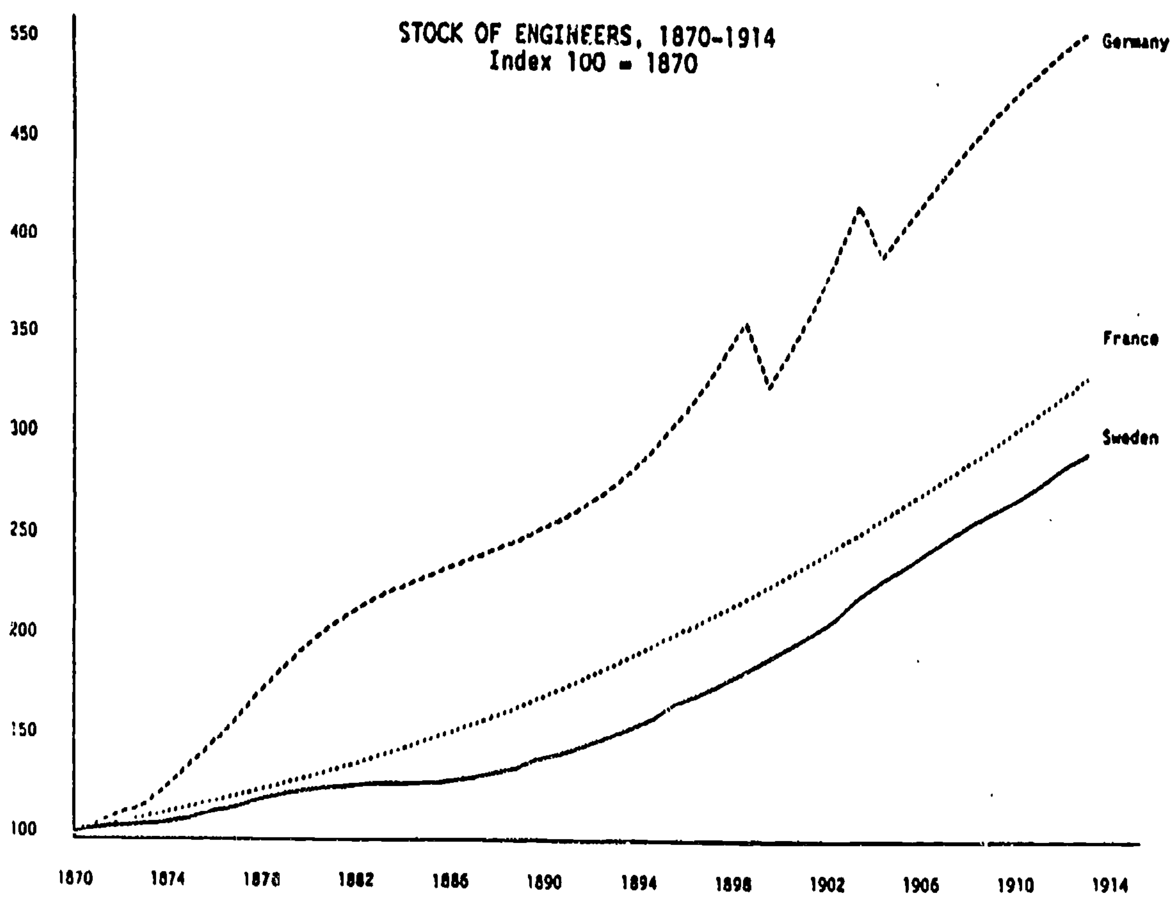
HIGHER ENGINEERING EDUCATION IN ENGLAND, FRANCE, GERMANY AND SWEDEN
Stock of engineers divided by constant U.S. $ 1977 GNP 1870-1914



Sources: Ahlström (1982), Kutznets (1971), Rostow (1980) and Maddison (1961, 1977).

Figure II:4b

STOCK OF ENGINEERS, 1870-1914
Index 100 = 1870



Sources: Same as Figure II:4a.

Table II:3

ENGINEERING GRADUATION AS A PROPORTION OF RELEVANT AGE GROUP

Country	Date	Proportion
United Kingdom	1978	1.7
Sweden	1977	1.6
France	1977	1.3
United States	1978	1.6
Germany	1977	2.3
Japan	1978	4.2

Source: Hutton-Lawrence (1981), p. 103.

knowledge base. Such talent is not taught at all at school; it is rather harnessed there, and as a rule in conflict with the assimilation of work skills.

As we will observe in the next chapter, the firm of the future will certainly present the individual with a much more "abstract" work environment than it does today. This is a continuation of a long trend out of the past, but the "information revolution" may mean that it will be speeded up. The rapidly increasing use of information technologies in industry, in any case, diminishes the relative importance of direct manual labour. To this we will return when we have introduced more facts about the nature of work in industry, and in particular about the nature of work in the emerging modern firms.

5. Cultural and Political Inclinations Matter

The "country squire" attitude combined with bad management and irresponsible unions have frequently been diagnosed as important sources of the British industrial disease of the post-war period: stagnation in the economy and the failure of one industry after another in export trade. Wiener (1981) gives a very different picture, however, of the British entrepreneurial class of the 18th and 19th centuries, as red-haired, uneducated, vulgar but shrewd industrialists and traders that saw profits as their main objective in life.

One factor in the cultural and political value formation that is particularly important on the innovative side of an industrial society is the status accorded to the bearers of technological change. In comparing German with British engineers, Hutton and Lawrence (1981, chapters 9 and 10) note that the Germans undoubtedly have a higher status in society. They are relatively much better paid and they tend to work in industry rather than in the bureaucracy. The German engineers have, in addition, a less theoretical education which includes a range of subjects of vocational significance, such as economics, business administration and law (see also Crockett and Elias, 1984). Once we allow socio-economic and non-economic factors to enter the economic analysis, we are in an entirely new methodological arena. Above all, the causal lags explaining the formation of values in society work over centuries rather than decades and take us outside the current technology of measurement. Where should we look for the beginning of the Western capitalistic culture? Who began it? Phoenician travellers and traders, Italian Renaissance cities or the British pre-industrial countryman? Parker (1984) tends to favour the Renaissance. Wax and Wax (1955) want to place the cradle of capitalist thought and action in the Scandinavian Viking culture, more than a thousand years back in time. The written documents exhibit a production-oriented society with a no-nonsense attitude, strict quality standards on cultural attributes (bad performing poets were simply thrown out) and an extremely profit-minded, individualistic value system. Recent archaeological excavations have unveiled large-scale production sites for weapons and jewellery, organised for export, just north of Stockholm, dated around 400 AD (Holmqvist, 1980).

Schumpeter (1943) very eloquently hammers home the strong relationship between individualism, democracy and capitalism and sketches a dismal future where economies of scale in production will breed industrial concentration to the extent that the industrial and political establishments will merge and destroy both democracy and individualism.

Olson (1982) follows up on this idea, telling the story that success breeds its own downfall through the creation of a sclerotic institutionalisation of an economy. The welfare economies of Europe, obviously based on past economic successes, have been taken by many to illustrate this economic decline.

The story from these writers appears to be that a capitalistically organised, efficient economy has to be supported by an individualistic, profit and market-oriented culture.

The Swedish economist Åkerman (1950) once remarked that the four fundamentals of economics, "interdependency, welfare, process and institutions" all had to be studied in one context if one was to understand economics. Institutions are the carriers not only of information but also of the appropriate cultural orientation. Indoctrination and reinforcement of a "useful" value system then become an integral part of the information and educational system of society. The family, the church, the school and media are producers of such indoctrination.

It is obvious that attitudes and values play a role in explaining economic performance of a country. It is possible, indeed, that economics cannot take us beyond the notion of an exogenous generating mechanism for technological innovations; a <u>deus ex machina</u>, as seen by the young Schumpeter (1912). However, if most of what we call technological advance really consists of the ways existing resources are allocated -- as we will argue later -- and if the intensity of the generation of new technological innovation really depends on cultural attributes like the commercial orientation of the value system -- as argued by Dahmén and Eliasson (1981) -- then we have at least an embryo for a socio-economic growth model.

Cultural, religious and political factors are extremely difficult not only to define and to measure but also to incorporate explicitly in economic thinking. There simply is no plae for them except as exogenous parameters entering the utility functions of individuals.

But in a context where human resources for economic growth are analysed, such factors have to be considered to understand the nature of the economic growth process as it evolves over long stretches of time. Do certain cultures have a value orientation that is favourable to industrialisation and commercial life in general? Does this mean that it is impossible to industrialise a primitive economy without ripping open its cultural system and established values? The interaction hypothesis also means that efficient economic performance creates new values and new preferences that may, in Olson's (1982) view, sometimes be counter-productive to the process that generated them in the first round.

The conclusion of Dahmén and Eliasson (1981) was that the culture of a successful industrial society had to be favourably inclined towards <u>active economic experimentation</u> among all its members, agents and institutions. The acceptance of free competitive entry in all markets and activities is one requirement. <u>The willingness to accept change</u> in various economic, cultural and political dimensions as a natural, pleasurabale and continuous part of a life experience, is another critical, competitive factor for a successful industrial society. This conclusion (or working hypothesis) carries far-reaching implications for the educational institutions of a country.

6. Free Competitive Entry Enlarges the Economic Growth Engine

The young Schumpeter emphasized the importance of creativity and innovative change for the capitalist engine to work, and for macroeconomic growth. The entrepreneur saw new combinations of techniques, talent and institutions that could be realised at a temporary, monopoly profit.

The Joseph Schumpeter of 1943, viewing the economic development around him, had changed his mind considerably. The efficiency of large-scale production techniques would generate enormous concentration and a threat to individualism, democracy and the capitalist market economy.

A series of simulation experiments on a dynamic "Schumpeterian" micro-to-macro model at the Industrial Institute for Economic and Social Research in Stockholm also suggest that without a steady inflow of varied, innovative technical change, strong tendencies toward concentration are exhibited -- the vision of the old Schumpeter. Perhaps even more challenging are the results that concentration breeds macroeconomic instability. Diversity in various forms -- structure, profitability, wages, etc. -- has to be maintained for stable macroeconomic growth (Eliasson, 1984b). The innovative entrepreneur is the main provider of diversity through the entry of new establishments that compete monopoly profits of established, large-scale producers away. More research has to be carried out to establish this property of a dynamic macro economy, but if the propositions are valid, they suggest that we should reason in terms of the old and the young Schumpeter simultaneously. And there is a message for the kind of educational inputs, the attitudes and the properties of the labour market process that are needed for long-term stable macroeconomic growth.

The organisation of the economy, and its institutions in particular, become central for understanding the dynamics of markets and the growth process. And, above all, the preservation of a viable entry function becomes central for a viable capitalist economy. Controlling entry reduces both vitality and competition. One wonders why the regulation of new competitive entry (new establishments) is a key policy in all planned nations and that it is typical of the regulated sectors of the mixed economies of the OECD world where political influences carry weight. Taxes, domestic banking, schooling and hospital care are cases in point.

If the creation of new institutions or new activities that enter into competition with existing ones is central to a viable economic process, the first question to ask is what is meant by new entrants and, second, why their numbers vary so much within countries and between countries. What are the motives that move new competitive entrants?

We will restrict our inquiry in this respect to the private business sector, notably the firms. But this restriction probably precludes the most interesting illustrations. The labour market and the public sector are the most regulated parts of the mixed welfare economies when it comes to new entry.

New and more educated entrants into the labour market, of course, constitute a competitive force for the established group, and since time immemorial established workers have tried to squeeze out such competition through craft union requirements restricted work practices, closed shops, etc. Many of these restrictions have been motivated by elaborate moral reasoning.

Second, the public sector is the largest single economic sector in most countries that practices restrictive competitive practices regulated by law. In most continental European countries, elementary and secondary schools are a public production monopoly. The main motive for the monopoly is to provide equal schooling opportunities for everybody. From this does not follow, however, the widespread practice that the actual production of schooling services has to be run by public agencies. As a rule the public production monopoly is supported by the teachers' unions. Competitive pressure on school performance in some countries, Sweden being an example, is additionally prevented by allowing little choice for the children or their parents as to schools.

If competition in the private sector, notably manufacturing industries, can be demonstrated to bring in new superior technologies, compete inferior productive units away or to force them to improve, thus fuelling the growth process, it should be a reasonable conjecture that this result could be extended to other sectors of the economy. (On this score we will note in chapters III and IV that the public monopoly of schooling is endogenously being eroded by technological change, making qualified education on the job and through careers more important, and through technological change in the sense that firms take on the schooling function themselves, perhaps because the quality of the public school system is unsatisfactory.)

This is the first critical proposition of this section. If competitive entry is more generally allowed or stimulated, removing public and private monopolies, economic growth will be speeded up. Under such a market regime, the supply side of the entire economy, not only the private industrial sector, will constitute the engine of the growth process (a Schumpeterian term). Barriers to trade are as harmful in public as they are in private production.

7. Government Infrastructures

The role of government in the economic process has been subject to much discussion in recent years. One could even talk about an awakening after the illusion of an all-informed, benevolent Government disintegrated in the 70s.

A study of the optimal size and organisation of public activity for efficient and fast economic growth would certainly warrant a special study. We do not have enough information to say very much, except that some welfare economies in Europe seem to have reached a stage of public involvement in the production machinery of their economies that does not contribute to economic welfare. Much of this negative involvement seems related to egalitarian ambitions that separate the value of inputs from its compensation to the extent that the intricate signalling machinery of a market economy gets disorderly (see, for instance, King and Fullerton, 1984, on capital income taxation).

In a historic perspective, we can describe public sectors as military machines that gradually took on the task of infrastructure builders to provide educated and healthy people for a growing industry that (to begin with at least) was mainly organised as a supplier of the military machine. The monarchs of the past long pursued what today are called industrial policies to promote manufacturing growth. Skilled craftsmen, entrepreneurs and industrialists were encouraged to immigrate and set up shop, not least in 17th-Century Sweden. Sometimes forecasts were wrong. Worrying about the long-term supply of high-quality oak for the naval shipyards, King Gustavus Adolphus had a large forest planted in the early 1600s. Now, some three hundred years later, the wood is ready to use. The development of orderly legal and enforcement systems, a monetary system, education and transport also meant building infrastructures that paved the way for an information and co-ordination technique to accommodate all the diverse transactions of growing market economies. The governments, so to speak, carried on positive, market-oriented industrial policies, stimulating and pushing activities that the markets were late in initiating. Education is one such infrastructure activity often pushed by "enlightened" kings. We should observe here that while the effects of human capital upgrading through education or health care showed up in the form of increased productivity in industry, the costs were incurred in the public sector (Eliasson, 1985b).

8. Education, Human Capital and Productivity

Where Does Education Take Place?

Human capital accumulation takes place in the educational system. Education takes place:

i) Within the family -- upbringing;

ii) At school -- formal education;

iii) On the job -- experience.

Even though a growing part of the resources devoted to education are used up in the public schooling system, the longest educational periods occur before and after school, at home and on the job. It is difficult to single out and estimate the resources devoted to education, since it is mixed with other activities. The resources devoted to schooling in industry may be much larger than we have previously thought (see Chapter V, 3), or quite small, indicating efficiency. It is necessary in this study to ask the question where the important, performance-enhancing qualities are acquired, and where efficiency in education is attained.

The School as a Filter or an Investment?

The educational process, as traditionally viewed by economists, was long seen as a human capital-enhancing investment, improving, so to speak, the quality of labour input in the production function. Educators normally took a broader view, seeing education as part of the social indoctrination system that was also part of the current cultural and political value system. In an inspiring article, Arrow (1973a) introduced the notion of education as a filter or a screening device, whereby the talented were distilled upwards in society and awarded a quality label (the diploma).

The filter theory is difficult indeed to test, and Arrow does not believe it to be more than part of the educational story. But if the filter plays any role, and in particular if it plays a dominant role, the implications for educational policies are far-reaching. And Arrow demonstrates mathematically that *if* the educational system is only a filter, society may be better off with no formal education at all. In fact, under certain simplifying assumptions as to the production process, "everybody would gain by prohibiting college". There will be no efficiency gains for society, because people are assumed to be as productive in one place as in another. The filter will draw resources, and inequalities in *ex post* incomes will be created by the filter. (Hirschleifer, 1971, produces a similar argument against "too much" research.)

A standard worry on the part of administrators of schools and universities are low levels of "graduation" on the part of admitted students. A typical feature of universities with tough entrance screening is that a larger fraction of enrolled students graduate with diplomas than in educational institutions with no, or low entrance filtering.

If school is predominantly a filter, worries about low graduation rates are justified, because many students will enter the labour market without the badge -- the quality label -- of many years of schooling. However, if schooling is a pure skill-enhancing investment, and if skills can be generally applied with the same output effects, there should be no reason to worry, at least not from the point of view of returns to society. The education achieved should have a productive effect on work where it is applied. However, where the quality label (the diploma) is missing, the individual may command a lower value on the labour market, at least until a potential employer has learned about his qualities by other means. So, it seems, the diploma commands a monopoly premium. On the other hand, if the allocation of people with a widely varying endowment of human capital matters significantly in a modern industrial society, then the absence of a reliable quality labelling will mean a loss to society, since this information has to be reprocessed over again through labour market search.

Arrow's filter hypothesis should be seen as an attempt to rectify general equilibrium economics under a situation of limited information. In fact, education at school, or in general, may be considered as part of the job market search process.

One critical assumption of Arrow's theory is homogeneity of labour quality, irrespective of where it is applied. While qualities differ and are labelled by the educational filter, each labelled quality has a given productivity effect wherever it is applied. Without that assumption, Arrow could not reach the conclusion he does about college (see Ysander, 1978). In fact, the assumption is probably wrong: the school can be only one part of the quality-labelling procedure that persists in the labour market and the job career structure. It is only natural then to expect some educational programme, or labour market experiences, to give negative labels, like the stigma that may follow from participation in public labour market or retraining programs (Burtless, 1984).

Communication of Knowledge or Consumption?

One should also distinguish between education as a way of improving the intellectual capabilities of students (reasoning, etc.) and education as the communication of experience and skills from an existing knowledge base. If the two aspects can be viewed separately, it may appear that lower level training and apprentice work is of the second kind, while university education would include more of the first kind. This is probably not correct. Much in the high-level executive jobs in society that are reached only after a long career (a combination of apprentice work and selection) has to do with acquiring a complex base of both general and specific knowledge and experience. This is a form of on-the-job training that creates an extremely complex fabric of knowledge. We will discuss it in the next chapter in the context of high-level management of the modern firm.

There are also two other dimensions of education, and especially the public schooling programmes in the modern welfare economies with heavily subsidised education. Education has a sizeable consumption content. Schooling for many is utility-generating in itself, and the more subsidised, the less differentiated as to remuneration the job market, the larger the incentives to regard education as partly, or wholly, an act of consumption. This appears to be especially appropriate for some graduate university training. In some countries students are even paid salaries that are not much below the market pay they will later fetch.

Political Indoctrination vs. Efficiency

Public formal education has been deliberately used, in many welfare states, as a vehicle for egalitarian policies. Liberal educational policies of the 19th Century were based on the investment notion. Everybody should be given the same opportunity to acquire human capital. What happened after education was up to the individual. The more far-reaching egalitarian ambitions of some welfare countries are based on particular propositions of the economic effects of schooling. If, for example, important parts of the educational process take place at home, then the school should be organised to compensate for the effects of a low-quality home environment. Hence, schooling should be standardized, so that nobody acquires more human capital than anybody else. Kids should spend more time at school. The monopolies associated with particular educational categories should be broken down by expanding education in these fields, and so on. This conception of education is especially intriguing in combination with the filter hypothesis. If education is really to a large extent a filter, and if egalitarian policies that run throughout the system lower the job market quality of the educational output, then the low talented end of the student input may come off worse as a result of more such egalitarian schooling based on an erroneous assumption of what kind of service the school gave to its students.

A particular aspect of education practiced everywhere, although more in some countries than in others, is indoctrination. The educational system has always been allotted the task of instilling the value codes of the country in its pupils. These may include nationalistic attitudes, certain morals, discipline or particular political ideologies. All these aspects mix. Part of the overall result is a set of attitudes to various dimensions of life. A particularly important one is how the individual sees himself as a participant in the labour market process: as a passive waiting agent or as an active searcher for new opportunities.

Curiously, the willingness to take risks and the ability to take initiatives appear to be factors that contribute to a positive labour experience. If employers want to avoid people who are passive and unwilling to put in an extra effort when things have to get done fast, then they should pay special attention to records of past experience or behaviour so as to filter out the wrong people. This indeed seems to be current labour market practice. If acquired attitudes to work are such an important influence on actual performance, how much more should attitudes developed during 15-20 years of public schooling be a prime concern in educational policy making.

Let us summarise the various dimensions of education.

The Efficiency of the General Schooling Process

Educational efficiency has already been the subject of considerable research. The quality of schooling has been assessed through its effect on grades, and attempts have been made to relate grades to productive performance on the job, usually measured by income. In attempting to compensate for the filter effect, IQ tests are inserted to obtain a "mental" quality grading of the individual. However, experience and research for the most part confirm that school grades and IQ scores reflect the ability of students to pass

Table II:4

EDUCATIONAL PURPOSES

1. Investment - upgrading of human capital
2. Filter - labelling
3. Search - signalling, information gathering
4. Consumption
5. Egalitarian device
6. Indoctrination

through school, rather than their potential as candidates for the job market. There is even evidence of negative correlations, or for other factors mattering more (see Murnane and Nelson, 1984).

In fact, it has been extremely difficult to explain more than a small fraction of the variations in income by observed socio-economic characteristics. Jencks (1972) lists a number of reasons for this, among them "unobserved endowments of native ability" and differences in luck. Varian (1980) even makes the "randomness of income" his main point.

The Returns to Mobility

What literature tends to neglect altogether is the enormous diversity of job opportunities that exists in an advanced industrial economy, and that an almost equal diversity of talent or human capital must be a characteristic of the labour force. Arrow's filter theory, as well as the idea of using IQ tests to control the filter assume the existence of universal quality gradings. Hence the possibility that one quality grading (label) has more than one unique on-the-job productivity is disregarded by prior assumption. Hence, most of the allocation functions of the labour market are assumed away: a set of tests and exams are all that is needed. Job-oriented talents of various sorts may be correlated, but multi-talented individuals nevertheless face a broad menu of productive and gainful job opportunities, so much so that it is not always easy to make a final decision. Nevertheless, an individual's particular talent mix is always likely to have some productive applications somewhere at some relative remuneration.

If, in addition, the talent and acquired skills are not immediately apparent, one would expect the outcome of the "matching process" in the labour market to exhibit a significant variation even for equally graded or labelled students. Hence, the design of the educational system at school or in the job market increases in importance -- whether as a filter or as a mechanism for identifying talent. The argument is very similar to that of comparative advantages and the growth effects of international trade.

A school can "filter out" people, but it can also "filter people in" to their right places in professional life, away from the wrong places. The job market and on-the-job training both have a filtering function. It must be as economical for society and the individual to have significant resources spent on a schooling or re-schooling process, mainly oriented towards helping individuals find the right jobs, as it is for manufacturing firms (as we shall see in the next chapter) to spend a significant part of their total costs on finding the right customer for their specialised products.

Holmlund (1984) demonstrates that it pays the individual to move and that mobility between jobs is the major vehicle for workers to improve their economic position. This also means that the value of their work effort and of their human capital increases. The fraction of workers that moves (in Sweden) is fairly low, however, and mobility has been constantly decreasing over the post-war period, an observation that underscores the importance of the design of the labour market search process. This is in marked contrast to the United States, where every tenth person changes job every year, and every sixth person moves house every year.

<u>The Development of Internal Labour Markets</u>

Holmlund (1984) shows that in Sweden job mobility initiated by the workers dominates. Layoffs account for only a minor fraction of all job separations. Labour market performance, however, depends on its institutional characteristics. The growth of large-scale business has meant that the labour market within the firm increases in importance.

At the same time, the human capital vested in individuals appears to have become more firm-specific (Holmlund, 1984). This observation emphasizes two policy conclusions. General education, currently offered in the public schooling system, is becoming more important, <u>if</u> general education increases the ability to acquire and retool specific human skills. Second, the shorter the life of specific skill investments, the more important internal firm retraining programmes become.

If school is mostly a filter, and if transaction costs in the labour market are high, then being careless in choosing your job, and especially the first job, will be costly. On-the-job search for new jobs seems to peak at an early age, when transaction costs are probably relatively low. For workers, search activities peak at 20-24. At that age about 20 per cent report some on-the-job search during the year, a figure that comes down to 5 per cent for 50-year-old workers (see Albrecht, Holmlund and Lang, 1985).

Not only employers are uninformed about the productivity of workers as in Arrow's (1973a) filter analysis. As Holmlund (1984) emphasizes, workers also have to learn about the job through actually trying, which may require a sequence of moves. If the situation is that a wide spectrum of differently combined talent meets an equally wide spectrum of talent requirements, the first trial step in the labour market is unlikely to lead to an optimal, or even a good, combination. In a simulation model, Nichols (1980) has demonstrated how more efficient search improves both the position of the workers, their productivity and their pay. In such a (labour) market setting, the value of an individual's human capital, irrespective of how it has been created, is maximised when he has found the "right job". Hence, the optimal design of the overall search process in the labour market is crucial for individual welfare.

Welfare can be reduced if laws enacted to protect workers on the job simultaneously sharpen the employer's screening procedures and reduce the payoff from worker-initiated search activities. The same can be said of progressive taxes designed to equalise after-tax incomes that reduce incentives to search. This also makes search, and the whole labour market allocation process, socially costly, by making inflation a necessary condition for the creation of sufficient incentives to move. Indications are that the total Swedish labour market programme, currently using up resources exceeding 3 per cent of GNP for a given inflationary target, may even have increased unemployment (Schager, 1985a, 1985b).

Search for new job positions is associated with various forms of uncertainty both for the employer and the worker. Hence, if successful search is to be easily initiated, it probably requires both previous practice and obvious pecuniary benefit. Increasing uncertainty and reducing compensation for search is probably debilitating for the individual, since it reduces the control the individual exercises over his own situation in the labour market (Magnusson, 1981; Seligman, 1975).

Two critical questions have so far been distilled out of this discussion:

-- To what extent does individual productive performance depend on skills and to what extent on job allocation?

-- To what extent does education in a broad sense contribute to an increased skill endowment and to what extent does it label or filter people?

The two distinctions run between the effects of investment, on the one hand, and market allocation on the other. And without some empirical control of the relative importance of these two factors, educational and labour market policies will be mainly groping in the dark.

Empirical testing -- or rather the formulation of empirical hypotheses to test -- requires that one takes both alternatives into account simultaneously, rather than exclude one through prior assumption. The latter has been current academic practice. The former, the only acceptable way in a serious policy context, requires a close look at the production process, which we will do in the next chapter. Before that, however, we will look at the traditional agenda of discourse in this area, and try to firm up a bit on a few provisional hypotheses to guide us through our area of application, the work environment in a modern industrial firm.

General or Specific Skills?

Becker (1964) introduced the notion of general and specific skills. General skills (by definition) could be transferred from one job to another.

Specific skills were developed on the job location ("on-the-job training"), and lost in value when the worker moved.

General skills were thought to be acquired at school, specific skills on the job. This gave a nice division of labour between the public schooling system and the firm as an educational institution.

For the sake of a theoretical argument, this may be a convincing distinction. It is still, however, an open question to what extent the same distinction carries any empirical meaning in a highly specialised industrial society. Work life is full of specialised skills that can be transferred to many jobs (welding, computer programming, etc.). Many of them are not taught at school. On the other hand, the public education system teaches a variety of skills with extremely limited applications -- graduate university training in some fields being an example.

At the same time, it appears to be a widespread experience that the more there has been of general education, the more flexible workers are when it comes to intellectual retooling, labour market mobility and transferability between jobs.

The empirical content of such experience, reported ad hoc, should certainly be investigated further before being used for far-reaching policy decisions. However, they are convincing enough to be brought in as assumptions in a theoretical argument. Does more general education give a higher "skill" to relearn and readjust; does more education filter out those who have these skills from the beginning, or is more education in itself a form of practice in changing environment, communicating with new people, etc.?

Becker's (1964) distinction between general and special skills is not consistent with another, frequently reported, experience from the labour market. Employers are often said to refrain from investing in their employees' skills, because once the employee has been trained he or she will be in the market for higher wage or salary offers elsewhere (see, for example, Ryan, 1984).

Incentives for In-House Training

"Slave contracts", or a Japanese-style labour market, are said to be remedies for employers not investing in their workers' skills. However, a more market-compatible solution for the financing of individual investments in skills through on-the-job training would be not to pay the young person more than he contributes to the company on the margin, or less. The only reason then for the employer to hold back the opportunity for employees to learn more on the job would be the risk of dissipation of unique skills through labour mobility. At the same time, if young employees are paid more than they are worth to the employer on the margin, because of union contracts or tight labour market conditions, the incentive for the employer will naturally be to get the employee on a productive job as quickly as possible. Such a situation will discourage both employers and young employees to aim long term for a more qualified job through job-related training.

Similar arguments are often heard in favour of patent legislations. If temporary protection to cash in on an invention is not granted legally, investments in innovations will be discouraged (see von Weizsäcker, 1984). Such arguments may be quite inapplicable when taken out of the narrow context in which they are often presented (Hirschleifer, 1971). If the innovator knows more about the innovation than others, Hirschleifer argues, he should also be the one best suited to exploit, most rapidly, the innovation commercially. This conclusion, in favour of the innovator, is probably wrong, for the talents to innovate and those to run a business are not the same, and a large part of both the innovation and the costs incurred are directly related to its commercialisation (see Eliasson, 1985c).

A similar information bias is, however, present in the labour market. And on corporate education and training programmes Hirschleifer's argument may yet hold water. The employer who trained the employee and who has monitored his progress will normally be the one who is best informed about his performance. If it is native talent that matters for productivity rather than acquired skills, the actual employer should always be willing to pay more for the best workers than for potential outside employees, and he should be <u>very selective</u>, and invest the marginal training needed primarily in his best workers.

<u>The Importance of Information, and of Individual Search Initiatives</u>

From the above it follows that a badly functioning labour market with passive workers who do not actively signal their competence to outside employers will lead to the creation of internal administrative labour markets within firms. If the employer has an information monopoly, his willingness to train his workers should be high, but he will allocate training selectively to the best. Lack of information on the part of potential outside employers will breed "implicit slave contracts" or lifelong employment relationships. There is only one efficient way of getting out of this implicit monopoly contract, namely, a more active, searching labour force. However, if labour is active enough to advertise its productivity features and to search intently for new job opportunities, it should also be aware of both the importance and the nature of good education and training. The young or the prospective members of the labour force should, therefore, be willing to invest in it him- or herself.

From an economic efficiency point of view, then, the whole question of employers being unwilling to fund corporate training programmes becomes academic in an informed and active labour market.

However, both in the monopolised and in the active and informed labour markets, useful education and training will go to the talented workers. The whole discussion about insufficient corporate training, or insufficient incentives for individuals to educate themselves, should probably be seen in that perspective. It is not economical for the employer to invest in not-so-talented individuals and it is not economical for the not-so-talented individuals to invest in themselves. The issue is one of welfare and distribution, and the most efficient way to achieve a "fair" outcome may not be to use the education system or to require firms to take on educational programmes which they do not find economical.

A well-functioning labour market requires efficient transmission of information. The most efficient information agent is an active worker signalling his competence and looking for new opportunities. But information cannot be effectively transmitted from one workplace to another if demonstration periods cannot be arranged for entrepreneurial activities on the part of individuals.

The more protected from competitive entry the labour market is because of job security laws or union practices, the less informed employers will be about the capability of individuals. However, the more informed and the more mobile the labour market, the less inclined to invest in talented workers will the employer be and the more of the financing and the risk associated with educational investment will fall on the individual or the state.

One should, however, be careful not to pay excessive attention to the formal side of schooling and training. What is learned on the job itself may be as important for the job career as what is achieved through a formal programme. This is certainly so for high-level jobs. This is the reason why the firm as an educational institution deserves a special section in the next chapter.

To perform a simple task, or a complex task that repeats itself over and over again can, as a rule, be learned effectively through a brief introductory course and a "break-in schooling programme". The ability to perform well in this respect and then to produce efficiently is often well paid in the labour market. And many people appear quite satisfied with a repetitive work experience. Complexity may, however, increase because the technical nature of the production process changes and forces adjustment on the part of workers. It should be noted that repetitive work is not restricted to manual labour. Much office work and many academic jobs are extremely simple and repetitive or tend to become so, if the holder of the job opts for such a work experience.

However, at some level the exercise of judgement or choice between vaguely defined alternatives begins to be a critical job performance characteristic. Again, this is as common with manual as with other jobs. Complex machine service or repair jobs are good examples. An argument of the next chapter is that these kinds of jobs will become much more frequent as the industrial economy advances. The talent or skill required on such jobs is mostly acquired on the job and in particular through a varied work experience. Hence, active job market search or active career plans with companies or institutions may be what really matters for human capital accumulation. To what extent does formal education prior to, or parallel with, the job career contribute to such a learning process, and to what extent do restrictive work practices and labour market legislation prevent people from doing something with themselves in the labour market?

9. A Working Hypothesis for Policy Makers

It is not possible at this stage to reach clear and simple conclusions about the nature of human resources that generate economic wealth and what policy makers can do about it. But a rough working hypothesis for policy makers can be formulated.

To begin with, productivity growth (when measurable) is always associated with significant structural, institutional and organisational change that also significantly affects everyday life of individuals. This process of change brings in new ideas, technologies and organisational combinations that make it possible to produce new things and/or more of old things with less input of resources. Hence, the better organised society is for such change, the more economic growth will be observed.

Also, the larger the fraction of the economy that is involved in the change process, the larger, proportionately, will be the engine of growth at work in the economy and the faster economic growth. It is wrong from a principal point of view to see the public sector as an alien part of the economic growth process, a burden that has to be carried by private industry. What we know is that the public sectors were quite small during the early phases of the industrial revolution, but at that time they often contributed to the growth process through introducing important infrastructural activities that did not spontaneously come about as part of the market process. However, today the public sector together with some domestic sectors that are typically protected from competition are the most conservative ones when it comes to structural and institutional change. Hence, it has become commonplace to look at private industry, and manufacturing in particular, as the engine of the economic growth process. But this is reasonable only under the special assumption that the typical market processes of competitive entry and exit are barred from the public sector, and other protected sectors as well (Eliasson, 1985c).

We have also concluded that the inclination of society to accept structural change or to allow it to expand into protected areas is part of the political and cultural heritage of a nation, that can be modified slowly through the educational process.

Again, the human capital resulting from the educational process at large is becoming increasingly more important for the production process, part of this input being an improved skill in moving, adjusting and relearning. This is probably a major explanation for the fact that a relatively shrinking private, and notably manufacturing, sector has been able to function as the central growth engine for a larger and larger load of public and protected activities.

The most radical solution to the perceived growth problem of the old industrial world that opened Chapter I would be to open up the entire economy, including the public sector, to free competitive entry and exit of institutions. Such a solution would most probably worsen the unemployment situation temporarily and in itself it is beyond the ambition of this study even to discuss this broader political issue. We note in passing that different countries have different borderlines between the private and public parts of the economy that often cut right across the classifications for institutions or economic functions. Thus, Harvard University is in the US private sector while the State University of New York is engaged in public activities. Government-operated business agencies are classified as private industry in Sweden and are part of the public sector in the United States. Hence, for practial purposes we take the politically imposed sectorial structures of the old industrial world as given and continue to look at the private sector as the growth engine that has to be reorganised over and over again to stay competitive in international markets. What kind of human capital inputs do the agents of the private sector demand, and will they demand in the future?

We conclude here that an endowment of continually updated industrial knowledge is what keeps production growth in industry going. Most of this knowledge accumulation takes place in the form of on-the-job training and selection in schools, in the labour market and through varied careers.

It will transpire in the next chapter that the emerging growth industries will require a different educational and training background to existing industries. Labour with the ability to handle abstract thinking and an ability to approach problems in multiple ways will command a premium in the labour market. Manual repetitive labour will be less in demand.

Here, we have already seen that ability and the willingness to move and adjust in the labour market depended positively on a good formal education and a varied work experience. The new entrants into the labour market from school undoubtedly have a competitive edge in this respect, and it looks as though the youth unemployment problem should be explained for the most part in terms of the market process, rigid wages and restrictive labour market practices (Björklund, 1985b).

Looked at this way, the labour market problem narrows down to two conclusions:

i) Economic growth depends positively on the availability of human talent. Availability is partly a question of proper schooling for the future job market. What it may demand in the form of education we will discuss in the next chapter. But availability of talent is as much, and perhaps mostly, a question of allocation of existing human resources through the educational system and the labour market. Our conclusion is that the more successful the macroeconomic growth process, the more dominant in this process the market allocation function will become.

ii) Individual welfare is directly linked to the adjustment process. As a rule, most people seem to benefit from this process, and the problem in the labour market can be narrowed down to one particular group, namely, those who have worked for a long time on simple, repetitive tasks in firms that happen to be competed out of business. This group appears to be difficult to retrain for tasks in the growing and more intellectually demanding industries.

We take up this problem in Chapter IV and conclude that, to be at all efficient, labour market policies should focus on the smaller groups that really have serious adjustment problems. For this smaller group more generous service can be afforded. Since these people have been in the labour market for extended periods of time, the service provided could, indeed, be regarded as the payoff from labour market insurance premiums they have paid in the form of unemployment fees and taxes.

In identifying and narrowing down the labour market problem to proportions that can be coped with, one could also loosen up restrictive practices elsewhere in the labour market and allow the competitive entry and exit process a freer play, with the likelihood that macroeconomic growth and new job openings will increase as a result.

NOTES

1. A technical note is required here. The feasibility of full information is closely linked to the notion of an equilibrium (model) economy (see Eliasson, 1985a, Chapter VII). In static, general equilibrium models in which information about the equilibrium can be gathered at no cost (the assumed "auctioneer" or central planner, present in all Walras-Arrow-Debreu-Hahn general equilibrium models) equilibrium and full information coincide. When information gathering becomes the dominant cost item, which is the case in manufacturing (see Chapter II), neither equilibrium nor full information are feasible states. The equilibrium becomes dependent on the technology of using information, which is a knowledge in itself, and so on. A whole array of solutions dependent on the state of knowledge are equally good. The nature of market search as a technique of gathering and using information becomes decisive for economic performance. Hence, socio-economic factors from hypothesis 2 come into play, and the optimal use of freely available information in the industrial policy model 3 is pushed into the background.

2. As in the micro-to-macro (M-M) model developed at the IUI (see Eliasson, 1976, 1985). Also see Day and Eliasson (1986). It is important to note that this is not the standard, general equilibrium Walras-Arrow-Debreu-Hahn etc. notion of a free market. General equilibrium theory includes no theory of the dynamic market process.

3. The military orientation of the Swedish state was probably not the right organisation for an innovative commercial activity. When military ambitions subsided, other industries than manufacturing were the first to experience a strong export demand pull.

4. It has to be noted that a significant share of the manufacturing labour force (some 5-8 per cent, down from about 15 per cent in 1975) is still employed in restructured crisis industries, and we doubt that these firms -- despite enormous subsidy grants -- will weather the next recession well.

Chapter III

THE MODERN INDUSTRIAL FIRM

1. What is a Firm?

The popular and (economic) theoretical notion of a firm has long been that of a goods-producing factory. It draws manpower from the labour market, savings from the capital market, and sends goods to the product markets for final consumption; and it takes prices in all markets as given, as long as it cannot exercise some degree of monopoly power. Veblen brought the notion home nicely in 1921 with the title of his book: "The Engineer and the Price System".

Received micro theory views the firm as a production function in the price system. This concept also has a strong hold on the minds of current commentators concerned with the economic effects of technological change. Technical change enters the standard production function as more or less unexplained shifts in materials processing performance. (It is difficult to tell to what extent this notion of the firm was adequate some one hundred years ago. We doubt if it was. Today it is grossly misleading, if valid at all.)

Apart from having a certain production function, the firm is first of all an administrative financial system that competes with the market for funds, people and customers. Second, the major advances in productivity performance, as we measure them, have to do with reorganisation of the internal life of the firm, or institutional change. Third, new forms of "soft" capital that are difficult to measure are beginning to dominate the "true" balance sheets of the modern manufacturing firms. The argument we will present here is that the bulk of activities going on in a modern economy, in the private sector of an advanced industrial economy, in the manufacturing sector, and within the firms consists of various forms of information gathering, interpreting and use. This in itself makes human resources the central capital item to consider in attempting to understand the workings of an advanced industrial economy. Modern information technology is making this focus even more relevant, a circumstance that places the educational process of a society at centre position in the capital accumulation process.

The transformation of input factors in the production process (e.g. labour, capital, energy) into some output measure is, of course, most generally embraced in the term "production function". This term has been repeatedly misused during the post-war period in the narrow context of a simple relationship between aggregate inputs and aggregate output or to represent a firm or a production establishment, to the extent that we agree with Murnane and Nelson (1984) who argue that a new term is needed to convey what is going on -- especially if we want to capture the subtleties of human capital inputs in production. For instance, the specification and quantification of the "production function" are generally not known at the micro level or, for that reason, at higher levels of aggregation. Business management only vaguely knows the outer limits of installed production capacity and the properties of potential production technologies available. Hence the notions of a fully informed, optimal choice of production and of the firm always operating on its production function are simply wrong, and of questionable educational value (Eliasson, 1976, 1984d, 1985a).

Some of the knowledge applied in the production process enters as quality improvements in labour inputs that are difficult or impossible to measure; some affect the quality of capital service inputs. Much, perhaps most, is acquired though trial and error and experimentation (or learning by doing, to use Arrow's 1962 term). The most important knowledge inputs affect the ways capital and labour and other inputs are combined and are part of a decentralised organisation of knowledge (Eliasson, 1984d). It is "tacit" (using Polanyi's 1967 term). Hence, no database will ever be able to reveal the true, potential production frontier of a production line, a workshop, a factory, a firm or an industry.

The resources used up within a modern manufacturing corporation for physical materials processing, for instance, are less, or much less, than half of total resource use, and the fraction is diminishing (Lindberg and Pousette, 1985). Service production of many sorts (R&D, product development, marketing, etc.) dominates. Most of it consists of some form of information processing activity that is also a dominant activity in the market surrounding the firm. To capture these one has to redefine the concept of the firm for use in analysing the effects of technological change. The following three criteria have to be satisfied. We need: i) A reasonably autonomous decision unit; ii) Delimited by variables that relate to the objectives of the managers of the decision unit; and iii) An (elementary) unit that exhibits reasonable definitional stability. The most obvious candidate is a financial definition of the firm, delimiting an intersection of the institution and the markets for money. This definition of a firm comes fairly close to the firm, or the group, presented as a decision unit in its annual report.

Generalising our discussion to the entire private sector makes our notions of production and of the firm even more appropriate. The non-manufacturing part of the private sector is currently the rapidly expanding sector. It is expanding for two reasons: a rapidly growing demand for services of all kinds in an expanding economy; a trend towards a larger service content of goods production. Both these tendencies have been exercising a strong influence on the "institutional composition" of the entire economy for a long time. So far, this has mostly been noted in economic debate as a rapidly growing and/or oversized public sector. Excessive political concern with crisis, manufacturing bulk producers, means that little seems to be available in terms of empirical knowledge and statistical data on the institutional dynamics outside manufacturing. For instance, technological change, shifting the industrial base from large-scale factory processing (such as in steel or pulp production) toward a product technology foundation, is blurring the statistical borderlines between manufacturing and the rest of the private sector. Even though most of our data will be on manufacturing, we are concerned with the firm of the private sector, when analysing the nature of the economic growth engine.

The growing service content of goods production and of consumption signifies a continued and perhaps faster transformation of advanced industrial economies into "information economies". As a consequence, the reader will soon observe that this essay is more focused on the nature, creation and application of industrial competence that makes the firms competitive, than on the skill content of factory production.

Nevertheless, the increasing accumulation and use of sophisticated knowledge to run an advanced industrial society is certainly affecting the markets for labour. A discussion of this and suggestions as to coping with our embarrassing lack of knowledge conclude this essay.

2. What Does a Modern Firm Do?

A financial definition becomes natural when we take a closer look at what goes on within a private firm. We can list at least ten activities in Table III:1.

Table III:1

MAIN FUNCTIONS WITHIN A LARGE FIRM

1. I. vation, entrepreneurial activities
2. Institutional reorganisation (owners, board)
3. Product development
4. Investment company
5. Commercial bank
6. Insurance company
7. Materials processing (the factory)
8. Marketing organisation
9. Educational institution
10. Welfare institution

Item 7 corresponds to the standard production function concept of the firm. The other items denote various forms of information gathering, analysing, and using activities at the interior of the firm or its exterior environment, product development and marketing being perhaps the most resource-demanding of these activities. Remove Item 7 and the service firm is defined.

Standard economic theory, notably general equilibrium theory, does not as a rule recognise costs associated with collecting, analysing and using information to guide a firm in its market environment. The presence of a so-called auctioneer is assumed. He does all this work free of charge. Modern search theory is a crude way of dealing with this problem.

Modern empirical research tells a very different story on how information is gathered and put to use within a firm (Eliasson, 1976, 1984d) or in a market process. Clower and Friedman (1985) are very careful in modelling the importance of traders as information carriers that co-ordinate and perhaps equilibrate a market economy. In fact, information costs seem to dominate total costs of production. The bulk of resource-using activities going on in markets is concerned with the intermediation of information and is carried out by traders called firms that act as intermediaries between firms -- seen as goods-producing factories -- and end users of goods. (Even this is a narrow perspective to take. Much of the intermediation of information takes place in the non-market part of the economy, the public sector, etc.)

The dominant part of interior firm resource use has to do with the collecting, analysing and application of information to get the right design of the product and the product itself to the right customer. If marketing and product development are defined as an information activity, probably more than 50 per cent of total resource use in a modern firm on the average is devoted to information processing in a broad sense, and most of it is applied to move the producer closer to the customer, thereby fundamentally changing the nature of the market process.

There is a large substitutability between the various forms of organisation of information processing. Some goes on within the goods-producing institutions, some in separate market traders. Whenever prices and technologies change, so do institutional structures.

Recent empirical research tells us (see Eliasson, 1984d) that organisational change between firms, between plants, and within plants is the major vehicle for productivity change. This process is an integrated part of information processing and production and, hence, spells out some important characteristics of technical change in the business sector that we have to recognise when we proceed to study the knowledge and skill requirements in industries. This is especially challenging in the context of the development of modern information technology, so we will discuss the various items in Table III:1 in turn.

a) Innovative Activities

A high proportion of information activities measured by resource use appears to be a characteristic of the successful firm, while a heavy concentration of resources to hardware production signals the opposite performance. For large, international Swedish firms it is possible to talk about three commercial legs -- product development, production and marketing -- where successful product development and superior marketing techniques have become decisive for the profitability of productivity growth (Eliasson, 1984a). Both product development and marketing are a typical human capital-intensive service production. It is also significant to note that a great variety of institutional and organisational solutions to handle the combination of product development, production and marketing and distribution are coming to the surface. Some internalise all activities within one firm. Some decentralise the various activities over many firms. Sometimes the critical manufacturing technology may reside in a service organisation that statistically does not belong to the manufacturing sector.

Innovative activities go on at all levels within firms. In the economic discussion it is often associated with the individual inventor who comes up with the unique idea. However, entrepreneurship at large, in the form of innovative entry, and (to use a modern term) intrapreneurship in the large business corporations both belong here. We have also observed that the large Swedish engineering corporations were very innovative indeed during the 70s.

b) Institutional Reorganisation

The most important innovative activity, however, has to do wih the structural adjustment process of the entire firm. Part of it relates to the pure technical innovations already mentioned; much of it has to do with improved techniques in all other areas of Table III:1, not least in marketing. Much of it also has to do with bringing in new ideas from the outside. Some would even argue that the bulk of R&D activities within firms in fact has to do with "imitating" competitors.

From the point of view of the firm as a whole, the most important innovative activity is to co-ordinate all ideas with the existing production process to engineer institutional change of the entire business entity. The initiation and realisation of this institutional, innovative surgery is located at the very top of the firm hierarchy where major decisions as to competitive reorganisations of the firm are taken, that is, at Board level and among the major owners of the firm.

A major reorganisation of a firm normally meets with strong and effective resistance from within. To break such resistance and to carry it through, the discretionary power vested in the owners is often needed -- together with a visionary talent that is not always present at these levels. The reorganisations we are talking about include mergers of various sorts, and the whole process of integrating new technologies, production processes and marketing arrangements of the acquired company with the old company, disinvestment of alien activities, the scrapping of commercially obsolete activities, and so on.

c) Product Development

The resources devoted to high-level innovative activities are almost impossible to measure. Primarily, it is a question of finding the right team to manage the firm. R&D spending can, however, be measured and most of it appears to go into product development. What is more, it seems to be mostly "imitative" in the sense that novelties from competitors' workshops are taken up and improved upon. Table III:2a gives data from one large Swedish firm on a cost-share basis. Table III:3a gives a breakdown of both total costs and total investment spending among the largest industrial groups in Sweden on R&D spending, process investments and investments in marketing and distribution.

The larger the firm, the fewer resources used in processing and the more in R&D.

d) Investment Company

Innovative activities of various kinds determine the technical and commercial frontiers of the firm. As a rule, they enter through new investments. Frontier and best-practice activities mix within firms and between firms. They all compete for resources and the worst performing activities, or firms, are eventually forced out. Investment resource allocation within a firm is normally accompanied by a continuous reorganisation of the firm. Together, this pair constitute the major vehicle for implementing long-term changes on the production structure of a firm, changes that in turn are decisive for productivity change. The two functions (items 2 and 4 in Table III:1) are top executive activities in a large firm. They include the decisions to invest, to decide on which existing units to expand, the decision to contract or to scrap, and part of the decision to enter new activities. The totality of this decision affects the entire business organisation top down and it relates directly to the in- and outflows of the organisation's funds. The management of funds is a major production activity of the large, modern firm, and efficiency in earning a profit, long-term and short-term, is the limiting factor of firm size and fundamental to the profitability of the firm (Eliasson, 1976). It is important enough to warrant consideration on its own.

3. Institutional Fragmentation

a) Changing Institutional Structures and Productivity

A stable unit of measurement helps to stablise the analysis of a firm's behaviour. Institutions like firms, or families, have conventionally been regarded as having structural configurations in economic analysis. We have here introduced a similar assumption by defining the firm as a financial decision unit. However, we have to recognise the enormous variety of activities that go on within that unit (see Table III:1). We also have to observe that some of them may either be carried out within the administrative and planned system called a firm, or externally in separate trading units, also called firms, in the market (see Eliasson, 1984d, on database designs), a circumstance that blurs the limits of the firm and the concept of a market. A market process is the combined action of its institutions (see below).

Finally, a realistic analysis has to recognise institutional transformation and recombination as an endogenous element of economic progress. In fact, institutional change appears to be the major vehicle for

Table III:2a

TOTAL COSTS[a] OF AN ENGINEERING FIRM BY FUNCTIONS AND DOMESTIC ACTIVITIES[b], 1981
(Per cent of total)

	Per cent
R&D, engineering design and documentation	17
Work scheduling	15
Production	44
Marketing and distribution	9
Financing and administration	5
Other	10
TOTAL	100

a Excluding depreciation and interest expenses.

b Excluding foreign subsidiaries, that are predominantly concerned with marketing.

Source: MOSES database. See Fries (1983).

Table III:2b

LABOUR INPUT BY TYPE OF WORK IN A FACTORY, 1974-79
(Per cent of total manhours)

Work scheduling	51
of which	
administration, planning	38
technical preparation	13
Production	10
of which	
supervision, service, quality control, etc.	33
direction production	33
transports, inventories	6
TOTAL	100

Note that data cover only factory production and item 6 in Table III:1.

Source: Eliasson (1981).

Table III:3a

INVESTMENTS BY THE 5 AND THE 37 LARGEST MANUFACTURING GROUPS IN SWEDEN, 1978

(The groups have been ranked by number of people employed abroad.)
(%)

	The 5 largest		The 37 largest	
	All group	Foreign operations	All group	Foreign operations
R&D	25	10	21	6
Machinery and construction	45	41	52	42
Marketing	30	49	27	52
TOTAL	100	100	100	100

Table III:3b

TOTAL WAGE AND SALARY COSTS IN DIFFERENT ACTIVITIES IN THE 5 AND THE 20 LARGEST SWEDISH MANUFACTURING GROUPS, 1978 (PER CENT)
(%)

	The 5 largest		The 20 largest	
	All group	Foreign operations	All group	Foreign operations
R&D	7	3	7	2
Process and	63	52	70	50
Marketing and distribution	30	45	23	40
TOTAL	100	100	100	100

Source: Eliasson (1984d).

performance improvements at the firm level. This also defines the distinction we want to make between dynamic efficiency and static efficiency. Static efficiency means doing the same thing better. This concept has to be defined at a fairly low level of aggregation within the firm, say, a production line or, possibly, at the product group level. Dynamic efficiency (what we also call flexibility) on the other hand is achieved through entry of new activities, and exit or recombination of established ones. Introducing institutional or organisational change at the micro level means pushing formal, mathematical analysis at the current state of mathematical economics out of reach.

We have observed that the conceptual designs (the taxonomies) of our databases become more or less arbitrary when we allow for institutional change. Both the "firm" and the "family" happen to be useful analytical groups because they define rather monolithic decision systems. Both are also linked up to a joint financial purpose that in modern societies corresponds to fairly well defined statistical systems. But neither the firm nor the family are stable institutional forms. The forms of interaction between firms, between firms and individuals, between individuals and households, and within both firms and families as "administrative processes" change under the influence of outside forces, like the competitive market processes.

The interior content of a successful business entity is anything but stable. If seen over a longer time span, surviving firms change the composition of their activities tremendously. In addition, both their products and their production processes change their technical specifications. At the same time, competition between firms and new innovative entrants force out outmoded and less efficient activities.

b) Producers and Customers Grow Together in Customer Markets

Furthermore, "industrial technology" is all the time making new institutional combinations superior to their predecessors. Thus, for instance, the more complex and specialised product designs are, the more efficient it has become to incorporate sales agents and separate traders and marketing organisations as part of the large production organisations. A growing part of the traditional market process has, so to speak, become part of the administrative system of large firms. Producers and customers form a symbiosis. Okun (1981) has coined the term "customer markets" to cover that phenomenon.

At the same time, the development of new complex products or production processes, including their maintenance, requires a large spectrum of specialised knowledge and talent. Even for large firms, it is costly and sometimes impossible to maintain such a knowledge base internally. The last few years have witnessed the development of a veritable jungle of small specialised service firms around the large production and market organisations. This is especially typical for the electronics and computer industry where small-scale human talent plays a critical role and where small-scale establishments become relatively efficient economically.

While economies of scale mean that administrative solutions are taking over market processes in customer markets, increased specialisation of products means that competitive entry of small service producers is breaking up administrative solutions on the factor side.

On the one hand, we have observed that economies of scale prevail in the financing, banking and risk-reducing functions. This is making industrial firms incorporate such activities into their normal business.

On the other hand, technological change is currently eroding the earlier advantages associated with large-scale factory organisation. The really strong technological push for small-scale production is most vividly exhibited in the new intelligence industries, that of electronics and computer industry and in practically all the entire surrounding software industry. Here individual talent and specialised knowledge are what matter and the consequence is a surrounding swarm of humming and profitable software firms. However, similar tendencies can be observed also in engineering industries. Even basic industries like steel -- especially high-grade, multi-quality special steel -- are seeing all kinds of small-scale production technology entering the market.

c) Institutional Fragmentation and Work Compensation

Since non-process activities are growing in relative importance, and since product development, marketing, etc., do not necessarily have to be an integrated part of the production organisation, we expect to see more of such institutional fragmentation in the future. It appears that the emerging service economy that is integrated with industrial production may be breaking the old factory-based industrial organisation apart, producing new and more rapidly changing institutional structures. If these tendencies continue, they will increase and personal initiative and adjustment abilities will command a premium.

There is one challenging economic aspect of our observations on institutional change in the private sector. All large-scale factory or business organisations have developed a certain internal compensation structure. This is partly the result of difficulties of measuring the productivity of individuals in an integrated production process (see Alchian and Demsetz, 1972) and partly an effect of social convention, legislation and union agreements. The output value of talented, skilled or hard-working labour is partly redistributed to the low-performing end of the labour force of the same production establishment. In an integrated factory, or at a long production line, it is difficult to identify individual contributions even though firm managmement as a rule does its utmost to identify and form small and separate "profit centres".

However, modern technology in modern information-based industries is changing the situation. With a growing number of specialised talent inputs becoming critical for the large business organisations, the potential for forming small separate profit centres within the organisation, or hiring the services externally is increasing. Furthermore, it is often the case that such talent is only a valuable input for specific, brief periods. Individuals or groups of individuals who want to keep the value of their labour for themselves can break loose from the large organisation. This arrangement is beneficial for them and often in the interest of the employer organisation. Recruitment practices and employment security laws also make separation of certain functions attractive to employers, who want to pay well when they need the service but who do not want to take on a life-long employment responsibility.

The servicing of products or installations, advertising, the organisation of marketing campaigns, educational activities, parts production, specialised engineering, etc., may even be more efficiently handled by separate, small firms. This is becoming desirable also for purely technical reasons. The modern welfare economies provide strong incentives for individuals to exploit such technical opportunities; labour market laws often make the employment decision a life-long relationship between employer and employee, if the employee so wishes; tax laws make it virtually impossible for the individual to collect the market value of his or her talent or competence for himself, if it is unique and large.

Leaving the team organisation of the large factory or firm and "going individual", or to a small firm, the high-performing individual no longer has to share the value of his output with the team. Secondly, running your own firm makes it possible to time your income flow personally over your life cycle and also to cash in on an income definition that minimises your taxes. The best examples of what is going on are offered by the rapidly expanding electronics, communications and information sectors with typically small-scale and sophisticated service production in combination with extremely large income opportunities.

This development, which is being encouraged by the extensive welfare and social security systems of the industrial nations, is probably already seriously threatening the position of the traditional large firm as a welfare institution and a vehicle for income equalisation. This does not seem to have been noticed yet, either by politicians or by economists. We will return to it later because the firms -- and for that reason, the family -- may (unknown to most) have been a much more effective egalitarian device than the public sector has ever been.

As a consequence, the not-so-talented, low-skilled worker may no longer be as protected as before from competition within a large, administrative and unionised factory organisation. In particular, in the future the low productivity workers may have to be satisfied with a compensation more in line with their productivity on the job. This particular aspect of technological change will probably be a concern of labour market analysts in the near future.

There is little statistical or empirical evidence to demonstrate the institutional fragmentation that has been going on for some time. The recent employment crisis in OECD countries, however, created a partial awareness and, in a sense, the demand for more public sector growth to solve the unemployment problem has been overtaken by the question as to whether private services take care of the people laid off from obsolete manufacturing industries.

It is probably true that part of the enormous expansion of employment in the private service sector in the United States is due to a widening income distribution and -- as a consequence -- the opening of more menial service jobs. However, much of the new employment is directly linked to hardware manufacturing production. Some of it consists of new types of jobs associated with new technologies being developed. Some of it was previously run as an internal firm activity. In the advanced industrial countries -- the United

States and Sweden -- business services have been the most rapidly expanding sector when it comes to employment (see Figure III:1). Expansion is not only rapid: the business service sector in both countries employs today a significant number of people.

4. The Definition, Limits and Increasing Structural Instability of a Firm's Organisation

There is a vertical and a horizontal dimension to the business activities of a firm. As it grows in size, measured as a financial unit, its horizontal size increases and "coordination" becomes a major information-demanding concern of top corporate management. The vertical dimension is what we usually associate with production flows. A small firm often has only one vertical dimension, one production line. Within a large firm, the business unit, the profit centre or the division are vertically organised. Technological change within the division means increasing the vertical flow speed to reduce factor use coefficients in all dimensions. There are heads of division that run and co-ordinate divisional activities, but they are always subordinated a higher executive level within the firm, before the firm reaches contact with the external markets (the Corporate Headquarters function reporting directly to the owners).

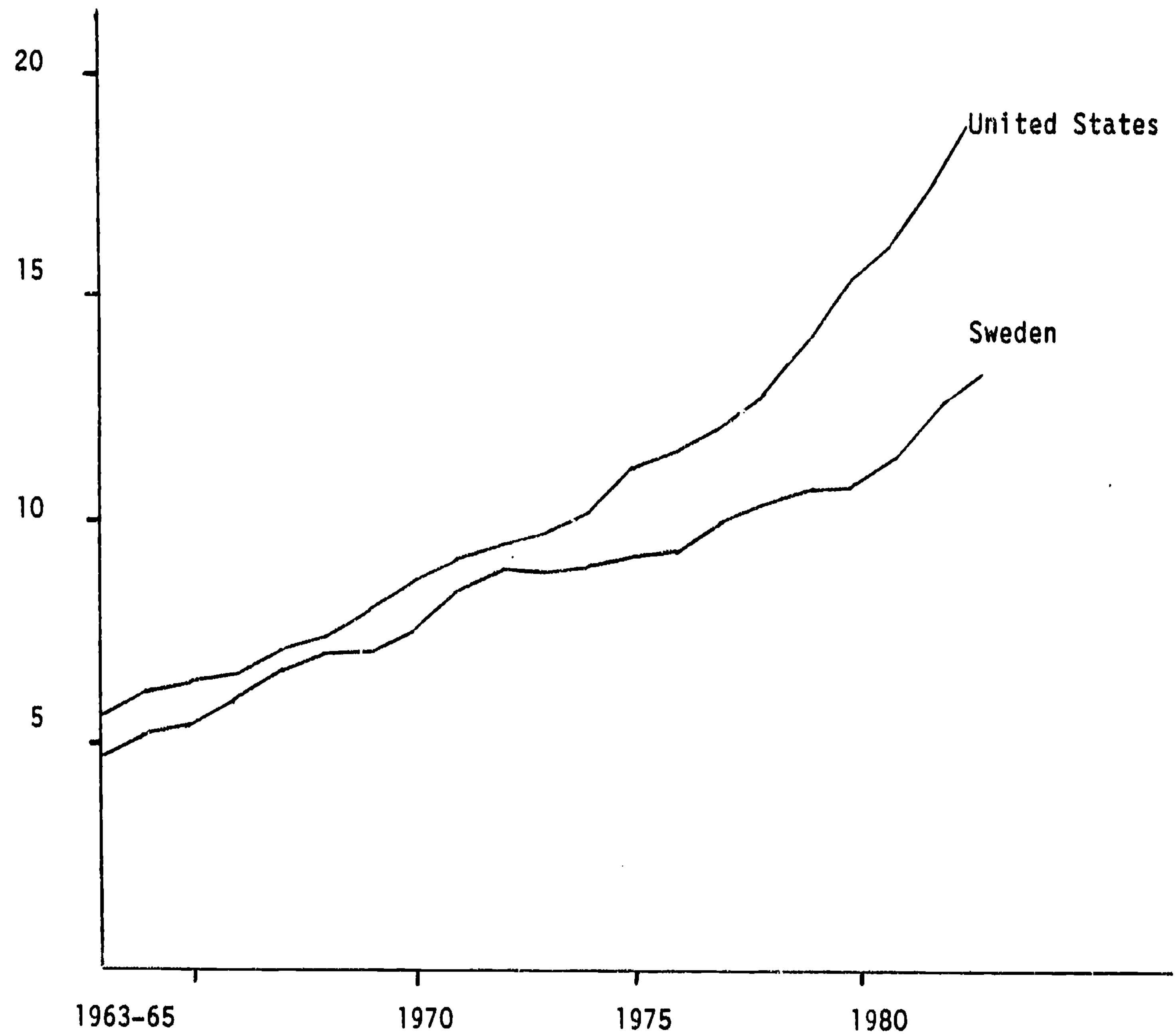
There are more or less decentralised organisational structures that control the interior life of a firm while the firm itself is a monolithically controlled financial system. The interior units are allowed more or less autonomous external, financial market contacts. But the normal situation is that financial management, practically always long-term finance and always equity finance, is centralised at Corporate Headquarters and linked up with ownership. It either isolates the interior coordination process from external market influence or transforms it into an administrative procedure (or a team) that in theory is more efficient than the market. This is at least the rationale for the existence of the firm as an administrative decision system (Coase, 1937; Arrow, 1974; Williamson, 1975), or rather as a financial decision system.

We will demonstrate that internal coordination between major investment blocks, divisions and reorganisation is the major vehicle for enhancing corporate performance. Hence, the financial definition of the firm as a monolithically controlled institution, or a financial intersection between administrative and capital market performance (Eliasson, 1976, pp. 255 ff.).

The firm of the economics textbook is still, however, that of a goods-producing factory. Economy of scale in factory production has been the basis for much theorising about the optimal size of the firm, productivity growth and market concentration. As industrial technology is gradually shifting from a base in cost-efficient production toward a product-based technology, economies of scale also begin to shift from factory production towards marketing, internalised financial intermediation and risk reduction (insurance).

Figure III:1

EMPLOYMENT IN BUSINESS SERVICES IN THE UNITED STATES AND SWEDEN IN PER CENT OF MANUFACTURING EMPLOYMENT



Note: Business service is defined as SNI codes 832100-833000.

The insurance function of a firm (item 6 in Table III:1) is closely linked to the finance function. We are thinking not only of the traditional property insurance activities that, to an increasing extent, are being internalised in large business organisations, but rather of the ways general risk reduction is managed (see Eliasson, 1984d). Sheer financial size makes it possible for a firm to absorb large risks. With a growing part of total investment allocated on product development (item 3) prior to production, with the length of product gestation periods growing and -- once in the market, because of more intensive product technology competition -- with shorter product life spans, the larger the total risk burden associated with each business activity. Hence, while the traditional risks associated with the factory investment diminish in importance, the total risk of the business as a whole increases. Thus, "one product" firms live a more precarious life than hitherto. This alone is enough to stimulate the growth of conglomerate businesses that can internalise both the investment banking and the insurance functions.

The interesting question is what such institutional reorganisation means for industrial efficiency at large. Could this explain Pratten's (1976) observation that while the Swedish firms operated larger production establishments, and were generally more productive and expansive than a matched set of British firms, the British firms defined as financial units were significantly larger than the Swedish firms and somewhat more profitable?

Technological change, including new materials, new tools, automation and robotics, combined with a growing demand for sophisticated and highly specialised products associated with advanced industrialisation, is placing traditional, large-scale factory production under competitive pressure. This tendency is reinforced by the growing service content of both products and production (Lindberg and Pousette, 1985). Production efficiency is no longer as dependent as before on efficient flow arrangements of teams of people and machines.

5. What Do We Mean by Industrial Competence?

Productivity of a firm has to be identified as the art of managing the entire firm and adjusting its organisation to changing market circumstances. Part of the competence to run a firm is to choose the right markets and the right products, and to leave commercially impossible activities in time. Hence, the result of industrial competence is always measured by the rate of return to capital.

Human capital is always the basis for superior industrial competence, whether at the higher management level or on the shop floor. To estimate human capital or competence from data on income -- which is the approach taken in human capital theory -- we have to know to what extent human capital has been awarded its "rightly" or "justly" derived monetary value in the market. This requires strong assumptions about market equilibrium that are never satisfied. To say anything on the matter of human capital, we have to back away from the notion of equilibrium economics and attempt to understand, and preferably to quantify, the disequilibrium adjustment process and the content of the skill endowment of a business when it comes to upgrading and co-ordinating its activities in a dynamic and not very predictable economic environment.

We should consider four levels of competence.

Table III:4

LEVELS OF COMPETENCE

1. Process (production line)
2. Product (market)
3. Management (firm)
4. Economic policy (national)

The first (and "lowest") level refers to the making of products (factory production), the second to their development, marketing and distribution. The third level takes in everything else at the level of a controlled business decision unit operating in product, labour and capital markets, and in our view delimits the concept of a firm. The fourth level has to do wth the interaction of "firms" in this sense with markets, the administrative action in the non-market part of the economy, and government policies in general, or, in short, the nature of the market regime.

Evidence has already been presented that the modern industrial firm -- and probably any successful industrial firm -- bases its competence on three legs: product development; factory production; and marketing. The profitability of the factory process in a modern manufacturing firm appears to depend significantly on the earlier product development phase and the later marketing stage. This means that item 2 in Table III:4 is very important at the firm level. However, both product design and marketing depend on a prior selection or choice mechanism that is traditionally called management.

For reasons of clarity of discussion, we want to relate Table III:4 as closely as possible to our previous Table III:1. It is obvious that levels 2, 3 and 4 in Table III:4 all deal with various forms of information and choice activities. Product development clearly belongs to this group of activities. It links one-to-one to the corresponding item in Table III:1. We (arbitrarily) assign part of materials processing (item 7 in Table III:1) and all other activities to <u>management</u>. It is they alone who deal with the use of information; most of it being concerned with <u>co-ordination</u>, some of it with innovative activities. It is typical of these activities that they all interact with one another. Few can be isolated and treated as a variable factor in a production function.

Thus, competence at policy and management levels depends on overview, co-ordination, and control of <u>the whole</u>, whether it be the whole economy, the whole firm or the whole of some activity going on within the firm. At this level we are not talking about "skills" or "experts" as representing competence, even though the management level may be populated by large numbers of experts, such as accountants, tax specialists or computer people. The top managers in firms command a very special competence. As a rule, they have some kind of academic background, but this is not sufficient, maybe not even necessary, for their special (top) managerial competence. We will attempt a more precise description of this competence presently.

Book or classroom learning of job tasks is not a typical feature at the management level. The nature of knowledge depends, however, on where exactly we draw the line between management and process levels. This will have to be somewhat arbitrary. The sweeping of floors of the executive offices is not a management activity even though it is often allocated as such in the cost accounts. Computer support (hard- and software) of management activities on the other hand is often classified as operating expenses. If we use the cost accounts of a business organisation to measure the volume of various kinds of inputs, which we have to do, a fair amount of not so sophisticaed and not particularly human capital-intensive production will be defined as management.

To complicate things further, looking at the process level (inside the factory), we find that even there management activities are important (see Table III:2b). A much finer statistical detail is needed to take us down to the level of pure hardware production, with blue-collar workers manning machines. To get a grasp of the extent of the vast array of non-hardware processing activities within a modern firm, we have added a tabular breakdown (still a very aggregated one) of the cost account taxonomy of a typical manufacturing firm (see Table III:2a).

A fairly large number of people in the factory are occupied with co-ordination of larger activity blocks, requiring overview rather than specialised expertise. The nature of competence needed at various "levels" in a business organisation is perhaps best illustrated by Figure III:2. The figure also leads directly into the next chapter on how competence is being created.

<u>Rationalisation</u> at the process level (item 1 in Table III:4) takes place at the third bottom level of the pyramid. Productivity improvements depend on skills in organising and updating the factory process. In the debate on productivity and employment, most attention has been paid to activities at this level. The results have often been uncritically generalised to the firm and the industrial levels.

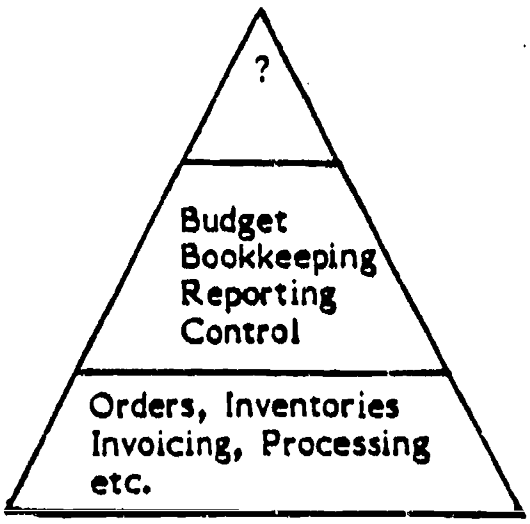
<u>Co-ordination</u> occurs at levels 2 and 3 in Table III:4 and consists in improving the low efficiency of a combination of given processes and products.

Large improvements in total factor productivity are achieved at this level. Modern information techniques have also been improving overview, transparency and control at this level, partly replacing certain middle management functions (see Eliasson, 1976, 1984d). Actual and potential productivity effects on the whole of the firm organisation at this middle level are much larger than the sum of productivity effects occurring at the rationalisation level.

By far the largest productivity effects, however, have occurred and will occur as a result of decisions taken at the top level of the pyramid in Figure III:2. They have to do with adjusting the organisation of the business entity to changing environmental circumstances, including the decisions "what to do" or "to close down". The nature of the knowledge capital residing at

Figure III:2

DECISION AND COMPETENCE LEVELS IN A BUSINESS ORGANISATION



	Type of decisions	Education
1	Strategic (Structural change)	Career Academic
2	Tactical (coordination)	College/ Special courses
3	Operations (rationalization)	Vocational

this level is difficult to identify and to measure. Its importance, however, is witnessed by the growing number of publications on engineering and management education. This concern in such literature, however, is mostly focused on the notion of industrial competence as technical (bottom level in Figure III:2) or controlling and co-ordinating (middle level).

To illustrate the need for a knowledge base to bring about structural change, let us take the large number of diversification ventures into high technology markets undertaken by large, mature firms with a view to creating a new product base, when the existing mature product range ceases to be profitable. Many, perhaps most, of these ventures have not been successful. As a result, successful firms tend to grow, eventually become large and then to start contracting, often destroying large resources in futile attempts to get back on a new technology and a new growth path. Exxon for many years tried to develop an "office systems" industry group, financing it from the enormous cash flow in oil activities. This was clearly a top-level activity, but the knowledge capital needed to run the oil business did not mix well with the knowledge base needed to develop such new activities and a significant part of "Exxon Enterprises" was shut down in the early 80s.

The development of Swedish industry during the last one hundred years offers a similar macro illustration that can be compared with the "transformation process" the Norwegian economy wants, and can afford because of its enormous oil wealth. In fact, the Norwegian "management problem" facing industrial policy makers is quite similar in scope and character to that of Exxon.

6. From a Process to a Product-based Industrial Technology

When looking at the firm of today and the typical firm of the past, some clear tendencies can be summarised:

1. Diversification of activities, products and skill requirements have increased. This is partly a reflection of the growing importance of engineering industries relative to basic industries, or producers of rather crude materials and simple products that dominated industry earlier. Increased domestic and international specialisation is another term for the same phenomenon.

2. This development also places product innovation rather than processing at the centre of the competitive economic process.

3. Longer gestation periods combined with rapidly growing investments in development costs appear as a significant characteristic of new product development.

4. At the same time, once in the market, product life spans have tended to shorten. This is also a reflection of the more intense, competitive market process associated with increased specialisation among more producers and traders.

5. Service content of the whole production sequence up to the final product is rapidly becoming a competitive edge. We have already mentioned the service contribution of R&D in new product development and the large addition to final sales value in the marketing process. However, maintenance contracts or guarantees and various insurance packages, the existence of large dealers, reserve parts and service networks are important product value-enhancing factors.

6. Unstable market environments and lowered predictability have become the typical business experience since the mid-70s.

7. More diversity and less market predictability (more uncertainty) have generally increased the environmental complexity associated with running a business firm. Information processing and use in a multitude of forms have become a major cost item.

8. One way of coping with increased environmental uncertainty is to absord it internally through expansion in size as a financial unit. The broader the array of products or activities, the easier to absorb local mistakes, and the easier to take bold, strategic moves in one area, by concentrating resources from many activities. While longer gestation periods, shorter product life cycles, less predictability and a more uncertain external environment in general have led to larger firms as financial units, the administrative system also increases in size.

9. The internal complexity of the modern firm. Top decision makers become removed from the actual production process, and more and more elaborate information, co-ordination and control systems are needed to run the entire enterprise. Very often these co-ordination systems clash with flexibility requirements. Remote guidance and

control of diversified, non-transparent business bodies over rough and unpredictable commercial waters have become a major element of business competence.

10. At the same time production technologies seem to be heading in the direction of small-scale processing of sophisticated products away from large production scale and simple products.

11. A break-up of traditional factor combinations at the earlier stages of production is creating a much more varied institutional structure around the traditional engineering firm. This development is encouraged because of the combinations of taxes, regulation and legislation that are typical of the modern welfare states. Such arrangements stimulate individuals to organise themselves in separate business entities, to keep the compensation from individual talents and specialised knowledge for themselves, through appropriate institutional arrangements.

12. One should, hence, expect self-employment to increase relative to "wage employment".

13. The same process is obviously also taking place abroad, intensifying international competition for domestic firms that are not leaders in their field in adopting the new technological opportunities.

14. On the whole, materials processing and large-scale factory production of a simple kind and of simple products appear to be suffering economically in the advanced industrial countries. This competitive pressure comes from two directions: internally in the form of competition for factors of production from the more sophisticated and profitable domestic producers who can pay higher wages, and from abroad through producers in less advanced countries who are learning the established and less advanced production techniques.

15. The limiting factor in this economic race is the availability of human knowledge and skills.

The new business environments thus characterised are clearly demanding a new breed of workers, managers and leaders. We have also emphasized that availability of human knowledge is more a matter of quality than of volume. A key question is to what extent the educational system at large is producing and deploying those skills adequately. We have already concluded that both generalised education and specific skills matter, and especially in combination. The specific skills are closest to the production process and offer development facilities "on the job". To this we will turn in the following chapter.

Chapter IV

THE CREATION OF INDUSTRIAL KNOWLEDGE AND SKILLS:

WHERE AND HOW?

1. The Policy Problem

A worrying conflict of concerns about the adjustment process in the old industrial world is creating policies that may block sound, long-term solutions of the structural problems.

On the one hand, new technologies being adopted faster in some firms and in some countries than in others, places increasing competitive pressure on the old industrial world. Some countries are concerned about their apparent lack of industrial and technological knowledge for adapting fast enough to counter such competition.

On the other hand, this adaptation of new industrial technologies or structures, whether forced or carried out through domestic initiatives, places many individuals under pressure to adjust. They are either forced into unemployment or initiate their own search for new knowledge and new jobs. The adjustment problem notably affects those who happen to be holding low-skilled jobs in the wrong firms.

Both sides of the adjustment problem have been dealt with in this essay, albeit emphasis has been placed on the first of them -- the "positive" one. The key questions have been: what constitutes industrial competence and -- in this chapter -- how it is created. The other side, the labour market problem, has already been discussed from the point of view of how to deal with the consequences of good or bad business performance.

Chapter III concluded with two observations: first that the availability of industrial knowledge, know-how and skills was a restriction on the competitive performance of industries; second, availability was partly (perhaps largely) a matter of labour market allocation.

As a consequence of these observations, this chapter has two purposes: the first is to identify the investment, or educational process, that generates the industrial knowledge presented in the foregoing chapter; the second is to identify and delimit the social side of the adjustment problem introduced there. We will find that the number of people actually or potentially affected is relatively small, that the problem to a large extent has to do with generational change, and that the social factor coincides with the educational process that enhances the economic growth potential. If the labour market problem could be focused properly, it shoud be manageable through a well-designed educational and labour market programme.

Both standard economic theory and official statistics display a strong bias toward the manufacturing and consumption of goods and the hours of the industrial worker as a factor input. This neglect of the service side, and the quality of economic activities dates all the way back to Adam Smith, who wrote condescendingly about the value of services, a view reinforced by Karl Marx that is still ingrained in the measurement taxonomies of all national accounts systems.

The neglect of service production as a quality-enhancing part of goods production, or in the use of goods, has created in turn a secondary neglect of the knowledge necessary to co-ordinate machinery and labour hours efficiently in production.

Bad theory and bad measurement in combination foster misunderstanding. Misunderstanding means something when the distorted knowledge is put to use for policy making. To produce a better (national accounts) measurement base and a useful theory for dynamic economic reasoning should be a prime long-term concern of politicians, who cause the worst damage to national economies when they act on misconceptions on how economies work. They act from a central level with the excessive leverage made possible by the resources controlled by a modern welfare economy.

2. Where Does Education Occur?

Human capital is (by definition) created through an investment process called education. We concluded in Chapter III that much of what we call education is not investment in the sense of building human competence for gainful occupation in the production system. Some of it is pure private consumption, some of it is part of an egalitarian process that may produce negative values for others, some of it is national indoctrination, and so on.

Human capital investments that are useful capital inputs in the production system take place at three levels:

-- At home (through upbringing);

-- At school (through education);

-- On the job (as career experience).

The first stage, upbringing, may be the most important one, especially in laying a foundation for effective education at school and on the job. Lack of knowledge of the input-output characteristics of the educational process prevents us from being more positive, except to say that in most countries educators and politicians have attempted to compensate individuals through the schooling system for an inferior family background. Experience is that such attempts have not been successful (Murnane and Nelson, 1984).

When we focus on the last two levels of human capital investment, discussion is made easier if we first restrict ourselves to competence creation for private industry (previous chapter) and simply assume that "high level industrial knowledge and competence" is created solely through a varied career experience in the labour market. The foundation for such a career is laid in the formal schooling system (middle level).

This means over-emhasizing the white-collar part of the labour force. In one sense this emphasis indicates where the industrial structure is moving on the margin. However, it also highlights the nature of the labour market problem, which involves directing the new entrants away from simple manual labour and retraining laid-off labour for different tasks in the growing service-oriented industries.

Hence, we will be very brief on the matter of hardware production and menial skills for factory and routine office work. This is the area where most of the negative experiences from new technologies -- notably through competition from other firms acquiring the new technologies faster -- have been felt, and also where most empirical research has been carried out (for more on this, see Part II).

In over-emphasizing the white-collar part of the labour force, we can also place the "filter" property of the educational system and of the labour market up front. As a consequence, it will be natural to begin with the firm as an educational institution, and then proceed to discuss what the formal schooling system can do to improve its educational output to the benefit of on-the-job schooling. Finally, we return briefly to the firm, the family and society as welfare institutions.

3. The Firm as an Educational Institution

The firm as an educational institution is the core issue in this chapter. Specific skills at all levels are developed in direct conjunction with the ongoing production process. The more sophisticated, specialised and complex, the less of the skill content can be abstracted from the ongoing production process and transferred in documented form through an external schooling system. Furthermore, schools and universities, by their very organisation and recruitment practices, will always teach an old generation of skills. Frontier technologies are developed in the firms. This is witnessed from many countries, where dominant, technology-based firms have employed all high-quality, specialised research talent in their field, while technical institutes and universities employ the cream of the nation's technical research personnel in secondary fields. These are the reasons why high-level industrial competence in technical fields can only be acquired through a job career.

In order to make the importance of this topic clear, we will quote from Eurich (1985) that in the United States the combined classroom teaching, college level and up, carried out by the private sector -- excluding similar teaching in the public sector and excluding direct worker on-the-job training and apprentice programmes -- amounted to an activity of the same magnitude as the combined total of United States college and university education, 8 million people being constantly in "corporate classrooms". If only 20 per cent of this was true, it woud be a remarkable observation and something the educational officials of a country could not be expected to neglect.

The extent of corporate educational activities makes them very important. The capital associated with product development, management, process innovation and marketing never shows in the accounts of firms. This human capital is, however, what matters in the modern firm. Some authors even want to define competitiveness as the unique knowledge base that makes the firm profitable. The ability to operate successfully the large, private, complex industrial organisations that dominate growth in the Western economies constitutes a major technological base, a human capital that has been developed on the job on the basis of a good formal educational system. Having said this, it is odd to observe how neglected the firm's role as an educational institution has been among those who talk and write and express such confident opinions on what is good and bad in business. Peters and Waterman (1982) do not even make education or training one of the criteria for "best" companies, despite the fact that all companies they have marked as "excellent" operate extensive educational programmes.

The productivity of high-level human capital in industry is both organisation-specific and related to the team of people and installed capital. It is, however, more mobile than hardware capital and very mobile as a team. Hence, the turnover of critical human talent becomes an issue in the investment, salary and employment policies of an advanced business firm.

It would, of course, be desirable to quantify the accumulation of unique human capital or business competence in a firm in the same way as we do with machinery capital, but this is close to impossible. Firms have no good statistical systems to keep track of such investments. Part of the competence built up is directly linked to selection procedures when hiring people at all levels, and much of further accumulation of skills relates directly to current work and individual career experiences and capabilities. One might even ask whether the fact that we measure hardware capital the way we do really does not mean that we are caught in a statistical illusion. Perhaps the concept of hardware capital is as impossible to capture in statistical terms as human capital.

To organise our thoughts under this ambitious heading, we have to introduce a few prior assumptions that will remain to be tested even after this paper has been printed. We will start by distinguishing between three layers of human capital in the business organisation that correspond to the listing of functions in Table III:1 and to the decision hierarchy of Figure III:2.

Table IV:1 is a somewhat broad statement; neverthele it distinguishes clearly enough between the different knowledge bases and correspondingly different backgrounds, educational processes.

a) Executive Competence

First, the decisions that really matter for the long-run success of a business organisation are taken at the very top, by owners, the Board members and the most senior executive people. The kind of knowledge they apply to their decisions is rarely taught in schools or universities. It consists of a combination of a variety of talent, experience and skill and the ability to co-ordinate. In addition, it is normally of the tacit kind: a combination of intuition and explicit awareness. Decisions cannot always be communicated in operational terms to outsiders, or even explained to others than those participating in the decision process (Eliasson, 1976; Pelikan, 1969; Polanyi, 1967).

Table IV:1

LEVELS OF MANAGERIAL COMPETENCE

Nature of knowledge	Level	Tasks to:	Education
1. Strategic knowledge	top executive	engineer structural change	Career, academic
2. Communication	middle management	inform, co-ordinate and enforce	College, special course
3. Operations	workers	produce	Vocational

Some 20 years ago, the "schools" of scientific management were seeking for generalised information, control and guidance systems that would remove the dependence of the firm on a particular group of people. The idea was that, though people would come and go, "the system" would remain and, indeed, itself take critical high-level decisions. Nothing of the kind, of course, has occurred: the disorderly 70s of the world economy have rather reinforced the old, person-dependent management style. A new management in a troubled firm as a rule removes the remains of the old management and introduces its own system. The system informs and co-ordinates the people. It is differently designed in different companies. For all practical purposes it cannot be explained in operational terms to outsiders. It is too complex. It operates as a special language for that particular firm. To learn the system, one has to participate (work) in it.

An important function of the new management system is to teach newcomers who will make their career in it. This educational function is an extremely important part of Western advanced, industrial technology. No business school can take on the task because much of the knowledge, and all the critical knowledge, is tacit. The ambition of all firms is, of course, to develop such a management system that keeps repeating success. More precision in presenting the human competence vested in it is currently beyond our reach; we can, however, conclude that the value of "downstream" human and hardware capital depends on skills demonstrated at this level.

b) Middle Management

The co-ordinators of existing complex management processes in large companies are a relatively large group of people below top executive level charged with changing existing process structures. Middle management forms the largest part of this group. Its task is to communicate targets down the organisation, monitor their realisation, and respond by communicating deviant behaviour and suggestions upwards.

c) Skilled Workers

The further down the scale, the more locally well defined the tasks, and the more specific the skills applied -- hence the easier they can be communicated. Variety diminishes in importance, repetitiveness and ability to perform a few tasks efficiently come into the foreground.

However, even at very local workstations in the factories, what might be termed "operational blueprints" or explicit instructions for work processes scarcely, if ever, exist. A typical workshop in engineering industries consists of a group of skilled and specialised workers organised in a product flow system. All important knowledge of how to do things resides in individual workers. There is no central production head or foreman who possesses it all. It is both special and difficult to communicate except through learning-by-doing.

In fact, this difficulty in communicating specialised skills appears to be the major obstacle to process automation, especially in engineering industries (Eliasson, 1980a). The reason is that no one, even at local levels, has a central process knowledge of what goes on and with the detail and precision needed to code the process for automated computer control. And the reason for this is that even specialised manual jobs are very complex and normally -- in advanced industries -- require a significant input of judgement. Nevertheless, at very low and simple levels, an exact computer representation (explicit logical presentation) of the work process can be obtained, and automation may be both feasible and economically motivated.

As one reaches higher levels of complexity, specialised knowledge has to be combined with flexible organisational forms. The explicit logical representation is beyond both economical and practical reach. However, even if each individual at a workstation may possess intuitive control of his/her work, a growing number of high-level people charged with co-ordinating all local tasks will have to rely on the incentive structure and the organisational forms to get the whole of the work accomplished.

d) The Development of Skills and Knowledge

To define the educational process at work at the three levels, a distinction should be made first between the acquisition of manual skills in factory production, on the one hand, and more abstract, theoretical skills on the other for the surrounding software production or non-process activities.

Craft or manual skills were earlier taught on the production site through various forms of apprentice arrangements. Later on, with the emergence of large-scale production sites, "vocational schools" associated and integrated with the firms developed on the initiative of firms themselves. This was the normal organisation of vocational training well into the post-war period. By degrees, however, ambitions to integrate vocational training with the regular public schooling system grew. In Sweden, for instance, a government educational policy was to take over the responsibilities of these firm-related schools. With the growth of labour market policies in the 60s in particular, the authorities began to establish and run retraining programmes that by degrees have become established courses, rather than the flexible programmes originally envisioned to take care of specific labour market demands.

This retraining activity to move people on to new and better jobs was one important element in what has come to be called the (old) Swedish policy model. The recent experience of these activities is that they have become alienated from the production process, that they teach obsolete skills, or practices and that they have taken on social ambitions and considerations that make their pupils less well adapted to the tough labour market life than they would otherwise have been (Björklund, 1985a). It is even the case that Swedish labour market education or retraining is no longer effective on the margin. Here, increased inputs tend to lower output. Rather than increasing such activities on the margin as they are currently organised, they should be reduced (Björklund and Moffitt, 1983).

Table IV:2 illustrates that introductory training programmes for the newly employed vary between industries but they clearly have significant scope.

A particular consequence of the ongoing, technological upgrading of industries is that information and service production, as opposed to actual materials processing, is becoming increasingly important. The work tasks are becoming more and more abstract and remote. New concepts and theoretical schooling are needed to understand not only one's own task but the whole process of which it is a part. This broader understanding is often quite essential for good performance on high-level jobs.

In the old days, skills were passed on directly by older colleagues who had already acquired them. Today, instruction on how to do things is increasingly presented in documentary form, sometimes directly from the computer and often in more than one language. This requires a corresponding education and training in receiving, understanding and applying abstract information.

The nature of jobs is constantly changing, requiring continuous relearning of skills, even for performing the same job function. Doubts are being expressed about how long the labour force can go on coping with this change, either because of lack of talent and basic schooling or because the change in itself is too demanding, socially and mentally.

Toffler (1970) made the pressure of faster environmental change his main argument in Future Shock. There is no clear and simple answer, except that well-educated people seem to be better at changing, relearning and adapting than people without a good general education, and especially people who have stayed long on the same type of job. It is also observed (Magnusson, 1981; Seligman, 1975) that people feel bad about their inability to improve their job situations. This can be due to risk aversion or absence of practice in changing jobs; but it may also be the result of an overregulated labour market, or a tax system that reduces the payoff from moving, thus tying people to their original jobs. We note (Bosworth, 1981; Deiaco, 1985) that for a particular professional task there is considerable substitutability between subjects of background education, but that once a job experience or a job classification has been established, substitutability of job background for a given professional task seems to disappear.

Table IV:2

AVERAGE INTRODUCTORY TRAINING PROGRAMMES FOR THE NEWLY EMPLOYED: SWEDEN, 1984

Sector	Months	
	Blue-Collar Workers	White-Collar Workers
1. <u>Basic industry</u>	3.3	3.9
of which		
- Iron and steel	4.0	4.2
- Pulp	3.1	4.1
2. <u>Intermediate goods</u>	1.6	3.7
of which		
- Chemical	1.3	4.3
- Metal	1.8	5.0
- Paper	1.6	2.1
3. <u>Investment goods</u>	3.2	8.1
of which		
- Machinery	2.4	5.0
- Electrotechnical	4.3	12.7
4. <u>Consumer goods</u>	3.7	2.0
5. <u>Construction materials</u>	1.1	3.5
Total	2.9	4.8

<u>Sources</u>: IUI MOSES database, and Deiaco (1985).

A varied job career requires a constant relearning of skills: this is part of the human capital or experience that people who have reached the higher professional levels often possess. It is interesting to note Holmlund's suggestion (1984) that the decreased mobility in the Swedish labour market, observed as less labour turnover between firms, may be due to an increased turnover of labour on job types and locations within the larger business organisations One of the reasons quoted is the improved career and on-the-job learning opportunities presented by "internal job markets". One should also remember that individual adjustment forced by environmental change is nothing new. It is not even clear that change in work environment is faster now than it was 20 years ago.

If structural change associated with economic progress means that new jobs are opened up in service-oriented and more educationally demanding industries, while jobs are disappearing in industries dominated by low-skilled, manual labour, we can conclude that the new entrants in the labour market should be as well prepared educationally as they can be. The adjustment burden will fall on the unfortunate few who are laid off from low-skill industries. They will have to retool from a routine repetitive job based on rote training, to an intellectually more demanding work environment that requires abstract thinking. Evidence suggests that such human retooling is difficult or impossible. As a consequence, rather than retraining labour, firms in distress and in need of fundamental reorganisation opt for replacing both management and work force. The case for reorganising businesses from within, to avoid forcing people to move, does not appear to be strong.

It is easy to forget that a major part of most work activities, and a part that has increased over time and that increases with the qualification level of the job, consists of communication between humans. This is the essence of an information society, even though the hardware side of communication called IT (for information technology) tends to attract most attention. In retrospect, man-machine interaction will probably be regarded as more typical of the worker environment of the past than it will be of future industries.

Communication has both an efficiency side, a human side and an educational side. It is important to "talk the same language"; it is important to organise and use information efficiently and it is important that humans understand each other without too much explanation, and communicate what they know with ease. The latter, and the combination of the three critical, strategic, communicative and operations functions of Figure III:2, is largely a matter of adequate organisation of people and of practice. It is extremely difficult to teach human interaction in the abstract, theoretical setting of a classroom with teacher and pupils. Whatever abilities and experience there were to begin with, a human being who has spent a long time on an isolated job, easily loses the competence he may once have had to communicate socially with a variety of his fellows. People who are not at ease in communicating with new acquaintances or in settling down in new job locations obviously will find change of job extremely demanding, even though they are capable of learning to perform the new tasks with ease.

We must recall here that the modern industrial firm has expanded dramatically during the last decades in activities that are almost purely concerned with human communication, with taking initiatives, with making judgemental decisions and with risking making personal mistakes.

Marketing is the most typical such activity. Research and development work is of the same kind although the nature of communication is different. People from different knowledge backgrounds using different specialised languages have to combine efforts. It is interesting to note that this works reasonably well under market pressure in large firms, while academic institutions have not succeeded at all.

For instance, modern, generalised electronics-based business information systems, currently being "attempted" by several large electronics firms, require that at least 12 "disciplines" represented and departmentalised at Technical Universities have to be merged.

Further breakdown and specification of production thus require more communication between humans (co-ordination, targeting, control) compared to longer work sequences of individuals in craft jobs. (Perhaps the problems associated with repetitive routine tasks on the production line do not really stem from a lack of variation in the performance of menial tasks, but rather from a lack of job-related human instruction.)

It is a common observation that state schools have practically no tradition in teaching social communication, or how to take initiatives and risks -- United States schools have some of this on the teaching agenda, but European schools practically nothing. Rather is there discussion about public schools and colleges destroying creativity, making students shy away from initiatives and risks and fostering passivity (see e.g. Illich _et al._, 1971). As a consequence, new competing educational institutions are being established within the business community to provide an educational product that the public schooling system has been unable or unwilling to supply.

4. The Firm as a Welfare Institution

The limits of a firm as a financial organisation are set where administrative efficiency on the margin falls below the alternative returns offered in the market. Hence, changing market conditions and administrative techniques force institutional reorganisation.

a) The Economic Rationale for Institutional Separation

An aspect of the internal team solution of a business organisation is that efforts and compensation cannot always be related one-to-one. This is as typical of the joint action of six men lifting a heavy burden as it is of large-scale factory work. The bureaucratic or administrative solutions of teams always mean interior redistributions of efforts and income. If the team cannot be reorganised continuously to fit particular jobs, some people will always benefit from the work of others. This is a well-known labour market experience, and it is interesting to speculate on how such interior, unintended redistributional arrangements within business organisations compare in importance with the welfare programmes of the public sector. Even though we cannot yet quantify, the implication is that the unintended income redistributions of large organisations contribute much more to the _ex post_ equalisation of incomes than the total of public welfare programmes. The effects of the former, by its very nature of being unintended, cannot be evaded. A corollary of this is that the market-induced institutional fragmentation made possible by technical and organisational change observed in the previous chapter will have far-reaching consequences on the final distribution of income.

Some efficiently managed large firms make deliberate and often successful efforts to squeeze "parasites" out of their operations (Eliasson, 1976). The "construction worker team" that negotiates a piece-work settlement with the construction company is a good example of an efficient team solution. Shirking is minimised within such teams because team members have usually been self-selected to be of equal quality, and supervise one another. Structural readjustments after major crisis periods often force reorganisation of firms (or teams) to achieve improved cost efficiency throug' forcing out overpaid, low performers.

b) Taxes and Economies Stimulate Self-Employment

The ongoing technical change in advanced countries, away from an industrial structure based on cost-efficient production toward a product-based industrial technology dominated at both ends by sophisticated, often small-scale, service production, is posing a growing market threat to elaborate internal (but unintended) redistributional arrangements associated with large-scale faccory production. There are three reasons for this development. Two are new, the tnird -- large tax wedges that separate disposable income from factor compensation -- has been at work all the time in high-tax welfare states.

First, the growing importance of specialised service inputs in final output of modern industries is making institutional separation easy. Second, the modern firm is, to a growing extent, becoming dependent on easy availability of a wide range of such specialised service inputs at different points in time to achieve overall profitability. The value of these specialised inputs when needed is high -- often five, ten or even more times what the firm can pay an employee doing the same service job. The economic rationale for separation of specialised service activities into small, high-performing teams is compelling. Forming small consultant firms becoming self-employed, furthermore, makes it possible both to distribute and define one's income over one's life cycle in accordance with one's own preferences. Hence, taxes place a leverage on the economic incentives for institutional separation already at work.

c) Blue-Collar, Non-Skilled Workers are Placed under Market Pressure

Human capital-intensive service production linked to manufacturing goods production is typical of the emerging, profitable firms. The mirror image of this is that the manufacturing of simple products with a minimum of human capital inputs is coming under growing pressure from more efficient competitors abroad, with competing alternative organisational arrangements that compensate workers more in line with their work contributions. It is only natural that many of tnese competitors are in the newly-industrialised countries, since their comparative advantages are in the manufacturing of not-so-human capital-intensive products.

The impact of the relative change in cost efficiency of factory production associated with foreign competition and technology is reinforced in some countries, not only by progressive tax legislation, but also cumbersome labour market legislation and union practices. For all these reasons large-scale factory production which employs the bulk of the unskilled and semi-trained blue-collar labour force is diminishing in economic importance as the competitive engine behind industrial growth in Western economies. Protected and not sufficiently skilled people are laid off in contracting industries and new hiri_ of untrained people are slow. The labour market is rather looking for, and handsomely paying for, well-educated technical staff suited for the educationally more demanding work environment of the future.

d) Modern Information Technologies Will Also Affect Routine Middle Management

A similar problem is also emerging at the middle management level because of the combined effect of a growing bureaucratisation of large business organisations and rapid advances in information technology in business information systems (Eliasson, 1984d). A large middle management cadre is typical of large business organisations. Their main task is to relay information (communicate) upwards and downwards in the organisation. Top-down communication mainly consists in imposing business targets. Bottom-up communication mainly consists in modifying targets to become reasonable and to control and enforce targets. Top-down transparency to allow top executive people to see through their organisation is the ambition of all information systems Communication through human beings is always subject to distortions. Modern computer and electronics-based information techniques that have developed rapidly in recent years are improving the potential for less biased information and commmunication systems within firms. The new, electronics-based database, communication and presentation systems largely bypass routine management personnel with a significantly reduced middle management involvement as a consequence.

One often hears about the need for a thinner management structure, or fewer hierarchical levels between those who do the job and those who run the organisation The organisation of communication links between the top and the bottom constitutes the technolog_ to operate large business organisations. At some size, in every organisation, diminishing returns for larger size sets in. There are three ways to deal with this. One is to introduce market principles into the business bureaucracy and reorganise the firm into divisions or subsidiaries, a reorganisation that allows delegation of authority. Another way is to use the market to 100 per cent and allow separation of certain activities that are easy to manage. The third way is to use more efficient informatior technologies that allow a thinner bureaucracy for a given size of the organisation. All three approaches are being used. They all affect routine middle management in a fashion s milar to local labour consequences from process automation.

5. Conclusions about Policy -- Education Through a Varied Job Career or at School?

A number of fairly distinct policy conclusions can be drawn from this overview of the applications of human capital to the industrial process.

First, the key to macroeconomic, firm economic as well as individual (economic) success is the right skill and human capital endowment. These endowments are distributed unevenly among nations and individuals, but they can be improved by investments in education. A significantly improved knowledge of the nature of these endowments is necessary for success of any form of deliberate policy action to improve the education system of an economy. Among the few concrete results of the inventory of what we know about education presented here, the most important one is that the economically important educational experience comes after school and is intimately tied to a varied job career.

Second, attempts at major reorganisations and reforms of the public schooling system on the basis of what we currently know about job requirements is not likely to do much good. Reforms, to result in improvements, should be incremental and gradually improve on the existing design. Under such circumstances the efficient way of improving the public schooling system is to stimulate local experimentation and to learn from the experience of local initiatives. To make the public educational system more experimental means making it more similar to the commercial activities of business firms. A business firm has to reorganise itself radically all the time to meet competition, without sufficient knowledge about how to do it. Firms try, and frequently fail. Large centralised systems, on the other hand, like the political system or the education system of a nation, should never be exposed to risks of fundamental failure and hence should remain conservative at central levels. However, if one is willing to accept a wide variety of educational outcomes at local levels, and a useful learning experience about how to improve upon the education system's design, local experimentation should be encouraged. This means giving up on some of the egalitarian ambitions associated with public education. As in any case, public education is not adequately attending to its other task of providing useful human capital for the production system, there seems no alternative to such restriction of ambitions unless it be reduced into insignificance by competition from outside the domain of public schooling. Then, of course, the egalitarian objective will still have failed. Hence, in effect there is no choice.

Third, the problems associated with forced structural adjustment on the private part of the economy become manifest in the form of business failures and new business opportunities as well as individual failures and new individual opportunities. There appears to be no need to care for business failures. The human, individual failures constitute the only policy problem. This is where labour market policies enter. A successful labour market experience means a continuous educational investment process in the form of a varied career, exposure to trouble and experience in solving human, technical and commercial problems.

New entrants in the labour market are, in principle, better equipped and prepared for the new jobs than people who have been in the market on the same job for a long time. A priority task of labour market policies must be to encourage people to get a varied labour market experience. If we look at those who have actually been pursuing a career, the group is relatively small, although growing. If we look at those who would have potentially benefited from attempting to pursue a career, the group may be very large. Whatever factors at work are holding back people from learning through a varied career, we can safely conclude that the labour market performs a much too important educational function to allow itself to be regulated by any vested interest group.

Fourth, those who carry the costs of adjustments in the labour market will not, as a rule, be the same as those who benefit. With a current upgrading of skills and educational requirements attached to new job opportunities in growth industries, failures will most frequently hit people who have not attended to the updating of their human capital, and who happen to have been working on the same repetitive job for a long time in a firm that is also subject to failure. "Intellectual retooling" appears to be the main labour market problem in a growth economy. If attitudes are biased in favour of accommodation to changes in job market requirements, adjustment problems will be natural, and smaller than if external change is opposed. To build attitudes favourable to change ought to be a priority task of the public schooling system if national objectives are to achieve fast macroeconomic growth. This is, however, seldom part of public school policies, and most schools are badly prepared for such tasks: recruitment practices for teachers tend to create the wrong type of teachers -- people who have rarely ventured outside the public educational system to obtain, for instance, a varied work experience.

It is fortunate that on-the-job schooling can compensate for some of the deficiencies developed at school. It is fortunate, too, that some modern firms have learned that offering a multitude of internal career and educational programmes is in their own interest. But this reorganisation of comprehensive education will be unegalitarian in final outcomes. Those who take initiatives and those who realise that lifelong, useful education consists in selection and investment, (not only investment) will succeed. It would be far more efficient from a welfare point of view if the public schooling system also organised itself accordingly.

Viewing the labour market process as part of the educational system implies a distinct change of policy. The old model of Swedish labour market policy had the express ambition to retool people for new jobs and new locations through retraining programmes. It was, however, based on a misconception by industries that consisted of factories with skilled blue-collar workers. Labour demand under this policy hypothesis shifted from one skill to another and the policy prescription was, first, to predict the demanded future skill composition and, second, to arrange training and retraining programmes in manual skills accordingly. Such manpower training programmes gradually became less efficient through the 60s and the 70s. Nobody in central planning positions predicted the emerging new industrial structures of the late 70s, the emergence of the modern manufacturing firm and -- in particular -- the nature of the so-called electronics revolution.

The advanced industrial firm is to a diminishing extent based on manual skills. Growing firms want people capable of abstract thinking and used to an environment with little manual work and few similarities with "the factory". The ability to make judgmental decisions and take initiatives commands a premium. Under such circumstances, a long and singular work experience becomes a negative factor both for labour market performance and for the ability to take on new jobs. The continuous, work-related educational experience associated with a varied job career becomes a critical positive factor for labour market success. Also for the firms it becomes important to have people continually on "the career move". It is the only way to get really competent labour. It is also the only way to observe and select the right people for high-level jobs. In fact, the further up the scale one gets in a modern firm, the more of an integrated part of production learning and competence enhancement are seen to become. The advanced industrial firm, and the large firm in particular, offers an increasingly larger relative share of such career jobs. There are many ways of organising work at all levels so that accumulation of career experience is facilitated. A key notion in all these arrangements is that education is integrated with work, and not imparted separately in alienated schools.

This listing of results allows three summary conclusions as regards the labour market problem facing the old industrial nations. First, some personal failures in the adjustment process are unavoidable. A labour market failure is normally defined in terms of failure to achieve previous, or higher job performance and compensation. This is natural, since changing job tasks always means switching human capital inputs, the old inputs losing in value. If the new job pays better, it means that you had earlier been under-using your human resources -- or, in short, holding the wrong job. On the other hand, the world is replete with job opportunities for those who take initiatives and those who accept a down-grading of work compensation. There is no way of getting around the conclusion that rigid work compensation rules cause unemployment. The current policy solutions tend to be bureaucratic and personally humiliating. An insurance arrangement that offers a whole spectrum of intermediate solutions between a full-time job and "phase out" should be feasible -- for instance, an insurance system that fills in the difference (or a significant part of the difference) in pay to an extent that increases with the length of the job career. Private professional insurance schemes already offer similar arrangements in a number of Western countries.

<u>Secondly</u>, however, the majority of people who change jobs do so on their own initiative and, as a rule, experience an improvement in their situation (Holmlund, 1984).

<u>Thirdly</u>, and finally, the ability to take initiatives in the labour market and to retool professionally hinge on education in a broad sense, while industrial policies enacted in the OECD world have been oriented toward avoiding the need for individual adaptation (Eliasson, 1984c) by conserving existing structures and worsening the long-term competitive situation of industries.

On this score, this essay points very strongly in one direction. If <u>industrial policies</u> are at all needed, they should consist of <u>improved labour market policies</u>, and <u>better educational policies</u>. However, no body or institution has the knowledge to prescribe <u>how</u> to improve policies apart from being aware that <u>experimentation and initiatives</u> at local and individual levels will help improve both labour market and educational performance. Improved policies are therefore synonymous with bringing competition into the labour market and the public educational system. And the main form of competition currently lacking in most countries is not job market competition between individuals (already intense at all levels) but innovative entry of new ideas, solutions and initiatives related to the institutional organisation and the administration of the public schooling system and the network of rules that make much of the labour market in the industrial world, in fact, an administered system. Competition is normally prohibited to protect monopolised educational and labour market institutions, except when education and the labour market are internalised in firms.

BIBLIOGRAPHY FOR PART I

Åberg, Y. (1984), Produktivitetsutvecklingen i industrin i olika OECD-länder, 1953-1980, IUI Research Report No. 25, Stockholm.

Ahlström, G. (1982), Engineers and Industrial Growth, London.

Åkerman, J. (1950), "Institutionalism" in Ekonomisk Tidskrift.

Albrecht, J.W., Holmlund, B. and Lang, H. (1985), "Job Search and the Transition to Employment: Theory and Evidence" IUI Working Paper No. 172.

Alchian, A.A. and Demsetz, H. (1972), "Production, Information Costs and Economic Organisation", AER.

Arrow, K.J. (1962), "The Economic Implications of Learning by Doing", in The Review of Economic Studies (June).

Arrow, K.J. (1973a), "Higher Education as a Filter", JPE 2, pp. 193-216.

Arrow, K.J. (1973b) Information and Economic Behavior, Federation of Swedish Industries, Stockholm.

Arrow, K.J. (1974), The Limits of Organization, New York.

Arrow, K.J. (1975) "Vertical Integration and Communication", The Bell Journal of Economics (Spring).

Ashton, T.S. (1948), The Industrial Revolution, 1760-1830, London.

Becker, G. (1962) "Investment in Human Capital; A Theoretical Analysis", in JPE, Supplement (Oct.).

Becker, G. (1964) Human Capital, New York.

Bergh, T., Hanisch, T.J., Lange, E. and Pharo, H.G. (1981) Growth and Development -- The Norwegian Experience 1830-1980, Flekkefjord.

Björklund, A. (1985a), "Policies for Labor Market Adjustments in Sweden", IUI Working Paper No. 163, published in Gary Hufbauer and Howard Rosen (Eds.) Domestic Adjustment and International Trade (Washington, Institute for International Economics, 1986).

Björklund, A. (1985b). Chapter IV in Att rätt värdera 90-talet, IUI långtidsbedöming 1985, IUI Stockholm.

Björklund, A. and Moffitt (1983), "Estimation of Wage Gains and Welfare Gains for Self-Selection Models", IUI Working Paper No. 105, Stockholm, published in The Review of Economics and Statistics, Vol. LXIX, February 1987, pp. 42-49.

Boserup, E. (1965) The Conditions of Agricultural Growth, Chicago.

Boserup, E. (1981), Population and Technology, Basil Blackwell, Oxford.

Bosworth, D.L. (1981), "The Demand for Qualified Scientists and Engineers", Applied Economics.

Braudel, F. (1981), The Structures of Everyday Life. Civilization and Capitalism: 15th-18th Century, London and New York.

Brooks, H. (1984), "Technology, Competition and Employment", Economic Impact, No. 48, 1984/4.

Burtless, G. (1984) "Are Targeted Wage Subsidies Harmful? -- Evidence from a Wage Voucher Experiment", The Brookings Institution, Washington, D.C.

Campbell, J. (1982), Grammatical Man -- Information, Language and Life, New York.

Carlsson, B. (1980), "The Content of Productivity Growth in Swedish Manufacturing" in The Firm in the Market Economy -- IUI 40 Years 1939-79, Stockholm.

Carlsson, B. (1983), "Industrial Subsidies in Sweden; Macro-Economic Effects and an International Comparison", The Journal of Industrial Economics, Vol. XXXII (Sept.).

Chen, E.K.Y. (1979), Hyper-Growth in Asian Economies -- A Comparative Study of Hong Kong, Japan, Korea, Singapore and Taiwan, New York.

Clower, R. and Friedman, D. (1985), "Trade Specialists and Money in an Ongoing Exchange Economy", IUI Working Paper No. 141, Stockholm, published in Day and Eliasson (1986).

Coase, R.H. (1937), "The Nature of the Firm", Economica.

Cohen, M.N. (1977), The Food Crisis in Prehistory, New Haven.

Crockett, G. and Elias, P. (1984), "British Managers: A Study of Their Education, Training, Mobility and Earnings", British Journal of Industrial Relations (March).

Dahmén, E. (1950), Svensk industriell företagarverksamhet, (2 band), IUI, Stockholm.

Dahmén, E. and Eliasson, G. (Eds.) (1981), Industriell utveckling i Sverige, IUI, Stockholm.

Dahmén, E. and Eliasson, G. (1981), "Företagen i det ekonomiska skeendet", in Dahmén and Eliasson (Eds.)(1981).

Day, R. and Eliasson, G. (Eds.) (1986), The Dynamics of Market Economies, IUI/North-Holland, Amsterdam, Stockholm, New York, Oxford.

Deiaco, E. (1985), "Investering i tekniker och den långsiktiga kompetensuppbyggnaden", Chapter III in Att rätt värdera 90-talet, IUI Långtidsbedömning 1985, IUI, Stockholm.

Denison, E.F. (1962), The Sources of Economic Growth in the United States and the Alternatives Before Us, New York.

Denison, E.F. (1979), Accounting for Slower Economic Growth -- The United States in the 70s, the Brookings Institution, Washington, D.C.

Eisenstein, E.L. (1979), The Printing Press as an Agent of Change, Vols. I and II, Cambridge University Press.

Eliasson, G. (1976), Business Economic Planning -- Theory, Practice and Comparison, John Wiley & Son, London, New York.

Eliasson, G. (1979), Technical Change, Employment and Growth -- Experiments on a Micro-to-Macro Model of the Swedish Economy, IUI Research Report No. 7, Stockholm.

Eliasson, G. (1980a), "Elektronik, teknisk förändring och utveckling" (Electronics, Technical Change and Economic Development), in Datateknik, ekonomisk tillväxt och sysselsättning (DEK), IUI Booklet No. 110, Stockholm.

Eliasson, G. (1980b), "Företag, marknader och ekonomisk utveckling -- en teori och några exemplifieringar", in Industriell utveckling i Sverige -- teori och verklighet under ett sekel, IUI, Stockholm.

Eliasson, G. (1980c), "The Firm in the Market Economy -- 40 Years of Research at IUI", in The Firms in the Market Economy, IUI 40 Years 1939-1970, Stockholm.

Eliasson, G. (1980d), Electronics, Technical Change and Total Economic Performance, IUI Research Report No. 9, Stockholm.

Eliasson, G. (1981), "Electronics, Economic Growth and Employment -- Revolution or Evolution" in Giersch (Ed.), Emerging Technologies -- Consequences for Economic Growth, Structural Change and Employment, Tübingen.

Eliasson, G. (1983), "Norway in a Scandinavian Perspective -- What would have happened without oil?", in Oil and Industry -- Are They Compatible?, The Bergen Conference on Oil and Electronics, Bergen; also IUI Booklet No. 153, Stockholm.

Eliasson, G. (1984a), De utlandsetablerade företagen och den svenska ekonomin, IUI Research Report No. 26, Stockholm.

Eliasson, G. (1984b), "Micro Heterogeneity of Firms and the Stability of Industrial Growth", JEBO, Vol. 5, No. 3.

Eliasson, G. (1984c), "The Micro-Foundations of Industrial Policies", in A. Jacquemin (Ed.), European Industry: Public Policy and Corporate Strategy, IUI Booklet No. 173, Stockholm.

Eliasson, G. (1984d), "Information och styrsystem i stora företag", in Eliasson, Fries, Jagrén and Oxelheim, 1984.

Eliasson, G. (1985a), The Firm and Financial Markets in the Swedish Micro-to-Macro Model, Stockholm.

Eliasson, G. (1985b), Dynamic Micro-Macro Market Coordination and Technical Change, IUI Working Paper No. 139, Stockholm.

Eliasson, G. (1985c), The Stability of Economic Organizational Forms and the Importance of Human Capital, IUI Working Paper No. 143, Stockholm.

Eliasson, G. (1985d), Theory Construction and Economic Measurement at Different Levels of Aggregation -- Parallel Theories and Data on Families and Firms, paper presented to the Conference on Dynamic Behavioural Analysis Using Panel Data, 1st-2nd June, 1984, Berlin, IUI Working Paper No. 152.

Eliasson, G., Holmlund, B. and Stafford, F. (Eds.) (1981), Studies in Labor Market Behavior: Sweden and the United States, IUI Conference Volume 1981:2, Stockholm.

Eliasson, G. and Lindberg, T. (1981), "Allocation and Growth Effects of Corporate Income Taxes -- Some Experiments in Quantification on a Micro-to-Macro Model of the Swedish Economy", in Business Taxation, Finance and Firm Behavior, IUI Conference Reports 1981:1, Stockholm.

Eliasson, G., Fries, H., Jagrén, L. and Oxelheim, L. (1984), Hur styrs storföretag?, IUI/Liber.

Eliasson, G., Bergholm, F., Horwitc, E.C. and Jagrén, L. (1984), De svenska storföretagen -- en studie av internationaliseringens konsekvenser för den svenska ekonomin, IUI Stockholm.

Eurich, N.P. (1985), Corporate Classrooms, The Carnegie Foundation for the Advancement of Teaching, Princeton, New Jersey.

Gerschenkron, A. (1966), Economic Backwardness in Historical Perspective, Harvard University Press, Cambridge, Massachusetts.

Gintis, H. (1971), "Education, Technology, and the Characteristics of Worker Productivity", AER (May).

Griliches, Z. and Jorgensen, D. (1967), "The Explanation of Productivity Change", Review of Economic Studies, Vol. XXXIV (3), No. 99.

Heckscher, E.F. (1935), Sveriges ekonomiska historia, Stockholm.

Heckscher, E.F. (1941), Svensk arbete och liv -- från medeltiden till nutiden, Stockholm.

Heckscher, E.F. (1953), Industrialismen -- den ekonomiska utvecklingen sedan 1750, Stockholm (translated into English as: Industrialism -- Economic Development Since 1750).

Hicks, J. (1977), A Theory of Economic History, London.

Hirschleifer, J. (1971), "The Private and Social Value of Information and the Reward to Incentive Activity", AER, 61, 561-574.

Holmlund, B. (1984), The Mobility of Labor -- Studies in Labor Turnover and Migration in the Swedish Labor Market, IUI, Stockholm.

Holmqvist, N. (1980), Vikingar på Helgö och Birka, Värnamo.

Hutton, S. and Lawrence, P. (1981), German Engineers -- the Anatomy of a Profession, Oxford.

Illich, et al. (1971), After Deschooling, What?, Perennial Library, New York, Evanston, San Francisco, London.

Jencks, Chr. (1972), Inequality -- A Reassessment of the Effects of Family and Schooling in America, Basic Books, New York and London.

King, M.A. and Fullerton, P. (Eds.) (1984), The Taxation of Income from Capital, IUI, NBER, Ifo, Chicago and London.

Klevmarken, N.A. (1983), Lönebildning och lönestruktur -- en jämförelse mellan Sverige och USA, (Determination and Structure of Salaries -- A Comparison between Sweden and the United States), IUI, Stockholm.

Kutznets, S. (1971), Economic Growth of Nations, Cambridge and London.

Landes, D.S. (1969), The Unbound Prometheus, Cambridge, England.

Lange, O. (1936-37), "On the Economic Theory of Socialism", Review of Economic Studies.

Lindberg, T. and Pousette, T. (1985), Service in Production and Production of Services in Swedish Manufacturing, IUI Working Paper No. 148, Stockholm.

Maddison, A. (1962), "Growth and Fluctuations in the World Economy 1870-1960", Banco Nationale del Lavoro, Quarterly Review No. 61 (June).

Maddison, A. (1971), "Phases of Capitalist Development", Banco Nationale del Lavoro, Quarterly Review No. 121 (June).

Magnusson, L. (1981), "Learned Helplessness -- Welfare for Good or Bad", The Scandinavian Bank Quarterly Review.

Miller, G.A. (1967), The Psychology of Communication, New York, London.

Moonen, J.C.M.M. and Wuite-Harmsun, H.E. (1984), Computers and Education: Policy Problems and Experiences, North-Holland.

Murnane, R.J. and Nelson, R.R. (1984), "Production and Innovation when Techniques are Tacit: The Case of Education", JEBO, Vol. 5, Nos. 3-4 (Sept., Dec.).

Nichols, P.A. (1980), "Is There an Efficient Level of Unemployment? Simulation Experiments on a Labor Market Model", in Bergman, Eliasson and Orcutt (Eds.), Micro Simulation -- Models, Methods and Applications, IUI Conference Reports 1980:1, Stockholm.

Ohlsson, L. (1979), "Att utmönstra industrier med goda framtidsutsikter", supplement to Vägar till ökad välfärd, DxJu 1979:2.

Ohlsson, L. (1980), Engineering Trade Specialization of Sweden and Other Industrial Countries, IUI and North-Holland.

Okun, A.M. (1981), Prices and Quantities: A Macroeconomic Analysis, The Brookings Institution, Washington, D.C.

Olson, M. (1982), The Rise and Decline of Nations, New York and London.

Parker, W.N. (1984), Europe, America and the Wider World -- Essays on the Economic History of Western Capitalism, Cambridge University Press.

Pavitt, K. and Soete, L. (1981), International Differences in Economic Growth and the International Location of Innovations, Science Policy Researchers Unit, University of Sussex (mimeo).

Pelikan, P. (1969), "Language as a Limiting Factor for Centralization", AER, 59:625-631.

Pelikan, P. (1985), Private Enterprise vs. Government Control: An Organizationally Dynamic Comparison, IUI Working Paper No. 137, Stockholm.

Peters, Th.J. and Waterman, R.H. (1982), In Search of Excellence: Lessons from America's Best Run Companies, New York.

Petersson, C. (1983), Ingenjörsutbildning och kapitalbildning 1933-1973, Lund.

Polanyi, M. (1967), The Tacit Dimension, Double Day Anchor, Garden City, New York.

Prais, S.J. (1981), Productivity and Industrial Structure, Cambridge University Press, Cambridge.

Riley, J.G. (1976), "Information, Screening and Human Capital", AER, Vol. 66, No. 2.

Rostow, W.W. (1980), Why the Poor Get Richer and the Rich Slow Down, Austin, Texas.

Ryan, P. (1984), "Job Training, Employment Practices, and the Large Enterprise: The Case of Costly Transferable Skills", in Osterman (Ed.), Internal Labor Markets, the MIT Press, Cambridge, Massachusetts, and London, England.

Samuelsson, H.F. (1977), Utländska direkta investeringar i Sverige, IUI Stockholm.

de Santillana (1958), The Crime of Galileo, English Ed., London, Wm. Heinemann.

Satinger, M. (1984), "Factor Pricing in the Assignment Problem", Scandinavian Journal of Economics, Vol. 86 (1).

Schager, N.H. (1985a), "Varför har vi ännu inte sett någon löneexplosion?", a special study in Att rätt värdera 90-talet -- IUIs långtidsbedömning 1985, Stockholm.

Schager, N.H. (1985b), "The Replacement of the UV-Curve with a New Measure of Labour Market Efficiency", IUI Working Paper No. 149, Stockholm.

Schultz, Th.V. (1979), "The Ability to Deal with Disequilibria", Journal of Economic Literature.

Schumpeter, J. (1912), Theorie der Wirtschaftlichen Entwicklungen, published in English, 1934, as Theory of Economic Development, Harvard University Press, Cambridge, Massachusetts.

Schumpeter, J. (1943), Capitalism, Socialism and Democracy, London.

Seligman, M.E.P. (1975), Helplessness -- On Depression, Development and Death, San Francisco.

Singh, A. (1977), "UK Industry and the World Economy -- A Case of De-Industrialization", Cambridge Journal of Economics, (1, pp. 113-136).

Sohlman, Å. (1982), Utbildning och arbetsmarknad, Studentliteratur.

Solow, R.M. (1957), "Technical Change and the Aggregate Production Function", The Review of Economics and Statistics (Nov.).

Spence, A.M. (1972), Market Signalling, Doctoral dissertation, Department of Economics, Harvard University.

Ståhl, I. (1974), U74 -- en samhällsekonomisk analys av den högre utbildningen, Stockholm (SNS).

Swedenborg, B. (1979), The Multinational Operations of Swedish Firms, IUI Stockholm.

Taylor (1929), "The Guidance of Production in a Socialist State", AER (March).

Thompson, E.P. (1963), The Making of the English Working Class (Page references to the 1982 Penguin edition).

Toffler, A. (1970), Future Shock, Bodley Head, Ltd., London.

Varian, H.R. (1980), "Redistributive Taxation as Social Insurance", JPE, Vol. 14, No. 1 (August).

Veblen, T. (1921), The Engineer and the Price System.

Vogel, E.E. (1979), Japan as Number One -- Lessons for America, Cambridge, Mass.

von Hayek, F.A. (1940), "Socialist Calculation", Economica.

von Hayek, F.A. (1945), "The Use of Knowledge in Society", AER.

von Weizsäcker, Ch. (1984), "Rights and Relations in Modern Economic Theory", JEBO (June).

Wax, R. and Wax, M. (1955), "The Vikings and the Rise of Sociology", The American Journal of Sociology (July).

Weber (1921), The Theory of Social and Economic Organization (1947, translated from Wirtschaft and Gesellschaft, Vols. I and II, 1920-21).

Weiss, J.H. (1982), The Making of Technological Man -- the Social Origins of French Engineering Education, the MIT Press, Cambridge, Mass.

Westerman, J. (1768), Om svenska näringarnes undervigt gentemot de utländske förmedelst en trögare arbetsdrift, Stockholm.

Wiener, J.M. (1981), English Culture and the Decline of the Industrial Spirit 1850-1980, Cambridge University Press, Cambridge, England.

Williamson, O. (1975), Markets and Hierarchies: Analysis and Anti-Trust Implications, London.

Woodbury, R.S. (1972), Studies in the History of Machine Tools, the MIT Press, Cambridge, Mass.

Ysander, B.C. (1978), "Homogeneity in Education -- a Comment on the Economic Theories of Education", in Bowman, Sohlman and Ysander (Eds.), Earning and Learning, Stockholm.

Part II

NEW TECHNOLOGY AND HUMAN RESOURCES

by Paul Ryan

Chapter V

THE WORKPLACE: CONTENT OF JOBS AND EFFECTS UPON SKILLS

A central concern about the effects of new technology involves its effects upon the skills and knowledge required for production. Many commentators hold that the effect of information technology (IT) will be a revolution in the nature of work, although there is radical disagreement within their ranks about the desirability of its effects. At one pole, IT is welcomed for the prospect of the redemption of work from a record of drudgery and degradation -- the "re-enchantment of the workplace" in the words of Howard (1981); at the other, it is feared for the prospect of the intensification of the same drudgery and degradation. The weakness of such expectations of powerful technological effects upon the content of work is underlined by both their inconsistency and their lack of historical originality. Much the same conflicting expectations were expressed during the first industrial revolution. More recently, "the same polarities of apocalyptic vision and manic enthusiasm have emerged as in the early fifties" (Winch, 1983, p. 3). We argue instead that a variety of considerations, both theoretical and empirical, suggest that neither extreme of prediction of the effects of IT is justified. At the same time, the nature of work and skill will continue to change considerably, at least partly under the influence of technology, just as it has since long before the industrial revolution. Our task is therefore to avoid the apocalyptic mode of interpretation in favour of an evolutionary analysis of the content of the knowledge and skills required for production.

1. The Interpretation of Skill

If we are to discuss the effects of IT upon skill, we need an understanding of the meaning of "skill". Economic theory takes skill to be unidimensional, comprising all developmental human qualities which are of use in production and which take time and scarce resources to develop. It includes therefore general knowledge, manual dexterity, technical understanding, etc. -- and not just the combination of manual dexterity and practical knowledge of the manual crafts to which the use of the term is usually restricted in non-economic discussions. The processes by which skill is developed range from general education, through vocational education and training, to simple work experience (Becker, 1964).

From this standpoint the degree of skill of a worker is usually measured by the resource costs of the "human capital" embodied in him or her.

Such a measure is however conceptually inadequate for many purposes. Some skills may be very expensive but still be of negligible economic value in that they are of little or no use in the production of marketable output (e.g. carriage building). Indeed a major effect of technical change is to create such disequilibria by making existing skills obsolete. Consequently we need to look also, and indeed even first, to the skill requirements of jobs. In cases of mismatch with the supply side, it is generally the lower skill requirements of the job that determine the amount of skill applied to production and the amount society must pay for it (Rumberger, 1983). The possibility of structural mismatches between the supply of skills and the demand for them has been argued vigorously in recent times, notably in the shape of an oversupply of general education (Berg, 1970; Spence, 1973; Freeman, 1976). In this analysis we will respond to such difficulties by focusing principally on the demand side, i.e. the demand for skills in economic activity; and, within that, upon the technical requirements for skill in production. In this sense, therefore, we can in theory adopt a unidimensional approach, seeking to establish the implications of IT for skill in production, where skill levels are measured by the resource costs of developing the skills required for the job.

This approach is subject to some serious limitations. There is first of all the limited value of the concept of a job's requirement for skill. In many jobs, the possession of more skill by a worker will mean higher productivity, which implies an element of arbitrariness in the selection of one particular level of skill as the job's "requirement" (Blaug, 1972). Secondly, there are the heterogeneity of skill (Schuller, 1983) and the difficulty of measuring the resource costs of its development (Hartley, 1972; Woodward, 1974; Drake, 1982), which make possible only the most broad-guage estimation of consolidated skill requirements (e.g. Kendrick, 1976).

The difficulty for a unidimensional approach to skill is particularly intense when the relative importance of its constituent components (e.g. theoretical knowledge and manual dexterity) is changing, as is the case with IT applications such as CNC. In such instances we can do no more than provide general impressions of the change in the overall skill requirements of production and concentrate instead on the more detectable changes in both the types of skill required and in requirements within each sub-category of skill. The potential complexity of even that task is illustrated by the pathbreaking work of Bright. In his studies of the relationship between automation of production machinery and skill requirements, Bright distinguished as many as twelve aspects of worker contributions, amongst which eight are at least partly skill-related in the above sense. He judiciously made no attempt to quantify the effects of automation upon the various sub-components of skill, restricting his analysis instead to qualitative changes and overall impressions (Bright, 1958). Some subsequent work has indeed used actual measures of job requirements for education and vocational training, notably those produced by the US Employment Service for the <u>Dictionary of Occupational Titles</u> (Horowitz and Herrnstadt, 1966; Ryan, 1977; Rumberger, 1981). Such data are however too imprecise and limited in availability to be of much help for this study.

The third difficulty arises from the fact that people change jobs and, to the extent that such changes involve learning new job tasks, the skills embodied in a person must be interpreted as not just their ability to do "old things" (current job requirements) but also their ability to learn to do "new things" (future job requirements). As the changes associated with IT may include higher rates of job change and occupational mobility, consideration of this flexibility-related component of individual skills is essential. It provides a central issue in Chapter VI, below.

There is yet another complication in the analysis of skill: the possibility of what has been termed the "social construction of skill" (More, 1980) -- the process whereby work with low skill requirements is nevertheless, through job controls exercised by occupationally based groups of workers, endowed with high pay and an aura of skill largely devoid of technical basis. The mule spinners in nineteenth-century cotton mills and the phototypesetters in the modern newspaper industry provide well known British examples of what might more accurately be termed the "social retention of skill". Technological advances remove the need for such prior skills as manual dexterity and layout, but the organisation of the workers (developed in the period when their skills were essential to production) proves strong enough for them to maintain control over the new "deskilled" ways of work (Turner, 1962; Cockburn, 1983; Griffin, 1984).

The possibility that skill may be socially constructed, while undoubtedly real, need hardly detain us at all. Not only are examples of successful resistance against the sub-division of labour rare in Britain (let alone elsewhere) but, even where they occur, the underlying reality remains one of technical deskilling. The "artificial" retention of skilled status by the groups involved may indeed slow down the rate of introduction of new technology but it in no way negates the fundamental change in the technical skill requirements of production, upon which this discussion concentrates.

Our view of skill therefore seeks as an ideal a unidimensional measure of the resource costs of developing the human qualities required to perform the tasks of jobs as they stand and as they are modified as a result of technical change. In practice, however, the heterogeneity of skill, the ambiguity of job requirements and the importance of occupational mobility require us to settle for a multidimensional and qualitative assessment of the relationship between new technology and skill.

2. The Division of Labour: Efficiency and Control

The typical modern organisation is characterised by extensive subdivision of labour. In both production and office work, the tasks that technology leaves to human intervention are conventionally combined into jobs in minimalist fashion. In the vocabulary of industrial engineering, the objective is to minimise cycle times, i.e. the time it takes to complete the tasks of the job before performing them again (Davis *et al.*, 1955).

The process of subdivision is subject to clear limits. Adam Smith pointed out that the size of the market for the firm's product acted as a key constraint on fragmentaton of tasks. The economic feasibility of specialising equipment and personnel on a grand scale is missing when variation in products makes mass production impossible; flexibility and adaptability are then the requirements and workers must be capable of mastering more than a small set of job tasks. Batch size is therefore a central influence on the subdivision of work (Sorge *et al.*, 1983). Secondly, firms which find their environment subject to frequent and unpredictable change, in either the products they can sell or the processes by which they are made, tend to find extremes of subdivision unsuited to high performance (Stinchcombe, 1959; Kanter, 1984). Thirdly, firms which find supplies of suitably educated and trained labour available in the external labour market, as is rarely the case for manual and technical work in English-speaking countries but common in Germanic ones, can reasonably afford not to press sub-division of labour to extremes but rather put to use some of the skills available to them (Lutz, 1981). Finally, a handful of experimental firms, often inspired by visionary entrepreneurs, have consciously rejected the deskilling norm in favour of deliberate enhancement of job content through programmes of job enrichment, etc. (Lawler, 1969). However, even given these qualifications, the organisation of work in the modern firm has generally been governed by extensive subdivision of labour.

The effect of such sub-division of labour is to limit the skill requirements of jobs -- in many cases, to very low levels indeed. The conclusion is particularly striking in the case of vocational training in the United States. According to one estimate, the resource costs of training (subsequent to general education) amounted to roughly four months' earnings on average for the lower 65 per cent of the jobs in the United States economy in the early 1960s (Ryan, 1977). To assert this is not, however, to argue that skill requirements in the broader sense are always and everywhere negligible. Economies such as the West German and British make more use, even after task subdivision, of vocational skill and knowledge than does the United States' one; while even in the United States the educational requirements of production have grown as part and parcel of the reduction of vocational training needs (Eckaus, 1964; Rumberger, 1981).

The reasons for subdivision fall into two categories: efficiency and control. Each is capable of raising the profitability of the enterprise, but they do so in different ways. The efficiency factor is best illustrated by thinking provisionally of the employee as a simple automaton, a passive and predictable performer of the instructions provided to him or her. On that assumption, subdivision of work is capable of raising productivity by reducing training costs, lowering transfer costs between tasks and facilitating mechanisation -- as pointed out long ago by Smith and Babbage (Council for Science and Society, 1981).

However, workers are people rather than simply sophisticated machines. A fuller account of the efficiency argument would have to take into account the preferences of workers themselves. If they place value on less narrow jobs, because, for example, of a desire for learning or variety in work, then workers are presumed to pay for such broad jobs by accepting lower pay than is available in cases of extreme subdivision (Scoville, 1969). It is however doubtful that the preferences of workers exert much influence on the subdivision of labour within large plants, where Taylorist industrial engineering and managerial control strategy act as the dominant influences.

Consideration of workers' preferences is however central to the "control" factor in the subdivision of labour. As individuals, workers potentially entertain objectives other than those of the directors of production. A variety of sources of divergence in objectives between employees, on the one side, and employers, on the other, can be postulated -- ranging from a fundamental clash of interests between capital and labour to the less dramatic proposition that different positions in the social division of labour result in differences in values and perceived interests. Rather than attempting to evaluate the issues in dispute here, we will settle for the "minimalist" proposition that employers and top managers generally face the problem of eliciting compliance with organisational objectives on the part of their employees, ranging from middle management down to shopfloor workers. The divergence of perceived interests may be mild or severe, but the issue is general. Thus middle managers may feel particularly threatened by IT, given its potential for bypassing them in flows of information and command within the enterprise -- with the result that their cooperation may become central to success in the use of IT.

One way in which those in command of the firm seek to align the objectives of their employees with their own is to subdivide labour. Narrowness in job assignments, if combined with clear monitoring of worker performance and suitable incentives and sanctions, constitutes a transparent and well-tried mechanism for control of the actions of employees. It constitutes the core of the traditional United States approach to what used to be termed shop management (Taylor, 1967). The worker is given a limited set of tasks to perform and is induced to perform them either by pecuniary incentives (Taylorism) or by high time rates and strict discipline (Fordism). The "control" or hierarchical aspect of task sub-division, stressed particularly in the Marxist tradition, accounts for the lower degrees of job fragmentation observed when the organisation of work is controlled by the producers themselves, particularly when a craft or professional identity is involved. Indeed, enforced subdivision of labour has proved a potent weapon in the hands of employers bent on wresting the control of process and product from the hands of entrenched occupational groups (Braverman, 1974).

The relative importance of the efficiency and control factors in fostering subdivision of labour has proved the subject of a lively controversy. In the eyes of some commentators, the importance of control in shaping the division of labour is so great as to overrule considerations of productive efficiency in cases where the two conflict (Marglin, 1974). Certainly examples can be found of job enrichment projects which yielded good results in terms of productivity and job satisfaction but where the implications of reduced task fragmentation for hierarchical control were associated with the cancellation of the scheme (Kaus, 1973).

At the same time, subdivision has been recognised as only one vehicle of hierarchical control -- and a potentially inferior one at that. Experience with Taylorist systems has involved widespread disappointment for management, which frequently finds itself incapable in practice of monopolising knowledge or production methods, monitoring employee performance and retaining control of systems of pecuniary incentives in the face of informal work group "subversion" (Whyte, 1955; Brown, 1973).

Alternative control strategies have developed in the areas where managerial experience has exposed deficiencies in the Taylorist ideal, as well as in the (less numerous) cases where the ideal failed to convince managers in the first place. The proliferation in the literature of categories such as "bureaucratic control", "normative control", and "responsible autonomy" reflects the importance of a managerial strategy which seeks to elicit worker compliance not by strict monitoring and narrow jobs but by the provision to employees of higher levels of job security, responsibility for their own actions and internal promotion prospects (Edwards, 1979; Friedman, 1977). In the useful distinction proposed by Fox (1974), such managerial control strategies seek to diffuse the relatively "high trust" which typically characterises employment in the higher managerial and professional echelons down into the lower reaches of the corporate hierarchy in both office and factory -- in marked contrast to the "low trust" relationships which are both reflected in and fostered by Taylorist methods. The "high trust" approach pervades employment under Japanese management, at home and, apparently, abroad (Dore, 1973, 1983; White and Trevor, 1983). The parallel tendency of West German enterprises to constitute jobs around a given technology in "enriched" form (i.e. more skilled work and less intense supervision) is usually attributed to the abundance of vocational skills produced by the country's apprenticeship system. It may have at least as much to do with the higher levels of workplace integration and employer-employee "trust" resulting from the Works Council system of co-determination (Maurice et al., 1984).

The differences between the high and low trust approaches can easily be overdrawn. Trust is itself a matter of reciprocity and degree, inevitably restricted by the different positions of employer and employee. Moreover, the subdivision of labour itself appears intense in Japanese firms in particular, even if rotation and promotion between jobs is commonplace (Kamata, 1984). In this respect, high subdivision of labour may be maintained even when non-Taylorist strategies of control are adopted by management.

3. The Implications of IT for Skill in Particular Occupations

There is considerable variety in the ways in which the introduction of information technology into the workplace may affect the skills needed for production. In this section we first examine the situation for a given mix of jobs, looking at the implications of IT for the efficiency and control influences upon the division of labour in the enterprise. We consider in the following section the compositional changes in the job structure which are to be expected as a result of IT. In each case we attempt to abstract the factors which will influence outcomes across the variety of contexts into which IT will be introduced, avoiding the more familiar approach of assessing IT sequentially for a series of prospective areas of application (office, factory, etc.).

The introduction of IT may exert several potentially important influences upon the subdivision of labour within the organisation. Both the efficiency and the control dimensions are involved. The range of evidence already available upon IT implementation suggests that in each dimension contradictory effects are possible. IT is seen to be associated with intensified subdivision or "deskilling" under some conditions and with reduced subdivision or "reskilling" under others. The central task is to isolate the factors which militate in one direction rather than the other. A simple diagram can be used to represent the four major categories of outcome envisaged. In Figure V.1, four representative possibilities illustrate the outcomes observed -- on both efficiency and control grounds some aspects of IT are conducive to deskilling, others to reskilling. We will discuss these four possibilities in turn. As many firm predictions of deskilling have been made, not least by Braverman (1974), we start with the factors conducive to the use of IT to reduce the skill content of production (Boxes A and B in Figure V.1).

A. Deskilling Tendencies: Eff[illegible]

On the efficiency side, IT [illegible] potential to deskill work by building much of the knowledge and s[illegible]ntly required of the worker into the computer, whether as hardwar[illegible] or [illegible]s software. The evaluative and decision-making powers of the [illegible]essor, in combination with its flexibility and cheapness, reduce [illegible]d for human intervention in a range of jobs of moderate complexity. The printing industry provides two of the more striking examples. Electronic methods of typesetting and colour scanning have drastically reduced the skills required to carry out each function (US Department of Labor, Bureau of Labor Statistics, 1982). The Bureau of Labour Statistics studies of technical change provide further less dramatic examples, including the skills of template makers and welders in fabricated metals; test desk operators in telecommunications; and automatic contour seamers in clothing (US Department of Labor, 1977, 1979b, 1982). In some prognostications, indeed, IT will impose upon the mental side of job requirements the same routinisation which was imposed at an earlier stage upon manual skills by mechanisation. The only limits concern the perfectibility of machine intelligence -- and, given current developments in such areas as chess-playing programmes, the limits appear to be moving backwards at a rapid pace.

The effects of IT upon skills. following this line of analysis, are commonly seen as the further polarisation of skill requirements between an élite of engineers, programmers and maintenance workers, on the one hand, and a residuum of clerical workers, cleaners, attendants and delivery workers, on the other (Crompton and Reid, 1982). The generalisations advanced by Bright (1958) in the light of his investigation of early automated systems tended to support such a view.

Other considerations point towards the use of IT for further subdivision on efficiency grounds. The equipment in which IT is embodied is often more expensive than the older vintage which it renders obsolescent. In some such cases the economic incentive is to specialise its use within relevant groups of employees in order to increase rates of utilisation and maintain low cost production. In the lower levels of the non-manual hierarchy, the introduction of both the word-processor and of computer-aided design (CAD) has sometimes been associated with a move towards more "dedicated" usage than was the case with typewriters and drawing boards. Thus the word-processing tasks of the office secretary tend in some large organisations to be concentrated in pools (akin to those developed for typing in an earlier period) in order to use the new equipment more effectively than if it were dispersed around a variety of individual offices or departments (Buchanan and Boddy, 1982; Long, 1984).

Yet even when equipment embodying IT is less expensive than were its antecedents, deskilling may still be the result if the new equipment is simpler and more reliable than was the old. Telecommunications provides an example. The move from the old mechanical-electrical to the new electronic telephone exchanges means a reduction in the bulkiness, price and unreliability of the equipment involved. The electronic exchange breaks down less often, thereby reducing the need for skilled maintenance labour. In addition, when it does break down, instead of undergoing complicated and costly repairs on site, its broken component ("card") is discarded and a new one inserted, thereby exerting further downward pressure on the call for maintenance skills. Labour needs for the maintenance of long-distance call equipment may fall by as much as two-thirds (US Department of Labor, 1979b).

A final contribution of IT to the reduction of skill requirements concerns its ability to speed up the training process for many jobs, thereby reducing the resource costs of producing the skills required for work. Computer-based instruction in school, home and workplace can improve learning speeds, in addition to the potential reduction of the costs of instruction. Japanese firms in particular have already made extensive use of video and computer-based learning techniques (GB Engineering Industry Training Board, 1979).

Figure V.1

DIAGRAMMATIC REPRESENTATION OF POSSIBLE EFFECTS
OF I.T. ON SKILL MIX WITHIN A GIVEN JOB STRUCTURE

Factors Affecting Task Subdivision	Skill Requirements: Reduced	Skill Requirements: Increased
Efficiency	A	C
Control	B	D

B. <u>Deskilling Techniques: Control</u>

Efficiency considerations are not the only ones conducive to the use of IT in deskilling mode. Control factors often point in the same direction, with two avenues of influence in prospect. The first is the extension of methods of "technical control", in which worker performance is built into capital equipment itself. IT-based machinery has "the attraction, from the management point of view, of substituting the variable behaviour of a labour force with the consistent obedience of a deterministic machine intelligence" (Bessant <u>et al</u>., 1981, p. 35). When IT reduces the requirement for human intervention in machine operations, the result is a potentially higher and more reliable level of performance. The second aspect concerns the increase in the availability of information about system functioning which is made possible with IT. More information about the activities of subordinates, in terms of both day-to-day usage of machine time (as with electronic point-of-scale cash registers and CNC equipment) and outputs (as with divisional operating results), means potentially more leverage for senior management over the activities of organisation members. On-line access to corporate data records can dispense in part with the services of intermediate levels of management, thereby potentially reducing their independence and influence. The information provided by IT may make it possible for managers to adjust workloads more readily and control the pace of work more effectively than in the absence of IT. It can also provide data on employee performance without the knowledge of the employee that the information is being scrutinised. The knowledge that scrutiny has become possible without the timing of scrutiny being known can mean a considerable boost to the efficacy of the monitoring function as a result of IT. In the words of a supervisor of an IT application in a retailing office, "you have the ability to review people's work without their knowledge.... I think it keeps them on their toes" (Zuboff, 1982, p. 147).

Instances of the use of IT to intensify subdivision crop up frequently in the literature. In the manual area the prediction of Braverman (1974) that CNC machine tools would be used to separate the manual from the mental side of craft work, thereby eventually attaining the objectives set out by Frederick Taylor, has found partial support in the practices of British firms involved in large batch production. In some such cases, the thinking and planning side of the machining process typically devolves to the technical department in which the part-programmers work, leaving to the shop-floor only the semi-skilled practical side of the work (Sorge et al., 1983; Wilkinson, 1983). Similar examples are reported for the United States (Noble, 1979).

As the use of IT to deskill work and increase productivity is potentially greatest in sectors where supervision has hitherto been technically difficult, the mining industry not surprisingly provides a dramatic example. Under recent technologies, faceworkers enjoyed considerable autonomy concerning work methods and speeds. The current plans for computerised mine operating systems (MINOS) in the British coal industry intend radically to alter the situation. The multidimensional set of computerised information and control systems involved (and particularly the FIDO component) are intended to provide colliery management with current data on equipment condition, workrates and causes of downtime on the distant coalfaces. The announced plan of the National Coal Board is to reduce to zero the one-third of shift time which is typically lost to what it classifies as operator-controlled or "avoidable" delays. Surface control-room personnel are to be placed in a better position not only to take remedial action but also to put pressure on faceworkers in cases of "avoidable" downtime. Deskilling of the faceworkers' jobs is an explicit part of the plan, in that automation has been designed as a "closed loop" system, in which the operator becomes a machine minder -- as opposed to the "decision maker cum machine controller" which an "open loop" design would establish. Preliminary implementation of parts of MINOS in coal preparation facilities has already been accompanied by management pressure to downgrade many jobs to less skilled and responsible categories as a result of automation. In this case the implementation of IT is explicitly oriented towards a low trust, Taylorist plan for work organisation (Burns et al., 1983).

The importance of Tayloristic orientations in the IT age is also highlighted by the production methods adopted by the high tech sector itself. The experiments in organisational structures conducted by "high tech" firms for their managerial and professional staffs have attracted interest for their orientation to creativity and flexibility (Kanter, 1984). At the same time, most microprocessor producers have shown a steady preference for organising production jobs on a low-skill, low autonomy basis -- with the job-enrichment methods of Zilog (a United States-based subsidiary of Exxon) as the exception rather than the rule (Gustavson and Taylor, 1983; Murray and Wickham, 1983; Howard, 1983). While there may be nothing intrinsically special about the production processes (as opposed to the products) of the IT producers themselves, there is an undeniable symbolism to the choices they have made.

In the non-manual area, the potential for intensified subdivision and hierarchical control through introduction of IT is sometimes taken to exceed that in the manual area, as if the office had until now remained relatively untouched. In fact the office has already undergone rationalisation, mechanisation and task subdivision in ways essentially similar to those in the factory. The early phase of computerisation, based around batch processing of data on centralised mainframe facilities, intensified such tendencies in clerical and administrative work. Several recent analyses support Braverman's (1974) contention that the computer was deployed, at least initially, so as to deskill office work (Crompton and Jones, 1984; Werneke, 1983; Barras and Swann, 1983).

In recent years the microprocessor has made possible a move from centralised batch processing of data to on-line interactive work at remote terminals. Although some have found that the result has been a reintegration of the job tasks of clerical workers, we must note at this stage two striking examples of the opposite, viz., further fragmentation of job content. In the first, the work of debt collectors for a large retail corporation in the United States was reorganised when a computer system took over the allocation of the accounts to be chased amongst a group of collection officials. The element of discretion in their jobs was thereby considerably reduced, being structured instead into the computer programme's operating rules -- which were themselves based on the work methods and speeds of one hardworking experienced collector. Higher management claimed that the use of IT had improved both efficiency and control. In the words of one manager, "it gives us tighter lock on the collector and we can hire less skilled (educated) people" (Zuboff, 1982, p. 144). An analogous case, involving the parts scheduling function in a British machine tool firm, is discussed by Wilkinson (1983, Ch. 8).

In the second example, the use of advanced telecommunications equipment and call scheduling by the United States national telephone company has meant for the dwindling workforce of phone operators a job in which a new call is automatically switched to them when they finish their current one, in which a 15-second norm is enforced for the completion of typical calls; and in which supervision is both intense and unseen (Howard, 1981; Kohl, 1983). It is this background "neutral" impersonality of supervision which is perhaps the outstanding contribution of the new technology from a managerial standpoint.

The role of hierarchically controlled organisational structure in promoting the use of new technology in ways which deskill work is thrown into relief by consideration of the way IT is used when the external control imperative is absent. Worker control over methods of production is much discussed but rarely observed in modern societies. Situations in which occupational groups exert considerable self-determination in the use of skills on the job arise almost exclusively in the professional area, craft groups having by and large lost control of the work process to employers at one time or another in the past. In the medical field, "the nature of hospital organisation is heavily influenced by the monopoly of key tasks held by doctors and after them by a hierarchy of para-medical staff" (Child, et al., 1984, p. 167). Senior medical staff have been able to insist that computer diagnostics be used to complement their skills, while encouraging the use of computerised laboratory test equipment and word processor/patient file systems to restrict the skills required of technicians and administrative staff. Thus computer diagnosis, by building the experience and skills of experienced clinicians into the automatic evaluation of patient symptoms, is capable, in theory, of matching the diagnostic performance of the best brains in the profession -- and, in practice, of at least matching the average (Rosenbrock, 1984).

Yet medical specialists have ruled out computer diagnosis when only a nurse is present, let alone by the unassisted patient on an interactive basis. In one British case-study the only relaxation permitted by the consultant in charge was to allow non-specialist doctors in local clinics the possibility of using the computer routine. On the other hand, automated biochemical testing, which could be used to allow technicians to carry out more skilled, non-routine work was in the same case-study implemented by the relevant consultant to specialise technicians into testing, thereby increasing their workloads and narrowing the content and skill requirements of their jobs (Child et al., 1984, pp. 171-2). The implications of control over work process for the mode of utilisation of IT are brought out clearly by these two contrasting experiences within one organisation. A bleak prospect appears therefore to face those who call for the use of IT to enhance rather than to substitute for skills (Council for Science and Society, 1981).

To leave the story at this point would, however, be to give a distinctly one-sided impression of the role of IT in the workplace. We must recognise at the same time that both the efficiency and the control tendencies are subject to important limitations in practice; and that in some contexts IT has been used in quite opposite directions to the Taylorist ones just discussed. We move therefore to consider the factors that provide examples in Boxes C and D in Figure V:1.

C. Skill-Using Tendencies: Efficiency

The proposition that efficiency will be increased by using information technology to deskill work rests in the first place upon an assessment of its technical potential which is likely to remain unrealistic for some time to come, if not indefinitely. Work may indeed be routinised by building discretion into the computer at the expense of that exercised by the operator. But the process is subject to strong constraints in practice. Even apparently routine jobs often turn out to require human ingenuity and initiative. While there is no logical impossibility to embodying all eventualities in a computer programme, practical possibility is a different matter. Thus a French bank attempted to make the work of its tellers highly rule-bound as part of front-desk computerisation. The problem was that transactions frequently involved anomalies from the standpoint of the rules of the computer system. Operating experience revealed large numbers of customer complaints. The result was a reversal of strategy, in favour of increasing teller autonomy in the use of terminals -- a strategy given the somewhat grand title of "local mastery" (Adler, 1983).

The same difficulty applies more generally to Bright's (admittedly tentative) conclusion that automation would tend to reduce skill requirements in production. He implicitly assumed that the very highest levels of automation on his scale could be attained -- in which equipment is capable of feedback-based self-adjustment to deal with all operating circumstances. The Three Mile Island nuclear incident of 1979 suggests that in practice even highly automated systems have limited self-correction capabilities in unusual circumstances, leaving a potentially crucial role for operator intervention (Commission of the European Communities, 1983). Consequently management faces a choice of strategy: whether to make the machinery as self-adjusting as possible and use personnel with limited skills, or whether to recognise the limits to self-adjustment and use workers with extensive understanding of the production process in question. Examples of both strategies can be found. There are also instances of management recognising as the result of bitter experience that the very incompleteness of automation, even with IT, makes it rational to maintain high levels of skill in the workforce, particularly when the operating environment is subject to unpredictable disturbances and downtime is costly (Senker, 1984a, Ch. 8).

The limited mileage to be gained in some contexts from a deskilling orientation in IT usage is illustrated by studies of the utilisation of CNC machine tools. Although some firms do use CNC, as they previousy more or less had to use NC, in deskilling mode, with a sharp separation between part-programmers and machine operators, they are in a minority. Knowledge of machining operations is so important for successful programming that employers at the very minimum fill programming slots by upgrading the skills of their craft and technician employees. Programmes are then typically proved on the machine itself by interaction between the programmer and the operator, who typically remains a qualified skilled worker.

According to the central comparative study of CNC in Britain and West Germany, it is only in the case of long runs (large batches) in large plants that the operation of the CNC machine tends to be left to sub-craft labour. And even then some firms, notably in West Germany rather than Great Britain, prefer craft operators in view of the expense of the machinery and materials involved (Sorge et al., 1983; see also Jones, 1982; Elsasser and Lindvall, 1983; Wilkinson, 1983). In at least one British plant (Westland Helicopters) reductions in operating costs as large as one-third have been claimed for an explicit policy of unifying programming, setting, operating and inspection tasks on CNC lathes (Wyles, 1984). Even in the British factories where semiskilled operators run the CNC machines without any role in setting or programming, CNC itself is not responsible for deskilling the work of the machinist. It is precisely there that the work had already been deskilled by the separation of set-up from machining taks, with the former allocated to skilled and the latter to semiskilled workers. In this area at least, computer-based technology is seen to slot into the pre-existing organisation of work rather than remould it afresh.

Similar considerations apply in maintenance as well as to production work. Bright (1958) recognised that maintenance work is less likely to be downgraded in skill requirements than is production work, but even there he saw forces pushing in that direction. However, alongside cases of the reduction and simplification of maintenance requirements as a result of IT, stand instances in which the opposite is found. The variety and complexity of equipment have increased steadily, with the electronic being integrated into existing electrical, mechanical, pneumatic and hydraulic systems. While workloads and complexity in maintenance can be reduced by preventive maintenance and by building self-diagnosis and modular replacement into IT systems, such tendencies have thus far proven distinctly weak. Maintenance requirements are dominated in practice by the increasing complexity of machine systems, requiring higher levels of theoretical and practical knowledge on the part of maintenance staff. Furthermore, the cost of downtime being in general increased by the sheer expense of much IT-based equipment, it becomes economically increasingly desirable to set the work up (at least for a core of maintenance workers) on a "multi-skilled" (or "craft consolidation") basis. Instead of allocating separate control area skills (e.g. electrical and mechanical) to separate trades, they are concentrated instead, in the "jack of all trades" craftworkers (US Department of Labor, 1979a; GB Engineering Industry Training Board, 1981; Cross, 1983; Incomes Data Services, Ltd., 1984).

At the same time, the presumptive need for multiskilling in maintenance work must not be seen as wholly the creature of current manifestations of IT. Economic advantages have been attainable for a long time now through multiskilling in maintenance, notably in capital-intensive industries such as chemicals. In countries where craft flexibility is restricted by custom or agreement, management found it worthwhile long ago in some cases to buy its way towards such patterns of work and skill (Flanders, 1964). As long ago as 1965, one in every eight United States refineries covered by a Bureau of Labor Statistics survey reported plans for multiskilling in maintenance (US Department of Labor, 1979a, p. 35). What IT contributes is an intensification of the benefits of multiskilling in the older process industries and the dissemination of such benefits to other sectors, notably the metalworking industries.

The utilisation of computerised equipment depends to some extent upon the nature of the technical change involved. In the CNC case the computerised machine tools are expensive relative to their NC and manually controlled antecedents (Ray, 1984). This increase in the price of capital relative to that of labour, along with the considrable increase in capital productivity made possible by CNC, makes it rational for firms to continue to use skilled labour on the new equipment as long as the superior knowledge of the craftworkers over the semiskilled operator makes even a modest contribution to the avoidance of downtime and scrappage. The improvement in capital utilisation rates and the reduction of scrappage from using rather than replacing skill will commonly save more than will be spent on worker compensation. The conclusion applies with even greater force to the maintenance of costly process plant; skimping on the quantity and quality of maintenance labour threatens costly losses of output. In other areas of IT application, however, the story will be different. Equipment embodying new technology may be more compact, less complex and less expensive than that which it displaces. Such is the case with electronic telephone exchanges, and microcomputers in the office. If the tasks which are automated are also routine, as with much data and word processing in the office area, the benefits of using highly educated and trained labour are far less compelling, and the savings in labour costs from downgrading skill requirements are more likely to dominate the organisation of work around new technology.

The possibility that IT may promote further deskilling for reasons of efficiency is in some applications hampered still further by the continuous nature of technical change. Any one IT-based system may well after sufficient operating experience attain a settled state in which the incidence of unforeseen circumstances has fallen to low levels and the routinisation of operating and even maintenance tasks becomes more readily attainable. Settled states may however be hard to attain in practice. The technology is likely to have been reconstituted well before early variants have settled fully. At a time of intensified international competition in manufacturing, IT threatens to introduce into production methods the state of "permanent revolution" to which Trotsky aspired in the political realm. Tendencies towards routinisation will be continuously subject to the restraints of renewed innovation.

D. Skill-Using Tendencies: Control

Similar counter-tendencies apply to the control possibilities opened up by IT. In the case of debt collectors, telephone operators and bank clerks, we saw cases where IT was indeed used by managers and owners to increase hierarchical control, partly through intensified subdivision of labour. The process is however subject to stronger constraints than are envisaged by the enthusiasts of control interpretations, whether capitalist or marxist. The history of work organisation under capitalism is replete with examples of innovative systems which were to solve once and for all the problem of worker control and motivation -- including scientific management, assembly lines, human relations and job enrichment (Littler, 1983). All have contributed to managerial objectives but none have lived up to the hopes of their sponsors. All have proved susceptible to what might be termed worker subversion. Once subordinates have come to understand the operation of the control system, they may, through superior operating understanding and sheer ingenuity, find the way to weaken its force and even, as in the "capture" of payment-by-results systems, turn it against managerial objectives. The undermining of managerial control systems by what may be termed worker resistance proceeds at two levels: the informal, in which individuals and work groups find ways around rules, and the formal, in which trade unions bargain about the rules and prevent the implementation of strict controls in the first place.

In the case of IT, similar possibilities apply as for previous control-related innovations. Taking the individual side of employee resistance first, the first issue concerns the flow of information provided under IT itself. If computerisation promises to provide management with a wealth of control-relevant information about the performance of subordinates, there may be little to guarantee that the information itself will be correct. A little distortion goes a long way in the interdependent sets of data stored by computers. Employees may falsify the information which they key in, whether to improve their own compensation (as in the case of teller theft) or to ease the burden of hierarchical control. In the example of debt-collection work referred to above, discrepancies emerged between the job performance claimed by the collectors and the revenues actually accruing to the firm -- with, not surprisingly, the former exceeding the latter (Zuboff, 1982). In that case managerial correctives may not have been too hard to develop. In others, however, the sources of misinformation may be harder to trace. Computer utilisation induces some people, and particularly creative people whose jobs underuse their skills, to play with the system. Computerised systems may be even more readily undermined and sabotaged by disgruntled employees than is the assembly line, which was supposed to chain the worker to the job but which proved intermittently vulnerable to sabotage and shutdowns (Edwards, 1979).

The constraints upon the use of IT to intensify hierarchical control go beyond the possibilities of information distortion. At the very least, employees who find deskilled jobs unpleasant and boring may vote with their feet and indulge in absenteeism and turnover to the detriment of the employer's operating costs. Thus, turning agan to the striking example of retail debt collection, the implementation of low autonomy, computer-governed working methods resulted in a turnover rate in excess of 100 per cent per annum (Zuboff, 1982). the antecedent turnover rate is not given by the source, but the implication of a substantial increase, along with the underlying drop in morale which it is presumed to reflect, suggests important hidden costs of such usage of IT which will discourage more perceptive employers from pursuing such tactics.

Observers have noted that the microprocessor increases the range of options in work organisation in information-handling activities. The advent of decentralised, interactive modes of computer usage facilitates a reskilled organisation of work, in contrast to the fragmentation of tasks encouraged by batch processing at the mainframe itself (Weir, 1977; Robey, 1980). An example of managerial preference for enriched forms of job design around IT is provided by the creation of the role of "client account manager" by the Prudential Insurance Company in one of its New Jersey claims processing centres. Instead of the previous centralised batch processing of claims by teams of specialised coders, keypunchers, etc., currently employees working with terminals at their desks are made responsible for all aspects of the maintenance of a set of client accounts (Guiliano, 1982). Similarly, some British insurance companies have used on line computing so that "the jobs of filing clerk, typist, checker and quotations clerk could all be performed by what would now be classed as junior underwriters" (Barras and Swann, 1983, p. 47).

There is of course nothing to compel employers to exploit the new technical options and reskill clerical work. Indeed, in one British study, the organisation of work around decentralised terminals was if anything even more fragmented than under centralised computer facilities (Crompton and Jones, 1984). The motivational problems of Taylorism do however point in the direction of reskilling (Crompton and Reid, 1982). The job enrichment strategy adopted by the insurance companies reflects managerial desire to use broader job content in order to improve both employee motivation and the quality of service given to customers -- a consideration clearly of less interest to management in the retail debt-collection case. Other examples of the explicit use of IT to maintain or raise the skill content of jobs involve lens grinding (Wilkinson, 1983, Ch. 5); pet food production (Dickson, 1980); and FMS operation (Gerwin, 1982).

A variety of managerial preferences for work organisation around IT is to be expected, just as a variety is found in the literature. In cases where employers bear significant costs for hiring and training, or where low employee morale has effects upon output that cannot be avoided by tight supervision, management is expected to avoid using IT as another means of deskilling work and intensifying hierarchical control. In this respect, as in others, the issues posed by the introduction of IT are by no means novel. It may alter somewhat the terms on which decisions have to be made, but the range of options and the influences upon choice both look highly familiar.

The above considerations point up the dangers of using managerial deskilling intentions as a guide to outcomes. Even when managers prove enthusiastic about the use of IT to intensify supervisory control, the practical possibility of so doing may lag well behind the desire. This is particularly likely to prove the case in British coal mining, where management anticipates a great tightening in supervisory control and hence in labour productivity as a result of the MINOS set of IT applications (Burns et al., 1983). The goods have yet to be delivered in that context. If managers in other sectors have often had to endure the frustration of their plans for tighter control over subordinates, how much more likely is such frustration in an industry with a strong tradition of work-group autonomy, solidarity and militancy?

The tendency for individual workers to find ways to foil the use of IT for intensified control is only one part of the reaction. There is also the collective dimension. Work groups and trade unions will often seek to influence the way IT is used in the same way that they have influenced the development of other systems of control. A particularly dramatic instance of organised reaction to managerial deskilling of work around IT involved a two-week strike by the Canadian postal workers in 1976, an action undertaken (despite its illegality) in response to a unilateral downgrading of many jobs by the Post Office management (Science Council of Canada, 1980, p. 43).

Collective resistance to new technology is most intense amongst occupationally based unions. Examples come to hand fairly readily therefore in the British context. The best known involves the introduction of computerised typesetting in the printing industry. In one of the few remaining centres of craft control over production, the composition of newsprint in Fleet street, the trade union of the skilled typesetters (the National Graphical Association) has during the last decade used its entrenched position in the organisation of work to regulate the introduction of IT. However, even here, the result has not been the avoidance of the deskilling of what was a traditional manual craft. Photocomposition has been accepted as inevitable, with the NGA striving instead to retain double entry and prevent single-stroke entry by journalists, advertising clerks, etc. Ironically, this oft-cited example of craft control involves a drastic reduction in skill content of work. The work of photo-typesetting involves little more than the skills of the word-processing operator. Trade union influence is in this case limited to pay rates and manning levels, the skill content of work proving beyond reach -- except insofar as the pace of innovation has been slowed (Martin, 1981, 1984; Cockburn, 1983). In other countries' newspaper industries, however, printers' unions have failed to attain even this limited degree of control over the use of IT (Griffin, 1984).

Craft union influence is present in two other areas of British manufacturing which are currently being reshaped around IT· maintenance and drafting. Maintenance work in Britain is typically organised by craft unions distinct from the general unions which tend to dominate production work. Furthermore, the different systems within maintenance tend to be organised by different craft-based unions. Thus mechanical work is dominated by the engineering workers (AUEW) and electrical work by the electricians (EETPU).

The demarcation rules traditionally maintained by such unions have often forbidden other workers from doing even the smallest portions of the work reserved for each union's trade territory (e.g. a fitter replacing a fuse). Such rules reflect in turn the determination of members to retain their identity and to bolster the availability of work to the membership of the trade. However, union policy towards IT currently consists of conditional acceptance from national leadership and variable insistence on traditional demarcation at the local level. Thus the introduction of new technology is not generally discouraged but rather policy is to capture the new work for the membership, or at least to insist on traditional lines of demarcation. The result is that, in both the metalworking and process industries, the promotion of multiskilling within the maintenance workforce is either avoided by management for fear of union hostility or introduced cautiously with the intent to buy out (or otherwise defuse) grassroots opposition to the incursion of other trades into traditional job domains. The effectiveness with which new technology is used will be reduced in practice when the reality or fear of opposition preserves customary demarcations. The effect is potentially serious in some contexts. In some process plants the share of maintenance workers in total employment is as high as one-third, while the speed with which breakdowns are repaired can contribute strongly to plant performance (GB Engineering Industry Training Board, 1981; Cross, 1983; Incomes Data Services, Ltd., 1984).

In drafting work, the desire of some drawing office managers to introduce CAD by specialising a subset of employees in its use, as outlined above, has in turn met considerable resistance from the unions involved. In Britain, AUEW-TASS is keen to bargain over the terms on which CAD is introduced, seeking not only to obtain guarantees against the job loss but also to secure non-dedicated patterns of usage in which all drawing office staff will be trained in the use of CAD. Not all employers have actually sought to implement CAD on a "dedicated" basis in the first place. Some fear the effects upon work quality of segregating engineering and drawing skills. But the others that have sought the subdivision of tasks within the drafting office have faced widespread opposition from, and occasionally intense dispute with, their employees (GB Engineering Industry Training Board, 1982; Incomes Data Services, Ltd., 1983; Arnold, 1984). This issue is not simply a British one. One major multinational firm even chose to locate its drafting work in Switzerland, despite the higher costs of such a location, in order to avoid the higher probabilities of disruption to such a strategically important corporate function from the industrial disputes which it felt more likely to occur in EEC countries (Buss, 1982).

Concern about the effects of new technology is of course widespread even outside the ranks of occupationally based trade unions. In Britain the national leadership of most large unions, along with the Trades Union Congress (Trades Union Congress, 1979), have since the mid-1970s produced a series of documents setting out policy towards new technology. This literature combines a recognition of the inevitability, and even the desirability, of IT-based innovation with an assertion of the importance of negotiating New Technology Agreements to influence the terms on which innovation proceeds. Union interests are to be protected by demanding participation in IT-related decision making; by estabishing job security for members; by pay raises and cuts in hours which share the benefits with labour; and by protecting health, regulating job content and preventing downgrading.

At a time of high unemployment, it is not perhaps surprising to find union influence on the introduction of IT, as revealed by the contents of actual agreements, to be both weak and heavily oriented towards job security, typically in the shape o^ guarantees against compulsory redundancy (Manwaring, 1981, Williams and Moseley, 1982). It is hard then to escape the conclusion that trade union restriction upon innovation of IT has by and large proved less influential in Britain than has resistance within the ranks of management itself (Swords-Isherwood and Senker, 1980a).

Within the generally limited and security-oriented influence of trade unions upon implementation of IT, concern for skills and control has a secondary, but still non-negligible, role. The model agreements proposed by the white-collar unions AUEW-TASS and APEX include restrictions on the use of IT to monitor worker performance or to specialise job tasks (Manwaring, 1981). Particular negotiated agreements explicitly rule out the use of information generated by IT systems for supervisory purposes (Benson and Lloyd, 1983, p. 176; Incomes Data Services, Ltd., 1983, p. 3). More generally, a survey of 105 agreements found that roughly one in every three referred explicitly to machine monitoring of employees, with a comparable proportion for task allocation and job content. The relevant clauses for the most part involved agreed standards protective of worker interests, although roughly one in every three of such clauses involved what was from the labour standpoint an impairment of standards (Williams and Moseley, 1982, Table 8). The effectiveness of such negotiated restrictions upon the actual use of IT for tighter control and task fragmentation remains of course to be determined in practice.

A separate channel of union restriction upon managerial use of IT for the intensification of control is suggested by the case of coal mining, to which reference has already been made (Burns, et al., 1983). There management intended to pursue its objective of increasing control at the coalface by staffing the relevant control room with members of supervisory and managerial unions (NACODS and BACM). In practice, however, the union of manual workers (NUM) managed to impose its own jurisdiction over control room personnel -- a potentially important victory in the struggle over the usage of IT in that industry.

All in all, the ability of unions to influence the effects of IT applications upon skills and job control is highly variable and generally on the weak side. Formal agreements cover only a small (if uncertain) part of the affected workforce. Their effectiveness remains to be demonstrated in the areas to which they apply. The combination of an economic slump and a managerial assertion of prerogatives at the workplace mean that the introduction of IT in Britain has generally proceeded on a unilateral basis, with the major restrictions upon deskilling arising not so much from formal union restriction as from managerial doubts about its desirability.

Managerial control over the use made of IT and its implications for skill are more marked still in the industrial relations systems of most other advanced economies, where both occupationally based unionism and shopfloor bargaining are weaker than in Britain -- if not wholly absent. It is true that collective bargaining in many European countries shows the same tendencies towards the coverage of issues of technology and work organisation, and even towards decentralised bargaining, that have marked the British experience. Moreover, in the Scandinavian economies the state has legislated to promote the influence of workers over technological change, on the one hand, and the skill content of the job, on the other. Such measures are relatively recent and their effects as yet unclear, but they offer to the representatives of labour a further channel of influence over IT implementation beyond collective bargaining (Benson and Lloyd, 1983, Chapter 8). In particular, the laws of 1977 in Norway and 1982 in France, both of which give workers influence upon the design of jobs and working conditions at the workplace, have the capability of slanting the implementation of IT towards a skill-using rather than a skill-reducing direction (Hingel, 1984).

Managerial discretion in the utilistation of IT is particularly marked in Japan and West Germany, the result of the high degree of social integration of workplaces in each country, as well as the uncompromising stance adopted by German managers in the face of union demands for negotiations about technical change. Ironically, it is in these economies that the use of IT to deskill work and bolster hierarchical control is most unlikely to be pursued in the first place. Both economies are built around skill-using rather than skill-minimising methods of production. The introduction of IT therefore may well lead to further enhancement of the already high skill content of production in these economies.

The most problematic case is that of the United States. From one standpoint American management should be particularly free to introduce IT as it sees fit, as well as particularly prone to do so in Tayloristic, deskilling mode. Mass-production developed in the United States, more than in any other country, around fragmented job content and informal on-the-job training (Sabel, 1982; Ryan, 1984a). The union movement is numerically weak and subject in most industries to the competition of non-union domestic rivals (Strauss, 1984). American management has long been noted for its insistence that all areas of workplace functioning which are not explicitly regulated in the collective agreement fall wholly under managerial _fiat_ -- and that technology and methods of production belong right there. Moreover, even when aspects of technology fall under collective agreements, management retains the right to make changes which will stand until a formal union grievance is lodged and sustained -- a process whose slowness in practice gives considerable power to management. Furthermore, the high rates of mobility which characterise the United States labour market suggest a flexibility in the allocation of labour which European economies might well envy. Such considerations point strongly towards the application of IT, if not actually further to intensify deskilling, then at least in harmony with a tradition of deskilled work. Indeed IT may be seen by many managers as _the_ way in which the "ideals" of Taylor and Ford are at last to be realised (Sabel, 1982, Ch. 5).

The crisis of recent years has however brought out an aspect of United States industrial relations which is distinctly unfavourable to the introduction of IT: the inflexibility of job content and labour allocation within the enterprise. The internal labour markets of unionised manufacturing plants operate under a set of rules concerning job content, pay rates and worker assignment to jobs, one of whose outstanding characteristics is their rigidity. Once the rules have been installed by collective agreement, they prove difficult to alter. Their rigidity reflects primarily their role in protecting the pay and job security of senior members of the unionised workforce: when pay is attached to the job (as under job evaluation) and when the claims of other workers to the job are restricted (as under seniority provisions for promotion and layoff), the incumbent senior workforce is largely protected from the competition of other workers. The United States industrial relations system is unique in the degree to which the definition of job structure provides the focus of industrial regulation (Doeringer and Piore, 1971; Piore, 1982; Osterman, 1984).

Employers may in the past have been content to set up fragmented job structures and accept strict rules on which workers are to do which jobs. In the recent period, however, many manufacturing firms have found such rules increasingly irksome as they struggle to deal with loss of markets. The central position of Japan in this process and the increasing sense that Japanese success arises largely from flexibility in the assignment of workers to jobs has resulted in strenuous managerial efforts to shake off the restrictions involved in the post-war system of job control. "The relaxation of work rules has been a major managerial objective" in the recent wave of "concession" (or "give-back") bargaining. Not surprisingly, according to the same source, "union resistance has been fierce, since such rules constitute an important part of job control, protecting workers from the arbitrary exercise of management power" (Strauss, 1984, p. 10). In industries such as rubber, the threat of plant closure and relocation to non-union areas rather than investment in existing unionised facilities has proved central to managerial attainment of increased flexibility in job definition and work assignments (Kochan et al., 1984). Success has from the managerial standpoint proved limited -- due in part to the desire of management to "have their cake and eat it too" (in the words of Sabel, 1982, p. 200) by raising flexibility in production without increasing worker autonomy and discretion. In this respect the United States appear ill-suited to the effective adoption of IT in production. Having come round partially to a sense of the dysfunctionality of strictly deskilled modes of IT utilisation, management finds itself hoist on its own petard, in the shape of the rigid Tayloristic work organisation which laid the basis of success in an earlier period.

4. Compositional Changes in the Skill Mix

The changes in skill needs associated with IT depend not only upon changes in the content of particular jobs but also upon changes in the balance of occupations at the workplace. The direction of intra-occupational changes has been found to be elusive, subject to a variety of contradictory influences. The inter-occupational ones which we now consider do however move the discussion to firmer ground. The general expectation is that the dissemination of IT will be associated with a marked compositional upskilling of the content of work, as automation removes the most menial jobs from both factory and office. In this section we review the evidence, examining in particular the experience of sectors using continuous process technology for an indication of the developments to be expected in the rest of industry.

Compositional factors have been shown to be an important source of change in skill requirements. Taking requisite general education as a (distinctly limited) index of skill requirements, Rumberger (1981) found that the tendency for educational requirements to fall within occupations in the United States between 1960 and 1976 was more than offset by growth in the employment share of education-intensive occupations, leading to a net increase in the "skill" requirements of the economy. In the British context, it appears that compositional factors resulting from structural change and economic cycles have dominated the skill utilisation patterns of the engineering (metalworking) industry (Lee, 1972; Fidgett, 1983). French data suggest similar compositional changes (d'Iribarne, 1982) -- though the stability of French occupational classifications has been found weak in practice (Lorenz, 1983).

The diffusion of IT may alter the mix of jobs in the economy by two routes: firstly, by changing the relative frequency of employment of different occupations in workplaces of given size, secondly, by altering the size distribution of workplaces. The first category reflects the potential of IT for automating the tasks of the least complex jobs at the fastest rate. Even the visionaries who set no limits to the degree of complexity which will ultimately be embodied in IT-based systems must concede that actual IT applications will proceed from the less to the more complex. Accordingly, in the near to medium term the labour-saving effects of IT will be slanted heavily towards less skilled jobs in factory and office alike.

In the factory, the development of continuous flow techniques of production, along with automated materials transfer, has already eliminated the jobs of an army of labourers and machine minders, particularly in the process technologies whose experience will be scrutinised in detail below. In batch production technologies, IT is currently, in the shape of pick and place machines, robots and FMS transfer devices, extending the range of automatic materials transfer from "large batch" producers (who had already pursued it by way of dedicated transfer lines) to medium and small batch producers (Ray, 1984) -- thereby continuing the process of displacement of the jobs of labourers, packers, etc. Robotisation and automatic insertion assembly are between them eliminating the jobs of many semiskilled manual workers, notably painters, welders and assemblers in consumer durables industries (Fleck, 1983; Commission of the European Communities, 1983; Schlesinger, 1984; Senker, 1984a, Ch. 5). Moving up the skill hierarchy, the injection of IT-based methods into design, quality control, testing and skilled production work (as on CNC machine tools) does not necessarily eliminate jobs as clearly and directly as does robotisation. However, to the extent that the productivity effects are substantial, the relative importance of these particular skilled jobs within the occupational structure of the enterprise will be reduced, except in the rare event of a compensatorily large increase in the corporate demand for the services of the functions affected. If we consider in addition the likelihood that maintenance requirements rise relative to production ones as automation proceeds, we conclude that IT is likely to slant the mix of manual work increasingly towards the more skilled and demanding jobs -- because the less skilled ones are the easiest, and therefore the first, to be picked off and because the services of the more skilled are required in order to do the "picking off". In economic terms, IT is a substitute for low skilled, and a complement to high skilled, labour (Eliasson, 1981).

In the non-manual area, compositional changes may be expected to be more dramatic still than in the manual one. In the non-manual area the "product" whose manipulation and transfer is facilitated by IT is information itself. Computers and telecommunications stand therefore to reduce the need for human handlers of the product (messengers, clerks, cashiers and telephonists) in much the same way as the need for materials handlers and labourers is curtailed in the factory. Centralised batch processing of data resulted in a large reduction in clerical labour needs in the 1960s and 1970s. Current on line processing options permit single handling of data, thereby applying the same logic to the specialised data handling occupations (coders, keypunchers) created by the first wave of computerisation (Barras and Swann, 1983). The productivity of those who process information is currently being raised by word-processors, copiers and desk top computers. In addition, IT promises before too long to overcome the major bottleneck present at the stage of information input. When adequate methods of optical character reading and voice inputting are possible, the requirement for the services of typists and keypunchers will be reduced still further. Many observers have therefore concluded that wholesale job losses will characterise the lower echelons of office employment in the near future. Predictions of losses of employment of up to a third within a decade are commonplace (Arnold et al., 1982, Table 3.1; US Department of Labor, Bureau of Labor Statistics, 1982). The degree to which actual employment will shrink is indeed uncertain, depending as it does upon the strength of the countervailing growth in the demand for information services. We do not have to wait for the issue to be resolved by experience to predict a general compositional upgrading of work in the non-manual area, as the numerical importance of data inputters and handlers declines relative to that of the more skilled equipment designers, programmers and information users.

Evidence of such trends has already surfaced. In telecommunications in the United States, for example, the share of females in the workforce fell from 57 per cent in 1960 to 50 per cent by 1978. Given the enduring sexual segregation of occupations, this provides a fair indication of the decline in relative demand for lower level occupations such as telephonists and typists (US Department of Labor, 1979b). In the British Civil Service, computerisation has been associated with a decline in clerical occupational shares (Atkinson, 1980). At the same time, the computerisation of the workplace involves an enhanced demand for the engineers, programmers and technicians whose skills are required for the installation and operation of IT-based systems. Software accounts for an increasing proportion of computer system costs, while the skills required for it are generally advanced and only slowly subject to routinisation and deskilling themselves (Bessant et al., 1981, p. 13; Allen, 1982).

Observation of a compositional upskilling of the workforce is by now commonplace, ranging from the case-study (Dickson, 1980) to the broad category of IT application (e.g. CAD/CAM; Gold, 1982) to the effects of IT as a whole (e.g. Commission of the European Communities, 1982, p. 115). A striking image is provided by Bessant and his colleagues in predicting that "the shape and structure of occupations is likely to change from the conventional pyramid, with large numbers of unskilled and semiskilled workers at the bottom, to something more resembling an orange or an onion...in which a bulge occurs at the middle level of skill" (1981, p. 72).

The consensus view of compositional upgrading of the workforce may derive further support from trends in the structure of employment by plant size. A central effect of IT is to improve the economic competitiveness of small-scale production, which uses IT-based equipment to produce goods in small and medium-sized batches and mass production. Such technological developments harmonize with a shift in consumer taste away from standardized products towards variety and product specialisation. According to some commentators, the result is that small-scale production becomes in many markets not just "beautiful" but also efficient (Sabel, 1982; Piore, 1982). Evidence of such trends can be found in the metal-working and textiles industries of Italy and Britain, where relationships between large corporations and small-scale subcontractors using high technology have evolved increasingly in favour of the independence and initiative of the latter (Brusco and Sabel, 1981). The importance of the phenomenon remains to be quantified. However, as small-scale IT-based production is likely to require a richer skill-mix than does its large-scale counterpart, the requirement for skills in production is thereby raised still further.

Two major caveats must however be levelled against the generalisation of the concept of occupational upgrading. The first concerns the production sector itself, the second the service sector. In the production industries, one cannot simply expect IT to "sweep the board" given enough time to do so. Large slices of such manufacturing industries as clothing, toys and furniture (Craig et al., 1983). In Britain at present the economic basis of low wage, labour-intensive employment is actually being bolstered by the intentional erosion of statutory wage protection. The cost of IT-based processes will have to fall to very low levels indeed before it can eliminate the menial jobs of such businesses.

Secondly, there is the expectation of continuing growth in the employment share of the service sector. As services comprise not only the skill-intensive professional services but also the relatively low-skilled personal services, continued expansion in the role of the latter will work against compositional upgrading for the economy as a whole. The recent warning by the British Chancellor of the Exchequer that future employment growth might have more to do with "low tech/low pay" jobs in services than with "high tech/high pay" jobs elsewhere shows how seriously this prospect is taken in official circles.

The Experience of the Process Industries

We may obtain a partial picture of the likely evolution of occupational structures in the factory from the recent history of the "process industries", i.e. sectors (such as petroleum and chemicals) which use continuous process technology to produce a large share of their output. They were the focus of new methods of automation and computer control during the 1950s and 1960s. Process technology replaces the previous labour-intensive batch system of production with the continuous flow of materials through the plant, the output of one stage acting directly as input to the next, with few or no stocks of intermediate products being held on the way. The Japanese corporation has already applied this principle of process production to the mass production of discrete solids, through the "just in time" system. Inventories are reduced to minimal levels at all stages of production, thereby approximating continuous flow conditions in machining and assembly contexts (Schonberger, 1982). IT facilitates this development in most sectors of manufacturing. The integration of workshop operations which is attainable even at present under CAD/CAM and FMS diffuses the conditions of continuous process production from the early process industries to much, if not all, of the rest of manufacturing (Bessant, 1983, p. 21). Under the most advanced systems, raw materials are transported automatically between computer-controlled machinery with little or no human intervention en route and without the need to hold stocks of half-finished goods along the way. Differences may well remain between the results for fluid and discrete solid products. In particular, the prospect for the full elimination of human intervention may remain technically lower in the transformation of metals, for example, than in that of fluids (Sorge et al., 1983, p. 162). The point remains debatable. In any event, the similarities, in terms of the reduction of operator intervention to well below pre-computerised levels, are likely to prove more striking than any differences that may remain after automation has run its course. The existing option of running night shifts in FMS plants with low or zero operator presence supports the point.

Information upon the occupational structure of the process industries is best sought from the United States, given the quality of its statistics and the early timing of process automation. Between the population censuses of 1940 and 1970 the official United States occupational classification system remained formally unchanged. Subject to provisos concerning the limited reliability of occupational classifications across time and sector (Hodge and Siegel, 1966), changes in the occupational composition of industries during this period shed light upon the effects of automation upon skill mixes.

We contrast the experience of three industries whose technology gravitated increasingly to continuous flow methods in the period (steel, petroleum and chemicals) with three non-process ones (aircraft, electrical machinery and textiles). The latter are chosen to represent a variety of technologies and skill mixes, from aircraft at one pole to textiles at the other. Table V.1 reports the employment shares of two groups of occupations: professional, technical, craft and manual supervisory (PTC), on the one hand, and operative, service and labouring (OSL), on the other. The PTC category includes the most skilled jobs in both manual and non-manual areas, while the OTS group covers the least skilled jobs in the manual area (Scoville, 1966). The table also reports limited data on the dissemination of digital process computers in four of these industries where usage had become important by 1970. Data are not provided in the source for textiles or electrical machinery, but there is reason to expect that process computerisation remained low in each case, and trivial in the case of textiles.

Occupational upgrading characterised the years between 1940 and 1970 in all sectors in Table V.1, in the sense that the employment shares of PTC were higher, and those of OSL lower, in 1970 than in 1940. (The only exception to the generalisation is the share of the PTC group in the aircraft industry, where the decline in the share of craftworkers between 1940 and 1960 more than offset the rise in the share of professionals and technicians.) Upgrading was particularly rapid in both chemicals and electrical machinery during the 1950s. By 1970 the shares of the skilled PTC groups had outstripped those of the less skilled OTS ones in petroleum, and come close to them in chemicals and steel.

If automation and computer control of operations lead to extensive occupational upgrading, then upgrading should be faster in process than in non-process technologies, and faster during the phase of computerisation than before. In practice each of these predictions receives at most limited support from the United States data. Occupational upgrading may indeed have proceeded somewhat faster in the "process" than in the "non-process" industries. As gauged by the last four columns of Table V.1, the rate of increase in the shares of PTC groups tended to be somewhat greater, and the rate of decline in those of OSL somewhat lower, in the process than in the non-process group in both the 1950s and 1960s. There are several exceptions, however, involving most notably the rapid changes in electrical machinery in

126

Table V.1

COMPUTERISATION AND OCCUPATIONAL MIX BY SECTOR, UNITED STATES 1940-70

	Number of Process Computers in Place			Changes in Employment Shares								Employment Shares of			
				PTC(1)				USL(2)				PTC		USL	
	1950	1960	1968	1940 %	1950 %	1960 %	1970 %	1940 %	1950 %	1960 %	1970 %	60/50	70/60	60/50	70/60
A. Process Industries															
Petroleum Refining	0	6	110	30.7	36.6	39.9	44.4	40.6	37.8	33.9	30.0	109	111	90	88
Chemicals (3)	(0)	(5)	(156)	19.9	27.7	33.0	34.5	50.5	46.3	38.6	36.7	119	105	83	95
Iron and Steel	0	3	132	29.5	34.5	38.2	40.9	58.5	52.8	48.5	44.9	111	107	92	93
B. Non-Process Industries															
Aircraft and Parts	0	0	252	51.6	50.9	48.7	50.0	35.3	31.7	30.8	29.1	96	103	97	94
Electrical Machinery	n.a.	n.a.	n.a.	26.4	27.7	32.5	32.9	50.7	53.0	46.9	46.9	117	101	88	100
Textile Mills(4)	n.a.	n.a.	n.a.	n.a.	12.4	15.1	18.1	n.a.	79.7	74.6	70.1	122	120	94	94

Sources: U.S. BLS (1970), Table 2
U.S. Bureau of Census, Census of Population, 1940, Vol. 3, Table 82; 1950, P-E 1C; 1960, PC(2)-7C, Table 2; 1970, PC(2)-7C, Tables 1, 8.

Notes: 1. PTC: "Professional and Technical" plus "Craft, Foremen and Kindred".
2. OSL: "Operative" plus "Service" plus "Labouring".
3. Computerisation figures apply to industrial chemicals only.
4. Yarn, Thread and Fabric mills.

the 1950s and the slow changes in chemicals during the 1960s. Taken as a whole, the similarity in the direction and pace of change between these two groups is more striking than the differences between them.

Nor is it clear that computerisation can be associated with an intensification in the pace of occupational change. The data on installations of computers for process control do at least establish that the 1960s were a decade of rapid computerisation, starting from a negligible base in 1960. Yet the rate of occupational upgrading in steel and chemicals proved in the 1960s substantially <u>less</u> rapid than it had in the 1950s, while in petroleum the differences between rates of change in the two decades were very small indeed. However, in aircraft, the period of rapid installation of computers for process control in the 1960s saw, perhaps not coincidentally, the reversal of the post-1940 trend towards the reduction in the shares of PTC groups.

The evidence, limited as it is, suggests that it was automation without computerisation, which appears to have proceeded at a rapid pace in the process industries in the 1950s, which provided the main fillip to occupational upgrading, with computerisation (until 1970 at least) as simply a reinforcing factor. Moreover, process-type automation is not the only factor leading to the compositional upgrading of the labour force, as two of the three non-process industries were generally moving in the same direction, albeit from very different starting points. The results underline the continuity of technical and occupational change and the dangers of dramatising the differences made by computerisation, at least in its early variants. Limited effects are certainly to be expected in a period when computerisation had by 1968 typically affected less than five per cent of employment in the plants involved (US Department of Labor, 1970). More substantial effects may be expected from computerisation <u>per se</u> as its coverage extends more broadly through the workforce.

The experience of the older process industries is relevant in addition [illegible] the issues of the previous section, <u>viz</u>., the skill content of particular [illegible]bs. The share of production operatives in the employment mix was [illegible]erically as great in the United States steel, chemicals and petroleum [illegible]stries in 1970 as it had been in 1940 (Table V.2). The content of work [illegible]wever changed greatly during that time as automation took over. In the [illegible]eriod (in Britain, at least) the steel and chemical industries were [illegible] by batch production at all stages. Work was typically heavy and ho[illegible], [illegible]lving for the key production grades the needs for considerable "feel" for [illegible] characteristics of the mix or melt, a feel developed only by long experience of the job (Parmagenta and Overy, 1984). The introduction of automatic controls and subsequently computerisation in the post-war period changed all that. The labouring component of the work disappeared as products flowed automatically from one stage to the next, largely out of human sight. The direct contact with materials of the production operative was eliminated and replaced by the distant supervisory role of the modern process worker, a reader of displays and a presser of buttons. Skill in the traditional manual, experiential sense was removed and in its place was substituted knowledge -- of both the equipment in question and, more generally, of the scientific basis of the process. In terms of job requirements, educational requirements increased while training and experience ones declined; and requirements for the vigilance and responsiveness which would avert major incidents and large losses rose as those of know-how and "feel" declined.

Changes occur also in the social dimension of skill: viz., the opportunity and necessity for interaction with other employees in order for production to proceed smoothly. Process technologies foster team organisation of work (Gallie, 1978), leading many to expect an increased requirement for social skills as a result of the diffusion of IT. A rise in the conceptual relative to the physical content of job tasks within process work certainly points in this direction. At the same time, the tendency for manning levels to fall as capital intensiveness rises, with individual workers responsible for whole series of automated equipment, functioning in relative isolation from other operating personnel.

The evaluation of these changes called forth much the same diversity as has the microprocessor in the recent period. Some have urged that the work of the process worker is a deskilled version of the old production crafts, with only managerial tolerance or control allowing for good pay and conditions of work (Stone, 1973). Others have by contrast seen in process work a form of liberation from demanding and repetitive work routines, along with an upgrading of intellectual contributions to work (Blauner, 1964). Recent investigation suggests that process work remains less than an experience of joy in work. Process workers complain about the isolation of much of the work; about the disruption of living patterns imposed by shiftwork; and about the peculiar demands made by a job in which there is for long periods little to do but watch, followed unpredictably by episodes in which rapid action is required if equipment and materials are not to be ruined (Gallie, 1978). One can imagine the state of mind of the operating personnel in nuclear power plants, for example, after the Three Mile Island incident; or of chemicals process workers after the Flixborough explosion in Britain in the 1970s.

Table V.2

SHARES OF OPERATORS IN TOTAL EMPLOYMENT IN PROCESS INDUSTRIES, UNITED STATES, 1940-1970

Sector	1940 (%)	1950 (%)	1960 (%)	1970 (%)
Petroleum	24.2	26.3	26.3	23.7
Chemicals	30.9	33.6	30.6	30.1
Iron and Steel	28.9	30.0	28.6	30.5

Sources: US Department of Labor, Bureau of Labor Statistics (1970), Table 2
US Bureau of Census, Census of Population; 1940, Vol. 3, Table 82; 1950, P-E 1C; 1960, PC(2)-7C, Table 2; 1970, PC(2)-7C, Tables 1,8.

The difficulty of determining whether the skill level of process workers is raised or lowered by automation in the undimensional sense is not however universal. In some instances a change in the overall level of skill required can be seen clearly alongside that in composition. Such cases arise when the upgrading of intellectual and technical requirements is small relative to the downgrading of traditional manual skills. An example is provided from the recent period by the automation of the job of dough mixer in a British biscuit factory. Much like the old steel and chemical workers, the "doughman" previously controlled the combination of ingredients and the duration of cooking, using a combination of feel and experience to decide what adjustments to make and when to conclude tbe processing of a batch. The introduction of computer control of mixing took away key discretionary elements from the doughman, leaving to the reconstituted job of the "mixer operator" the lesser tasks of starting, supervising and stopping the process. As the new job was constituted by management, only limited understanding of the process and equipment was required of or developed in process workers (Buchanan, 1983).

Thus, even in process technologies, Taylorist applications of new technology are not unknown. The crucial question facing the long-term viability of such strategies concerns the scale of the resulting costs to be faced by management in terms of greater downtime, absenteeism and turnover. Where capital intensity remains limited, as appears likely in the biscuit factory, Taylorism may remain a popular strategy.

The experience of the last 30 years in the process industries suggests therefore that automation does indeed result in marked long-term changes in both the content of skills required for production work and the balance of occupations required by the enterprise. At the same time, the alterations in skill content for production operatives need not -- and under Tayloristically inclined management, do not -- mean an overall upskilling of job content. Similarly, the occupational upgrading of the workforce, while substantial over the longer term, appears little more intense than in non-process industries before the advent of computerisation. The extension of computerisation and decentralisation in information utilisation at the workplace may indeed mean such discontinuity that the past will provide only a poor guide to the future. Extrapolation from initial applications is particularly hazardous in the case of information technology (Brooks, 1983). Past experience, for what it is worth, does however suggest that computer-based automation will continue existing tendencies in the division of labour; and that it will tend to upgrade the human contribution to production, although deskilling will still result when capital requirements are low and management is wedded to the Taylorist interpretation of work.

5. Conclusion

If one central conclusion emerges from the by now vast literature on IT, it is that technological determinism cannot fill the bill. As argued long ago by Bright, there is no unique way in which IT will be used, whether to enrich work or to intensify hierarchical control. The conclusion is expressed by the FAST Programme report in terms of a "fairground" of possible outcomes (Commission of the European Communities, 1982); the "plasticity of the social implementation" of technology by d'Iribarne (1981),; and by Bessant (1983), in terms of a "design space" around IT. The microprocessor has already been applied in a variety of ways in different contexts. Production equipment embodying IT is set up in one plant around specialised machine-minding jobs, in another around the skills of technician operatives. In this sense there is little new about IT. It appears rather as a new formulation of old problems, one more factor in the variety of influences upon the organisation of work and the utilisation of skills.

At the same time, new technology may have some predictable influences upon division of labour and skill requirements. In the first place, the range of options itself may wax and wane as one technology replaces another. In particular, by grafting the decentralisation of information processing and utilisation onto existing centralised computing systems, the microprocessor has widened the range of choices in many areas of work organisation. Thus in the non-manual area it has enhanced the possibility of clerical autonomy in the handling of client accounts, as illustrated by the French banking and American insurance examples. The incorporation of microprocessor controls in numerically controlled machine tools makes programme editing at the machine technically feasible, thereby increasing the range of possibilities in the organisation of programming and operating tasks. More generally, the development of CAD/CAM and FMS production systems appears to be changing the terms of competition between hierarchical, division-bound organisations and innovative, matrix-structured ones in favour of the latter. To the extent that such is the case, technical change is indeed encouraging the development of more skill-using and less hierarchical forms of work organisation.

We have seen that changes in job content and skills associated with the utilisation of IT are influenced by particular characteristics of both the IT application and its context. The major influences include: the change in capital-intensiveness of operations as a result of moving to IT; the extent of automation and the degree to which human intervention is still required; the reliability of the equipment; the degree to which small-scale production is made economically viable; and finally -- and prospectively most important of all -- the nature of control over the organisation of work, whether hierarchical or collective; and, to the extent that it is hierarchical, the strategy of employee motivation and control favoured by management. If the range of possible outcomes is therefore nearly as great as the number of permutations of these factors, there is nevertheless one distinctly more deterministic aspect of IT applications. By removing from human intervention the most routine job tasks in factory and office before moving on to the more complex ones, and by creating more complex job tasks in erecting and maintaining the automation of the less complex ones, IT continues (in the production industries at least) the trend towards the occupational upgrading of the workforce which was already under way as a result of pre-computerised forms of mechanisation and automation.

Perhaps the most striking cases in the IT literature, and the ones most supportive of an optimistic standpoint, involve instances of conflict between managerial control strategy and the operating requirements of IT systems. In the French bank, the American retail debt collection office and the English biscuit factory, management organised work around new technology in classical Taylorist mould -- minimising skill requirements and employee autonomy. In all three cases the familiar forms of Taylorist dysfunction showed up: notably low product quality and high turnover. Such less immediately visible manifestations of inefficiency may result in changes in managerial strategy, whether as a result of learning from experience or from extinction at the hands of more perceptive competitors. Cases of enterprise extinction as a result of sub-optimal utilisation of IT will necessarily show up only rarely in the literature. Of course, examples of managerial correction in the light of operating results are however fairly common. In France, in addition to the case of banking, we find that in an artificial fibres plant management tactics shifted from using computerisation to intensify hierarchical control over employees towards using it to support semi-autonomous work groups (d'Iribarne, 1981, p. 19). In Britain managements have not infrequently set out to use CNC to promote deskilling and subsequently changed course in favour of skill utilisation (Senker, 1984b, Ch. 3). In such cases new technology will indeed have exerted a marked influence upon the organisation of work, by rendering increasingly costly the low trust, highly regimented form of organisation.

At the same time it is too much to expect dramatic results from IT on this front. In some applications of IT its high reliability and ability to intensify hierarchical control make the quality of employee commitment relatively unimportant for production. In others, managers have defied the critics of Taylorism and maintained Taylorist forms of work organisation, with or without concomitant losses of operating efficiency. The list of IT-users which have opted to maintain or even intensify structures of work fragmentation and hierarchical control is strikingly long.

In this respect, as in other (Sorge, 1984), the main advantage of IT may be to galvanise political discussion of a key issue in social welfare and prod the state rather than the corporation towards action on the quality of work. The Norwegian and French governments have during the last decade passed laws which assist employees to put pressure on their employers to redesign the most deskilled jobs -- thereby demonstrating that social concern about the availability of jobs does not preclude consideration of the quality of jobs. The limits to such reforms are clear. However, instead of relying passively and optimistically upon IT to "re-enchant the workplace", those who hold deskilled work to be a major social problem may instead use the issues raised by IT as a focus for political action and pressure for state intervention.

Chapter VI

INFORMATION TECHNOLOGY AND HUMAN RESOURCE DEVELOPMENT

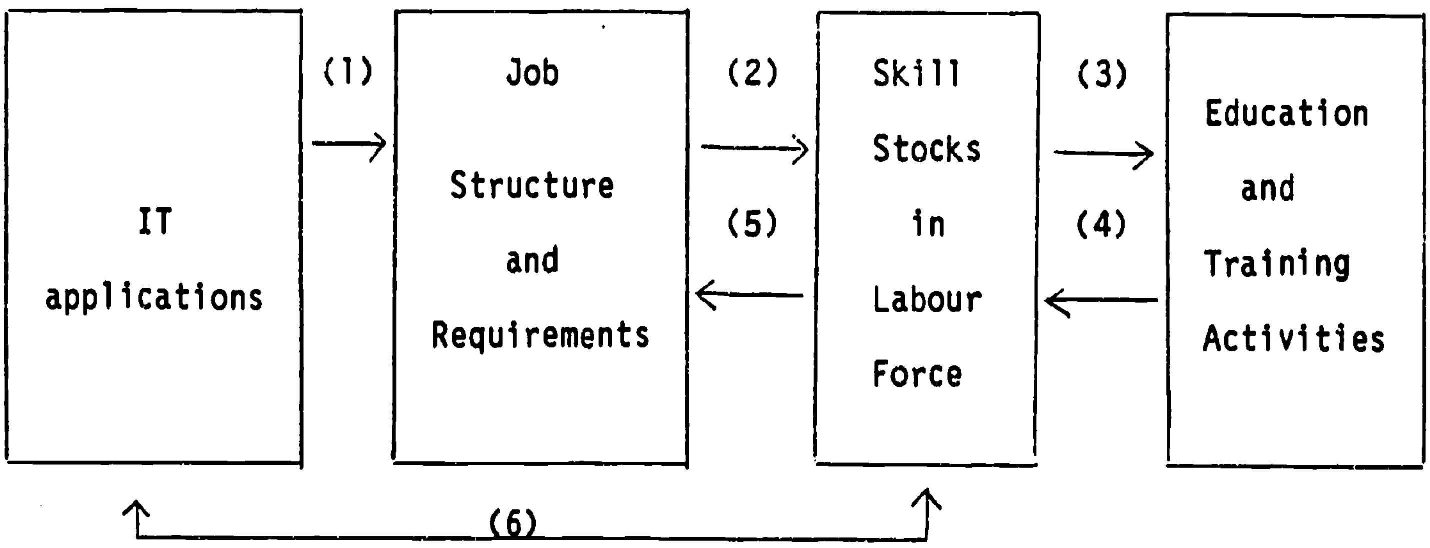
Those who predict rapid and fundamental changes in the structure of job skills as a result of the dissemination of information technology not surprisingly go on to urge that IT has profound implications for the education and training of the workforce. If IT is to result in a general upskilling of work and a continuous restructuring of production methods, then it seems logical to call for the development of a foundation training with a strong technological element for all young workers, as well as lifelong access to education and training in order to cope with future changes in job requirements. On the educational side, the advent of the computer society has led to calls for the recasting of formal education in order to emphasize abstract and analytical skills, together with numeracy and the computer literacy which will in future become part of life in broader society as well as at the workplace. This chapter will argue that such propositions are not only over-simplified but also distinctly misleading, at least in the sense of any inexorable requirements of IT itself. However, as in the case of job structure, the issues raised for training and education by the IT "enthusiasts" have a validity and importance quite apart from the presumed requirements of IT itself.

In order to establish at the outset that there are no simple answers in this area, we consider first the links between IT and human resource development. As depicted in Figure VI.1, changes in the occupational structure of the economy will undoubtedly lead to changes in the education and training of the members of the labour force. The relationship is however far from close. There is no necessary link between the educational and training requirements of jobs and the skills embodied in the workforce (line 2 in Figure VI.1). In some cases, people may be under-prepared for their jobs; in others, they may have received more knowledge and skill than they can use in their jobs. In addition, the timing of the education and training received can vary -- from being completed before job entry to being conducted in phases during the period of job occupancy (link 3).

Not only is the relationship between jobs and skills loose, it is also characterised by reverse causality. Although it is customary to think, as was largely the case in Chapter V above, of job design being set by management according to considerations of efficiency and control, there is also a potentially important influence for skill supplies to take into account (link 5). Comparisons of work organisation in matched French and West German factories have noted the richer skill mix and the lower supervisory content of work organisation in Germany. The difference is attributed in part to the superior supply of skilled (and therefore more self-reliant) workers produced by the German apprenticeship system (Maurice, Sellier and Silvestre, 1979, 1984; Krais, 1979; Lutz, 1981). Similarly, the deskilling inclinations of some British users of CNC machine tools have been attributed in part to the difficulty of securing a supply of skilled labour (Jones, 1982).

Figure VI.1

LINKS IN CHAIN BETWEEN IT AND HUMAN RESOURCE DEVELOPMENT



This chapter examines in turn three aspects of the development of skills in the modern economy: the quantity and quality of education and training provided (section 6.1); the content of education and training (6.2); and the distribution of opportunities to learn skills (6.3). In each case an attempt is made to outline the situation as it stands in practice before moving on to assess the potential implications of IT. Finally, section 6.4 discusses the evidence for reverse causality, with the quantity and quality of skill provision appearing as a powerful influence upon the speed and success attained in the race to apply IT in practice.

1. <u>IT and the Provision of Skills</u>

The advent of electronics at the workplace promises at least to underline some deficiencies in the systems of vocational education and training of many advanced economies. In this section we begin with the category for which problems of provision are most distinctive: costly transferable skills. Two representative cases are examined: electronics engineering, for which skill development occurs primarily in formal schooling apart from employment; and craft maintenance, for which skills are developed largely at the workplace as part of an employment relationship. The discussion turns then to less costly and more employer-specific skills, such as those of managers and process operatives, in order to see whether IT is likely to alter the difficulty of provision in those areas as well. Finally the case for universalisation of training provision as a response to the needs of new technology is discussed.

Problems of skill supply related to IT have already emerged in occupations where substantial knowledge of electronics is required -- notably in the design and maintenance of the equipment and systems in which IT is embodied. The demand for electronics engineers and electronically trained maintenance craftworkers has already substantially outstripped supply in a variety of advanced economies. The same is true to some extent as well for other skills directly related to IT, such as those of software programmers and CNC operatives. We concentrate upon the situation of the engineers and maintenance crafts both for their numerical importance and for their representativeness of the factors at work in other, less strategic occupations.

Electronics Engineers

The existence of a shortage of engineers and technicians in Britain has been considered by various studies (Finniston, 1980; GB National Economic Development Office, 1982; Tarsh, 1984). Its scale is reflected in the statement by manufacturing firms in 1983 that they would collectively have increased their employment of electronics engineers by nearly one-half of existing levels were they readily available from the external market. It is not that the supply has failed to respond strongly to the increase in demand. Between 1981 and 1983 alone, the number of electronics engineers at work almost doubled, from 26 000 to 46 000 (Northcott and Rogers, 1984, p. 64). However, not even this rapid increase in supply proved capable of meeting the boom in demand.

In this respect, as in others, IT underlines a long-standing problem in the market for university-educated employees: serious lags in the reaction of supply to demand and difficulty in providing appropriate price signals. For electronics engineering the training period is long, requiring a three- or four-year university course plus further practical work experience. The length of the gestation period may indeed be reduced by adapting the already existing skills of electrical and mechanical engineers through upgrade courses -- and indeed a near-doubling within two years in the employment of electronics engineers in Britain could only have come about by way of extensive upgrading. At the same time, the responsiveness of supply from related fields is limited by the need for the services of engineers in more traditional applications, leaving university training of new entrants as the marginal source of supply. Lags in adjustment and shortages are therefore the inevitable result of rapid increases in demand for electronics engineers.

Three adjustments may serve to reduce the severity of shortages: price rises, alteration of work organisation and state educational policy. In the first place, the shortage of engineers is expected in a competitive market to increase the relative price (earnings) of the skills in excess demand (Arrow and Capron, 1959; Freeman, 1971). The price increase then encourages university students to alter their subject choices at the margin towards electronics engineering, thereby increasing supply in three to four years' time. In the meantime a second adjustment serves to reduce demand: employers, finding the services of electronics engineers both scarce and increasingly expensive, reorganise work so as to concentrate their engineers' time upon the tasks where they are most urgently needed, leaving the less important ones to technicians and other less qualified personnel. In this way a fluid market system might limit the scale and duration of shortages of engineers to moderate levels.

It would however take a strong brand of "market optimism" to predict that shortages will therefore be mild and transient. The difficulty concerns not the danger of overshooting, resulting in alternating periods of shortage and surplus, as in the cobweb models upon which the literature has concentrated; but rather the logically prior constraints upon price adjustment itself which are generally ignored by competitive theory. To the extent that engineers are employed in large organisations with structured payment systems, the firm may encounter difficulty in raising the pay of engineers without doing the same for related, non-manual occupations -- managerial, professional and technical.

On the surface the problem looks like one of rigidities resulting from job-evaluated payment systems, where the content of the job rather than the state of the external market governs relative remuneration within the organisation. Such payment systems are indeed common in non-manual work in large organisations and will indeed impose restraints upon adjustments in pay, given the infrequency of revision of most schemes (Daniel and Milward, 1984). The more fundamental difficulty lies however in the concept of equitable differentials which job evaluation schemes typically embody -- and which other employees will typically be reluctant to see violated simply because of shortages in the external market. Such desires for horizontal equity in internal wage structures have been found powerful relative to market forces in studies of manual occupations (Doeringer and Piore, 1971; Ryan, 1980; Marsden, 1982). They are likely to be weaker in professional employment, where union membership is less common and differences in individual remuneration more common than for manual workers. Certainly the earnings of electronics engineers have been subject to little or no restraint from this source amongst the new and rapidly growing IT producers in Silicon Valley, and elsewhere. However, the bulk of employment for electronics engineers continues to be found in large, older organisations whose engineers are subjected to many of the same "internal labour market" procedures as are manual workers (Mace, 1979). In Britain in particular the earnings of engineers in general have been found by a recent enquiry to be too low to provide sufficiently strong incentives to enter the profession (Finniston, 1980, Ch. 3). The upward adjustment of price to reduce the depth and duration of shortages is therefore stymied by the rigidities of corporate pay structures (Tarsh, 1984).

A similar phenomenon in educational institutions intensifies the difficulty. In order to accommodate any increase in interest in studying science in schools and engineering/electronics in universities, a rising supply of qualified teachers is required. However, given the low level of teaching salaries relative to those for scientists and engineers, schools (and to a lesser extent, universities) have experienced difficulty in attracting and retaining sufficient staff to meet prior teaching loads, let alone cope with current increases. The education system might be expected to respond in turn to its shortages of personnel in science and engineering by raising salary levels in order to compete more effectively with the private sector. However, the strength of the sentiment of equal pay for teachers of all subjects in the school requires (particularly when teachers are highly unionised, as in Britain) that the pay of teachers in other subjects rise as well -- a fiscal impossibility. Yet another constraint is thus imposed upon the response of supply to shortages in the area of professional skills.

The prospects for limiting the severity of shortages in electronics engineering will therefore depend to a considerable extent upon the policy of the state, which, as the provider of most of the finance and (in some countries) arbiter of the number of places provided, can exert a potent influence upon outcomes in this area. We see the state moving in two contradictory directions, in Britain and the United States at least. On the one hand, government shows concern to alleviate shortages by diverting teaching resources towards engineering, science and computing in schools and colleges. At the same time, however, the general campaign to reduce state expenditures has in both countries damaged the ability of educational institutions, particularly in the public sector in the United States, to provide the equipment and teacher salaries necessary to provide effective education related to electronics engineering (Useem and Kimball, 1983). Similarly, an aspect of the 1980-81 cutbacks in university education in Britain which attracted widespread criticism was the concentration of the cuts upon newer, less élite universities such as Aston and Salford, where science and engineering subjects were more strongly represented than in the rest of the university sector. Taken as a whole, therefore, state educational policy in Britain and the United States has proven distinctly ambiguous towards the professional education required for information technology. The difficulty is however absent in countries which have remained largely unaffected by monetarist ideology (especially Sweden) or whose industrial systems show a highly technical ethos and a status bias in favour of engineering (especially Japan and West Germany).

Maintenance Craftworkers

The skills of maintenance craftworkers have in common with those of engineers not just the infusion of new electronics content but also a requirement for a long and costly training period. Where they differ is in the much greater importance of workplace-based training and job experience relative to that of formal schooling in the effective development of skill. Theoretical understanding is certainly important for craft work and that part of the skill is also best developed in a classroom context; but there remains the requirement for extensive on-the-job training. Consequently such skills are developed in most countries primarily through workplace-based apprenticeship-type programmes.

The market economy has generally failed to provide an adequate supply of such skills. The problem is not one of lagged adjustment so much as a structural limitation on the willingness of the parties to training to incur its costs. In competitive theory, to the extent that the resulting skills are highly "general" (i.e. transferable between employers), the trainee is predicted to incur the costs of training by enduring a period of low earnings, consistent with his or her low productivity during the training period. The trainee's willingness to do so depends upon the increase in future earnings, when the skill learned comes to be sold in the labour market. Employers are therefore not called upon to finance such training -- nor, so the theory predicts, will they be willing to do so. Any firm which invests in training for a transferable skill will find itself incapable of earning a return on its investment, as other employers who find it advantageous to meet their skill needs by hiring ("poaching") skilled workers rather than training themselves acquire a competitive edge in product markets. At the same time, the employer will be willing to provide as much training as employees themselves demand, as its trainees are financing the learning themselves (Becker, 1964).

Problems of skill provision can arise even in the competitive model of the labour market. Given the inalienability of human skill, trainees will find it difficult to borrow to finance training -- and therefore, in the case of a prolonged period of low productivity, unable to finance the sacrifices involved when the costs of training fall wholly upon them. State support of trainees then becomes crucial to the undertaking of training, as for school-based skills such as engineering. For maintenance crafts, however, state aid to trainees -- while recommended by some orthodox economists (Lees and Chiplin, 1970; Ziderman, 1978) in the form of maintenance grants, loans and the like -- fails to address the key issues. Susidising employee willingness to be trained offers little benefit when the key scarcity is employer willingness to offer training in the first place.

In practice the burden of costs for workplace-based training in costly transferable skills falls heavily upon employers, with trainees bearing small or negligible shares of costs. In most countries trainees are indeed paid less than both workers who are not in training and skilled adults. The differences are not however great, so that little sacrifice, if any, is required of persons undertaking industrial training. Thus in modern Britain, the typical apprenticeship for craft or technician work in engineering is estimated to cost the employer as much as £ 12 000; costs to the trainee are not reported, but they are certainly well below that -- and possibly even negative at a time of large-scale unemployment and scarcity of alternative sources or income (Atkinson, 1982). Substantial costs to the employer are also found for initial training in case studies of training (Thomas et al., 1969; Ryan, 1980), as well as in surveys of training costs in West Germany (Edding, 1974; Noll et al., 1983). The costs of training conducted on the job are certainly difficult to estimate (Drake, 1982), but the dominant role played by employers in finance as well as provision stands out strongly.

Undoubtedly in some cases the willingness of employers to finance training at the workplace reflects a degree of specificity in the skill to that particular firm's operations -- a factor emphasized by Becker as the only one which permits employers to incur training costs in otherwise competitive markets. The heart of the explanation must however lie elsewhere, as the skills involved in studies of training costs are generally singled out partly for their high transferability between employers. Orthodox theory neglects the crucial fact that the training-related aspects of wage structure are determined by a set of considerations quite apart from the conventional requirement of clearing the labour market. Such considerations involve the bargaining objectives and strategies of trade unions -- and in particular the way in which unions seek to regulate the entry of young workers into the firm and the use of trainee labour by the employer.

National variation in such matters is considerable, but all respond to a common issue: how to ensure that the workforce is reproduced through training while preventing the trainees themselves from posing a threat to the job security and earnings of the trained workforce. The difficulty with the competitive scenario is not that low trainee pay is an impossibility. It was indeed common in earlier periods, for example, under apprenticeship in Britain until the 1940s. However, low trainee pay creates an incentive to employers to reorganise the division of labour and substitute productive work for training during the training period, to the detriment of the quality of training but to the benefit of profits. Such substitution takes job opportunities away directly from the adult workers who would otherwise be performing the tasks in question; it also sets the interests of trainees and youths against that of experienced and adult workers, thereby weakening the bargaining power of the worker collectivity and jeopardising its ability to raise pay. The trade union has therefore an interest in restricting the competitive threat posed by such pseudo-trainee labour. While some strong occupationally based unions have sought to counter the threat by imposing quotas on the employment of youths and trainees (as through apprentice-journeyman ratios), most unions have preferred to respond by pay policies which remove the incentive to employers to substitute trainees by making trainee labour expensive and breaking the putative link between trainee pay and productivity in training.

The way in which such objectives have been pursued by trade unions remains an under-researched topic. At the same time, clear variations can be seen across countries. The most common regulatory policy sought by unions is a standard "rate for the job" policy, in which there is no concession in pay for the use by firms of trainee labour, trainees being paid the same as experienced workers in the same occupational area. An approximation to such policies is seen in the United States, where collective bargaining agreements typically allow only short and temporary reductions in pay for trainees even in the more skilled jobs in the manual area (Ryan, 1984a, Table 7.1). In Britain, the Netherlands and Italy, apprenticeship has traditionally been encouraged by the system of "wage for age" pay schedules in collective agreements, under which the pay of young workers (and therefore most trainees) increases (as a ratio of adult pay) with age. Unions have however sought to increase such ratios over time, with cumulatively large effects over the post-war period in Britain (Ryan, 1984c) and, apparently, Italy (Pescarollo, 1981). Only in West Germany has a tradition of low apprentice and youth earnings been maintained until the present, in the shape of the allowances provided to 15-18-year-old non-students whose economic activities are governed by the apprenticeship system. The acceptability of such a regime from the union side reflects safeguards against the exploitation of trainee labour embodied in particular in the state's willingness -- in principle if not always in practice -- to take away from those employers who fail to train to mandated standards their rights to have youths on their premises (OECD, 1980; Sadowski, 1981; Taylor, 1981).

The result is that, by one institutional mechanism or another, employers who provide training in costly transferable skills such as maintenance crafts must nowadays provide the lion's share of the finance themselves. The situation is most striking in the case of West Germany, where the low allowances of trainees are often viewed with favour as a way of cutting the burden of training costs on firms (Jones, 1982; Jones and Hollenstein, 1983). The link between trainee remuneration and employer costs is certainly direct and strong, but it is striking to find that, even in West Germany, employers who provide apprentice training bear costs which are substantial and which have risen over time (Noll _et al_., 1983).

The result of the skewing of training costs towards firms depends upon the nature and cost of the training involved. For skills such as maintenance crafts, the training period is long and the costs involved are potentially great. As the resulting skill is usually highly transferable, the result in the balance of incentives is shifted from training the unskilled towards hiring the already skilled. Most employers reduce the number of training places they offer to below levels capable of meeting even their own needs for skill; others do no training at all. Those who provide training do so at all because at some point the labour market proves an inadequate source of supply when all have reduced their training activities; because they possess some insulation from competitive forces in labour and produce markets; or because training within the firm permits the specificity of skill to that employer to be increased by the redesign of jobs and training (Taylor and Piore, 1971; Ryan, 1984a).

The limited willingness of employers to provide training in costly transferable skills is intensified under conditions of recession. The pressures imposed on the profit margins and costs of producers in manufacturing industry in particular during the last decade have all too frequently resulted in cuts in the corporate training budget. The ease with which training funds can be sacrificed without short-term loss is increased by accounting conventions which treat training outlays on current rather than capital account; and by the difficulty of finding places in the firm for ex-trainees when employment levels are contracting. Thus in both Britain and the Netherlands recent years have seen large reductions in the amount of apprentice training provided by firms (GB Engineering Industry Training Board, 1984, p. 28; Sellin, 1983, p. 80).

Furthermore, the efforts of public policy to enhance the quality and quantity of training have had some unintended effects in the area of costly transferable skills. Quality regulation is most marked in West Germany and Britain, where the dominant role in training lies with employers rather than the state. The erection and tightening of standards for private sector training since 1950 in Germany and 1964 in Britain (under the Industrial Training Boards) has certainly raised the quality of apprenticeship substantially in each case. It has also raised correspondingly the cost of each apprentice taken on by employers, thereby paradoxically increasing the disincentive to train and jeopardising the attainment of quantity objectives.

Public action to increase the quantity of training has been pursued through two channels: direct provision in vocational schools and regulation of private provision. In Sweden, Belgium, Italy and France, the state is the dominant provider of initial training, acting through a network of courses and certificates provided in public vocational schools. In West Germany, France and Britain, by contrast, the state has sought instead to encourage the provision of training places in the private sector by offsetting disincentives to train (OECD, 1979b; Ryan, 1981; Hayes, 1981). Thus under the 1964 Industrial Training Act in Britain employers were required to pay a payroll levy to an Industrial Training Board which would in turn provide grants to those firms which provided recognised courses of training. A national training tax is levied on firms in France; payments can be reduced or avoided by providing training within the firm (OECD, 1973b; Jallade, 1982, p. 89). In West Germany a national training levy system was authorised in 1976, to be activated only when the supply of apprentice places offered by employers failed to exceed the number demanded by young workers by at least 12.5 per cent (Taylor, 1981, Ch. 11).

None of these attempts to restructure incentives facing firms in the labour market can be said to have succeeded. In Britain the scale of cost redistribution was too low to cover training costs right from the start, with the gap growing instead of dwindling over time (Ryan, 1981). In France the apprenticeship tax has indeed led firms to increase ther outlays on training -- but with an excessive emphasis upon managerial and white-collar training (Méhaut, 1983). The need to prod employers to increase their training activities was least urgent in West Germany. The training levy was never actually imposed in practice -- although a moderate decline in apprentice numbers since the measure was struck down in the courts in 1980 suggests that the threat of its activation did indeed help to maintain training activity during the late 1970s (Sellin, 1983).

In one economy in particular state intervention concerning training provision continues at negligible levels. In the United States firms are free to provide their employees with the amount and quality of training which they see fit without significant influence on the part of the state. "The first and most important point about American human resource development and utilization policy is that there is none" (Nollen, 1984, p. 21). Disincentives to train in costly transferable skills show up then not in overt quantitative skill shortages but rather in low training quality. Faced with high costs of trainee labour, employers tend to remove training from the employment contract, leading to heavy utilisation of pre-employment formal training in public and preparatory schools; and to restrict training within employment to informal, on-the-job methods which cost relatively little but whose quality is generally low (US Department of Labor, 1964; Strauss, 1965; Horowitz and Herrnstadt, 1969; Ginzberg, 1979; Ch. 12; Ryan, 1984a).

Employers' provision of training in costly transferable skills is not however universally deficient. At the level of the firm, large employers with considerable market power and progressive management often provide a considerable volume of high quality training -- turnover-related disincentives notwithstanding. Such a policy is facilitated by high-wage position in the labour market, which reduces the severity of the turnover threat in any event. But there is a distinct element of managerial discretion as well: attaching the high priority to human resources within corporate strategy which is seen in corporations such as Matsushita in Japan, Siemens in West Germany and (in recent years) Polaroid in the United States. Such companies typically react to economic downturns by increasing rather than slashing their training budgets (Hayes et al., 1984).

The generally high commitment to training of Japanese corporations is in turn facilitated by the system of lifetime employment, which provides the employer with security of retention of investments in training and thereby greatly attenuates disincentives to train (OECD, 1973a). A similar result is attained by different means in the case of West German firms. The generally high status of training in the culture of corporations as a whole, together with state intervention to ensure high levels of quality and quantity in training, has resulted in a generally adequate supply of skills in labour markets -- which in turn eases greatly the firm's fear that if it trains workers its investment is in jeopardy.

The contrast between Japan and Germany, on one side, and other advanced economies is striking but can easily be overdrawn. In Japan, training for production jobs is typically given informally on the job. Production operatives commonly report a desire for more training than they receive, while a substantial minority of firms avoid providing (more costy) off-the-job training despite recognising a need for it (Japan Ministry of Labour, 1980). In Germany, employer insistence on control over the training function has permitted the continuance of a substantial tail of low quality apprenticeships, particularly in the artisan sector (OECD, 1980).

A corporate policy of favouring employee self-development goes harmoniously with one of favouring skill-using applications of new technology. The limits to the latter, as discussed in the previous chapter, do however serve as a caution against optimism about the prospects for encouraging firms to take employee training and education more seriously -- a perennial characteristic of government policy in Britain in particular. Such appeals fall on stony ground not because firms have failed to think seriously about the role of training and not just because of the disincentives associated with skill poaching. The key problem is the preference of many employers for the limitation rather than the development of the skill aspirations of their employees as part of the low trust approach to employee motivation. Narrowness of training is as explicitly preferred by many firms as is narrowness of job design, and for the same reasons. A case study which illustrates the point in the context of IT concerns technicians in an electronics assembly plant in Ireland. Management policy was geared towards the routinisation of their work and the curbing of their apparent enthusiasm for learning and product quality -- as part of the assertion of values of production over those of quality and learning (Murray and Wickham, 1983). A preference of firms for the limitation of the access of their employees to learning opportunities has been documented in other circumstances (Lee, 1972; Ryan, 1984a). Its extent and durability serve as a caution against any belief that positive attitudes to human resource development will sweep the corporate world, prominent recent converts notwithstanding.

Access to training opportunities may be dominated by employers, but the role of individual initiative is not therefore negligible. Even if any one employer limits the training content of employment, creative use of turnover by employees can result in the accumulation of a considerable set of skills from a series of jobs. The relevance of this route to skill has been curtailed by the subdivision of labour, while its hit-and-miss nature renders it a "fragile" basis for skill acquisition, whether conducted within or between enterprises (d'Iribarne, 1982). In the United States job mobility has remained a significant source of skill development in markets where employers seek skill but are unwilling to provide training (Taylor and Piore, 1971). It remains relevant to occupations closely related to IT requirements and therefore in strong demand (technicians, etc.), but its scope elsewhere has been drastically curtailed in recent years with the rise in unemployment and the difficulty of finding jobs.

Turning now to the skills of interest for this discussion, there is indeed evidence of employer reluctance to train for electronics engineering and craft maintenance in some economies. In the case of electronics engineers in Britain, the recent PSI study found that nearly as many employers intended to meet their needs for electronics skills amongst their engineers by recruitment as by sponsoring and financing upgrade training. Consequently "with a substantial proportion of establishments relying on recruitment without doing any training ... there is clearly a possibility that, given an upturn in the economy, a more acute shortage of specialist engineers could develop quite quickly" (Northcott and Rogers, 1984, p. 65).

In the craft area, training for maintenance work tends to be concentrated in the larger firms, with the smaller ones relying upon informal training and recruitment to meet their needs (Senker et al., 1981, p. 11). The tendency towards multiskilling of maintenance in sectors applying IT in their processes has also brought to light labour market constraints upon the willingness of firms to provide or finance the necessary upgrade training on any large-scale basis. In one study of metalworking firms in Britain "some fears were expressed by maintenance managers that increases in training and skill levels of maintenance staffs might make them more attractive to other departments and companies" (Senker et al., 1981, p. 11). Equipment service firms, with their greater discretion over pay and benefits, posed a particular threat as did, to a lesser extent, self-employment in the same servicing business. Concern over potential losses of craft labour after providing upgrade training was particularly intense in the case of electricians given training in electronics when internal wage structures prevented parallel increases in pay to discourage turnover (Incomes Data Services Ltd., 1984). Along the same lines, users of robotics in Britain tended to report that their "greatest single problem ... was the difficulty of retaining suitably trained maintenance men, especially in firms without technical personnel due to a lack of any other automation" (Fleck, 1983, p. 53).

Employers react to such disincentives to train by limiting still further the numbers of the maintenance workforce to whom upgrade training is provided; by attempting to concentrate the training upon longer service and "loyal" employees; and by limiting the duration of courses and spreading them out over time for any one employee -- all of which serve to limit the "exposure" of the company's investment in skills. The constraint of potential turnover may not prove the binding one upon the move to multiskilling in practice, particularly at a time of large-scale unemployment. Employer control strategy and employee demarcation rules may well be more potent in practice. But the potential influence of labour market factors upon supplies of costly transferable skills remains substantial.

Other Skills

Problems of skill provision are less serious for many other occupations which IT is likely to affect, particularly for those on the "line" rather than the "staff" side of corporate hierarchies. The skills of managers and operatives are typically much less costly to develop (in terms of foregone output) than are those of professionals and craftworkers, respectively. The willingness of employers to provide and finance employment-based training is increased still further by the greater firm-specificity of the skills involved. Typically skill development occurs along career lines of progression within internal labour markets -- a method which reduces the costs of training and increases the rate of skill retention within the firm (Piore, 1968; Doeringer and Piore, 1971; Osterman, 1982). The link between occupation and method of skill development is certainly not the same in all economies. In the United States, France, Italy and Japan, skill development through upgrading in the internal labour market applies to craft and even some sub-professional work as well; while in Britain and West Germany craft-like training methods dominate internal progression in a range of production and office occupations (Marsden, 1984). Nevertheless, in all economies the lower cost of training and the greater firm-specificity of skill imply less concern for provision for managerial and production skills than for craft and professional ones.

One cause of concern has however surfaced in the literature: the danger that IT may make the creation of job ladders along which such skills are learned more rather than less difficult. Thus in the area of drafting, any tendency towards employee specialisation on CAD equipment threatens to break the link between drawing and design skills and make less likely the upgrading of employees specialised in the less demanding drawing tasks to the more demanding design ones. The capital cost of CAD may push employers to extend polarised forms of work organisation into areas hitherto marked by internal upgrading of skills. A lack of internal upgrading has been observed in large United States drafting offices (GB Engineering Industry Training Board, 1982; Arnold, 1984). Similar fears have been expressed concerning the possible utilisation of word processors to extend the scope of typing pools in clerical occupations.

The cost of some IT-based equipment may indeed push the organisation of training away from upgrading in limited, firm-specific skills. The problem is however unlikely to be severe. The alternative for firms is to acquire skills instead from more formalized sources such as vocational schools -- implying a lower cost of training to the firm but also greater transferability of skill and more independence on the part of employees. The preference of firms for skill development through internal upgrading rather than through formalised external training (Osterman, 1984; Ryan, 1984a) suggests that it will take a considerably greater increase in the capital cost of IT-based equipment than is the case for CAD and word processors before employers will abandon internal upgrading as a form of skill development.

Universal and Lifelong Training?

The problems of provision for particular costly and transferable skills are dwarfed in the eyes of some commentators by the broader ones of providing for a postulated wholesale upgrading of the skills of the labour force. In some accounts IT will, both by increasing the skill content of particular jobs and by removing the need for the least skilled jobs altogether, require universal training within the labour force, particularly amongst young workers. At the same time, by continually replacing old skills with new ones, IT will require the continuous reconstitution of skill within the labour force, for which a system of lifelong upgrade training and (for the less fortunate) retraining will be necessary. Such predictions are advanced to support current policy objectives in Britain (GB Department of Employment, 1981; GB Manpower Services Commission, 1982, 1983). More generally, the movement in support of "alternance" training in particular has derived substantial support from such prognostications of the effects of IT (Colasanto, 1983).

Were the diffusion of IT to produce such effects, there would be considerable cause for alarm, particularly in countries like the United Kingdom and the United States whose training provision for even existing skill needs is radically deficient. In practice, however, the implications of IT for skill are, as we have seen in Chapter V, far from unambiguous; while, to the extent that upgrading of skill requirements is likely in many sectors as a result of IT, the rate of change may prove no more rapid than in previous periods. In that event the case for universal and lifelong training cannot be based upon technological change itself -- although it may still be justifiable on grounds of equity and social opportunity.

Taking first the case for the universal training of young workers, it can only be supported on grounds of efficiency under highly specialised and improbable circumstances. Were IT to eliminate completely the low-skill end of the distribution of jobs then all members of the labour force -- or at least those in employment -- would indeed require non-minimal levels of vocational training. However, we saw in the previous chapter that, while IT-based innovation does indeed tend to eliminate the less skilled jobs in factories and offices, the process is subject to clear limits in terms of both scope and speed. The long-standing process of upgrading in the production industries has a long way to travel before culminating in the elimination of menial jobs in industries such as textiles and clothing. A large supply of unskilled and semiskilled work will endure, particularly in the "secondary" segments of manufacturing and personal services. The most that can be supported on grounds of economic expediency alone is therefore a provision of vocational education and training to labour force entrants which expands over time as the overall upgrading process proceeds.

The economic case for universal training has however been developed not only in terms of the requirements of jobs as they are constituted at any one point in time. It can be argued that the provision of skills in excess of job requirements leads to at least partial adaptation in the same job requirements. Employers, realising that skills are readily available. consciously or adaptively redesign work around a richer skill mix. Some have attributed the greater skill intensity and lower supervisory content of work organisation in West Germany than in (matched) French and British factories to the abundance of skills produced by the unique West German system of near-universal apprenticeship for 15-18-year-old school-leavers (Maurice, Sellier and Silvestre, 1979, 1984; Krais, 1979; Sorge and Warner, 1980; Lutz, 1981). Similarly, a study of the content of the jobs of client interviewer and branch office manager in the United States Employment Service found that the variety of tasks performed by interviewers increased (albeit modestly) with the education and experience of the job's occupant (Rosenfeld and Thornton, 1976). Then, to the extent that a more skill-intensive occupational structure improves the economic performance of the enterprise, universal vocational education and training acquires thus an economic justification beyond the simple needs of jobs (as constituted in its absence).

A positive relationship between skill mix and economic performance has been inferred in studies of the productivity differences between the British, West German and American economics (Prais, 1981; Caves, 1980). The argument thus carries weight -- but some points of uneasiness remain. On the side of education, studies of the relationship between education and jobs within large organisations suggest that the possession of more education by the employee may lead not to the upgrading of the job but rather to overqualification and problems of motivation (Berg, 1970). The "human capital" policy experiments in the United States during the 1960s, in which deprived workers were given remedial education and job training, proved a disappointment to their sponsors. The beneficiaries of such programmes showed limited gains in employment and earnings, suggesting that their additional skills had for the most part lain fallow in the face of unchanging job content in the secondary segment (Piore, 1973). Moreover, while the West German system of near-universal training may result in a rich skill mix, it has certainly not done away with unskilled and semiskilled work. The jobs of assembly-line operatives and clerical personnel are filled by people who either have been trained well beyond the needs of current jobs (as in case of clerical apprenticeships) or have been trained in totally different skills (as in the large numbers of ex-apprentices from the artisan or handicraft sector who find their way onto production lines in manufacturing; Lutz, 1981). As long as such jobs remain numerous, despite the inducements to reskill work and despite the potential onslaught of IT, the problem of excess training and potential waste of resources has to be addressed.

Defenders of the West German system urge in response to this difficulty that universal initial training may still make its contribution to productivity in less immediately obvious ways. To the extent that workers will be required by economic change to move to other occupations in the future, the cost of retraining (and, indeed, in some cases, its very possibility) is reduced when they have received a broad foundation training at the start of their working lives (OECD, 1980). The argument is plausible, although there is no evidence at hand on the relationship between initial investments in training and the cost and success of subsequent retraining. In any event, the argument depends upon dubious assumptions about the rate of skills redundancy and retraining, to be considered below. There is however a further potential channel of influence on productivity for universal initial training. West German employers and educators insist on treating apprenticeship not just as a system of technical skill acquisition but also as one of education, socialisation and personal development (or Bildung; Taylor, 1981). To the extent that learning a trade -- however little related it may subsequently prove to job tasks -- provides a young person with a sense of confidence, self-worth and interest in work, it may thereby contribute to the social integration and productivity of enterprises in general.

A justification for universal training in terms of socialisation and normative integration is however difficult to assess from the efficiency standpoint. All one can say is that it provides a partial, residual justification for universality in initial training. The justification must be partial, as the argument can cut the other way. It could be regarded (by the social observer or by the young worker him- or herself) as insulting to be trained in a vocational skill which one has little prospect of using directly in work -- if indeed work can be found with it in a time of high youth unemployment. The young person's motivation to learn is likely to suffer when the prospects of using the skill in a job become remote. Better then to dedicate resources not to training well beyond the margin of likely skill requirements but rather to the creation of jobs for those most threatened by unemployment -- and, for those who will gain employment in which the skill will not be required, to make the provision of the training conditional upon action to curb the provision of low-skilled jobs by firms themselves (Tipton, 1982).

The argument for universal initial training therefore has the merit of urging an increase in the provision of training above current inadequate levels in economies such as the British, the French and the American. It cannot however stand up on narrow economic grounds alone, with or without bringing IT into the picture.

A second possible implication of IT for vocational education and training also concerns universalisation -- not just across members of the labour force but also within the typical working life. The prospect that IT will, by introducing a state of continuous upheaval in production methods, intensify the rate of industrial restructuring has led some commentators to urge that job skills will be made obsolete at so rapid a rate that most members of the labour force will require recurrent access to continuing education and training.

Once again, however, while such prognostications may well correspond to the direction of change to be expected from IT, they are at fault in mistaking a possible, quantitative change for a certain, qualitative one. The first difficulty is that the prospects for restructuring have usually been exaggerated in ex ante assessments of emergent technologies other than IT (Brooks, 1983). On the one side, the reconstitution of production methods has, since Marx, been accepted as a permanent characteristic of the capitalist market economy. A high rate of occupational industrial reallocation of labour characterised the entire post-war period in OECD economies, with only a moderate tendency towards acceleration of pace in the second half of the 1970s (Ryan, 1981, Table 1). On the other hand, IT may well not result in a significant increase in the pace of restructuring. Moreover, while even a constant rate of restructuring becomes more difficult with unemployment at contemporary levels (OECD, 1979a, 1979c), the scale of gross labour flows between industries and occupations is in most countries so large as to calm concern about the feasibility of attaining the (much smaller) net flows required for restructuring (Thatcher, 1978). The issue cannot be settled as yet, but the evidence of the early phase of automation and computerisation (for what it is worth) produced little evidence of discontinuity (section 5.4 above). The likelihood of an exceptionally rapid diffusion of IT rests upon its potential for drastic cost reductions in many applications -- the contribution of an innovation to profitability having been found a key determinant of speeds of adoption for new technologies (Mansfield, 1961). However, even large-scale reductions in operating costs may not suffice to push IT utilisation ahead at great speed in view of the high capital costs of many applications, along with the oranisational difficulties involved in understanding the potential of IT, selecting suitable systems and assessing their financial prospects (Frohman, 1982; Gold, 1982). Thus a recent study of CNC machine tools asked "why has diffusion been relatively slow." -- noting that after 10 years' availability only a small share of machine tools have NC controls (Ray, 1984, p. 65). The rate of takeup of IT is therefore particularly difficult to predict. Until more evidence becomes available, there is good reason to doubt that the rate of skill restructuring will be substantially higher than under previous experience of technical change.

However, even were the rate of occupational and industrial restructurng of employment to prove considerably greater as a result of IT-based innovation, the case for lifelong education and training would still require further justification. On the upgrading side, much of the change associated with IT has thus far involved only a modest upgrading of existing skills for those members of the workforce who continue in employment. Employees who operate and maintain equipment in which microprocessor controls have been incorporated typically receive short courses (usually from equipment manufacturers) to expand their skills to include the necessary electronic-related components (Senker et al., 1981, Chs. 5, 6; Sorge et al., 1983, Ch. 7; Cross, 1983, pp. 22-3). Even in the highly successful example of the creation of CNC "machine managers" in a British helicopter factory, operators without prior experience of even NC equipment received only four weeks' formal training for their newly enriched jobs (Wyles, 1984). In view of the limited numbers receiving such training and the brevity of most of the courses received, changes associated with IT to date leave a long way to go before lifelong training is required for the majority of persons within the enterprise. Moreover, the other aspect of lifelong training to which reference is often made, the need to retrain persons whose skills are made redundant by IT, has its force greatly weakened -- on grounds of economic efficiency alone, it must be re-emphasized -- by the expectation that unemployment will remain high in advanced capitalist economies well into the foreseeable future. It may indeed be socially outrageous to discard adult workers into unemployment and early retirement when their skills are made obsolete by innovation and instead train up young workers in the new skills required. Such is however likely to be the patterns of action chosen by many employers if left to their own devices. Even in the internal labour markets of large Japanese companies, with their job security for adult employees, management shows a preference at the margin for transferring displaced older workers into related enterprises and training youngsters in new skills rather than retraining the displaced workers themselves (Okamoto, 1983). On narrow economic criteria the choices of employers cannot be faulted. Certainly, the economic criterion of efficiency alone will not require wholesale retraining as a result of the diffusion of IT unless the tendency towards enriched job content proves much stronger than was envisaged in Chapter IV. An alternative justification for lifelong education and training (as well as universal youth training) may nevertheless be found in considerations of equity, but this is an issue we leave to section 6.3. below.

2. The Content of Human Resource Development

Even if IT does not of itself require universalisation in the provision of vocational education and training, it may still alter radically the content of human resource development. It was argued in Chapter V that changes in the content of skill associated wth IT will frequently be more visible than those in the level of skills required as a whole. Corresponding changes in the content of education and training follow directly. Specific changes in the content of education and training encompass more than simply the injection of electronics content for some IT-related occupations. The possibility of radical changes in methods of working, particularly in process and managerial occupations, raises the possibility that methods of training must change along with the content of skills.

The prospect that the conditions of work of continuous process industries will spread to other production industries was discussed in the previous chapter. A marked shift in the content of skill was noted as a result of automation, moving from an experiential and intuitive understanding of the production process towards an abstract and technically grounded one. At the same time the role of the operator no longer demands regular physical intervention, but rather attention to displays and readiness to intervene rapidly and precisely when the process moves outside its operating specifications.

It is not easy to develop a training system for such conditions of working. Certain requirements are clear: a need for attentiveness and a high degree of personal commitment to the job. To the extent that understanding of the technical basis of production is made part of the job, a higher level of general and technical education is required. To the extent that less is learned by experience, a lower level of on-the-job preparation is required. In that respect, the content of human resource development shifts from the experiential to the cognitive and from manual dexterity towards personal reliability. The extent of the changes required depends strongly upon the work organisation chosen by management. At its least formalized, the skills required may be developed as in much of existing process industry, by simple on-the-job learning along job ladders, with selection for upgrading according to seniority and reliability. In such cases, the central task for schooling is normative -- to develop attentiveness, reliability and internalisation of rules in young people (Murray and Wickham, 1983). However, should managers decide on and enriched skill mix around new technology and follow the example of some Japanese firms and create a new breed of technician-operatives with a broad understanding of the production process, then an increase in the intellectual content of work and in the technical, school-based component of its development will result.

The difficulty of developing a training programme for such "neo-trades" (d'Iribarne, 1981) is illustrated by the absence (until recently) of process operative in the long list of occupations certified by the state for apprenticeship training in West Germany (Krais, 1979). Despite concern since the 1950s about developing formal training for process work (Taylor, 1981), the uncertainty about demands upon the technical knowledge of process operatives plus the difficulty of formally training people in responsibility and reliability have contributed to this outcome. The most that can be said is that both cognitive and normative requirements upon the worker are likely to increase -- and that as these are developed more effectively in schools than on the job (relative to the experiential skills they replace), the shift in the content and location of training suggests an increasing role for formal education (Gintis, 1971; Edwards, 1976).

The shift from informal to formal methods of training for process work is hindered not just by the difficulty of devising appropriate training content and methods. In facilities where informality dominated in the past, senior members of work groups have been seen (notably in the British steel industry) to resist the reduction in their influence over the content, training methods and even allocation of training which is a corollary of formalization (Taylor and Lewis, 1973).

Problems of training arise also as a result of the costliness of process-type equipment, particularly after the incorporation of computer controls. The costs of arranging illustrative crises in which the skills of the process operator can be tested and developed has led to widespread use of computer-based simulators for training -- as in the case of airline pilots and nuclear power operatives (US Department of Labor, Bureau of Labor Statistics, 1979a). Computerisation thus increases the costs of training on the job while simultaneously making technically feasible an off-the-job, albeit also expensive, alternative.

Changes in managerial skill requirements associated with IT will also mean changes in methods of skill development. In order to utilise effectively the wealth of information provided by IT about organisational functioning, managers will require greater powers of data assimilation and analysis than in the past. In order to assess the potential of IT for the improvement of organisational functioning, managers will require greater powers of abstract and holistic thought than in the past. Such skills are scarce amongst managers in some countries. The degree to which they are developed depends upon the content of both managerial education and corporate job structures. A country like Britain suffers on both counts. Managers certainly include many who have developed vocationally relevant knowledge in university as engineers, accountants and statisticians. At the same time, a substantial proportion of British managers lacks higher education in any field; while, of those who have received higher education, a non-negligible proportion have specialised in the humanities and thereby avoided recent exposure to numeracy, let alone computers. Furthermore, at the level of managerial work organisation, companies in Britain and France (in contrast to those in Japan and Germany) show extensive and enduring functional specialisation amongst managerial and professional workers -- with the clear division between "staff" and "line" careers militating against broadly based views of corporate requirements, in contrast to the higher integration of knowledge within management in Japan and Germany (Ball, 1979; Finniston, 1980; p. 37; Sorge and Warner, 1980; Sorge et al., 1983, Ch. 6). Existing systems of skill development for managers in Britain and France may thus become increasingly dysfunctional as the advance of IT proceeds.

The content of skills and training associated with IT has been discussed at more general levels as well. "The list of general qualities needed to work with new technology is not very long and it is well known", according to Sorge (1984, p. 39) -- including analytical, problem-solving and logical capabilities. To this is added the ability to learn itself, which the changing requirements of IT may demand of an increasing fraction of the labour force (Hayes, 1981). More generally still, d'Iribarne (1982) has urged that the advent of IT will require a "veritable technological culture" in which presumably all members of the workforce will acquire "qualification", in the French sense of a broad foundation training in the theory and practice of particular technical systems based on IT. Similarly, if less dramatically, commentators in Britain and the United States have urged the need for universal development of computer literacy amongst school pupils.

The implications of such generalisations for human resource development range from the mundane to the spectacular. At one pole, schools will be required to develop familiarity with computing equipment and VDU operation in all young people, much as the "three R's" were to be instilled in all in a previous period. At the other pole, all members of society are to be plunged into a world of heightened logicality and abstraction of thought, consistent with the requirements of programming and using advanced IT systems. The demands on the school and training systems, not to say upon the abilities and interests of many students, would then prove correspondingly great.

The element of reality in such generalisations is unmistakable -- but so too is the element of exaggeration. The diversity of occupational requirements, whether or not affected by IT, is implicitly ignored in such statements. Were a general upskilling of work and an elimination of Taylorism anticipated of IT, then there would be a case for such propositions. However, the experience of work, with or without IT, will for many prove less demanding than such predictions imply. A good example is provided by the case for universal computer literacy. A wide variety of methods has already been developed for bringing the potential and practices of the microcomputer to public attention (Lariccia and Megarry, 1984). Exposure of students to computers has already become widespread in schools (OECD, 1984a). At the same time the use of computers in schools frequently fails to live up to any idea of universal familiarity with computing principles and methods. Computer organisation in schools located in working class communities has in the United States proven heavily oriented towards "drill and practice" functions, teaching existing materials in a pedestrian way but using microcomputers to do so. Only in the more student-centred classrooms of affluent communities have programming, problem-solving and modelling applications proven central (Kling, 1982; Useem and Kimball, 1983). The conclusion for the design of schooling matches that for the design of work: IT tends to be used in ways that mirror the pre-existing procedures and values of the user organisation. Nor can it be argued that working class schools are necessarily in error in their approach. To the extent that much work will be organised around IT in repetitive and routine ways, and that their students are socially destined to do such work, their usage of the computer involves a functional adaptation to the realities of the job market, in addition to reducing apprehension about new technology.

Changes in the content of skill may also affect the supply of training through the balance between transferable and firm-specific elements within skills themselves. If problems of skill provision are in most economies more marked for transferable than for specific skills, then any tendency for IT to increase specificity (for a given level of training costs) would imply a lessening of market-related constraints upon employer willingness to train -- and potentially significant improvements for economies such as the British, the French and the American. In some assessments IT is indeed expected to do just that. The sheer variety of ways in which IT is applied in firms has led Krais to anticipate an increase in the firm-specificity of employee qualifications -- in contrast to the presumed standardization of processes and skills under earlier forms of innovation (1979, p. 36). Certainly the skills of process workers, which we have seen as becoming increasingly important as IT diffuses through the production industries, have long been taken as the epitome of firm-specificity. At the same time, however, the tendency towards reduction of manual dexterity in favour of abstract knowledge and technical understanding implies an increase in the transferability of this component of skill. The situation is therefore subject to contradictory forces and the overall outcome both uncertain in general and likely to vary from occupation to occupation. A basis for optimism that problems of training may be reduced may however be found in the tendency for the skill elements whose transferability is increased to be developed in schools rather than on the job. Manual dexterity is developed through job experience, while abstract thought, technical knowledge and reliability can be imparted in classrooms -- and therefore more readily provided by the state, whose willingness to pay, while subject to clear constraints, is generally higher than that of employers in the economies where training has proven problematic.

3. Equity and Distribution

The distribution of opportunities to learn skill has long been a source of critical comment in advanced economies. West Germany, with its near-universal provision of apprenticeship to young school-leavers and its linkage between apprenticeship and higher education, is less prone to criticism on this score than are other economies. Yet even there, criticism has been directed at two limitations of opportunity which appear in more intense form in other advanced economies. The first concerns the plight of the lower tail of the distribution of student achievement in formal education, many members of which do not receive offers of apprenticeship. The second concerns the displaced adult worker, whose access to retraining and thereby to re-employment has been found to be relatively limited. In this section we discuss these problems in the light of the effects anticipated of IT before turning to the relationship between considerations of equity and the case for universal training.

The supply of opportunities to train is more restricted relative to the potential demand for training places in most advanced economies than is the case in West Germany. The gap has grown as the economic depression takes its toll of training places in the private sector. The supply of places in the private sector is rationed according to criteria selected by employers. Given the costs which fall upon them, the clear interest of employers is to select candidates for a combination of trainability (i.e. cost of training) and retainability (i.e. likelihood of not quitting). The willingness of trainees to incur sacrifices in order to train -- the central issue in human capital theory -- is in practice largely irrelevant to the allocation of training places. Access to training lies for the most part outside the reach of individuals' decisions. The allocations made by firms not surprisingly favour the previously trained, longer service members of the existing workforce, whose skills have already been developed to some extent and whose links to the firm have been proven by experience. Thus upgrade training related to new technology tends to be concentrated within the ranks of the already skilled rather than being spread around more evenly amongst employees. The prevalence of "jobless growth", together with the cost and difficulty of redundancies, makes access to training particularly difficult for labour market entrants. Young and (particularly in Japan) female members of the workforce are therefore overrepresented amongst the losers (Méhaut, 1983). The position of youth is ameliorated somewhat by higher trainability, to the extent that ability to learn and prior education are superior amongst the more able and better educated young workers. The low achiever group amongst youth has however particular difficulty in securing access to training places -- a problem compounded by racial discrimination in hiring.

The most limited access of all is however that of the displaced adult worker whose links to the firm have been broken by redundancy and whose occupational skill may no longer be in demand. The layoffs in durable manufacturing industry in the EEC and the United States have thrown many middle-aged males onto the labour market. Their ability to acquire courses of retraining for employers proves very low indeed. They do indeed commonly possess a skill of their own, and if it is related to the requirements of job vacancies then that should encourage employers by reducing the costs of developing the requisite skill. However the costs of adapting old skills to new jobs can be high, particularly when the technical discontinuity is marked and where a well established occupational identity makes adaptation emotionally as well as technically difficult. Pay structures usually require the payment of a full adult wage to workers during retraining within the firm, while age restrictions on access to apprenticeship typically debar them from consideration. Adult access to training is therefore particularly low and a major source of concern about equity in the allocation of training opportunities.

Concern about inequality in access to training opportunities is clearly a matter of social values. Most governments have however shown at least some concern about limitation of access amongst some of the above groups and devised policies to counteract it. The focus of compensatory policy varies by times and place. In the United States during the 1960s public policy focused upon disadvantaged racial minorities, with remedial education and basic training as the favoured instruments (Magnum, 1968). Since the mid-1970s European governments (with the exception of Italy) have focused their concerns to a greater or lesser degree upon the lack of jobs and training amongst young workers, to the detriment in particular of displaced adult workers (Ryan, 1983; Sellin, 1983). Retraining of displaced adults had become an explicit responsibility of the state in most countries by the 1970s but only in Sweden has an effort been made to ensure general access to retraining (OECD, 1979a). The neglect of adults is one of the least defensible results of the preoccupation with youth (Thurley, 1982).

The methods of official intervention comprise two categories: direct public provision and attempts to alter employer choices. Direct provision in publicly run schools and centres dominates the retraining of adults, consistent with the reluctance of employers to provide such training. In the youth area, the slanting of training places towards young workers has however been pursued largely by incentives aimed at employers, as in the shape of the contrats d'emploi-formation in France and the YHOP/YTS traineeships in Britain. The emphasis upon employer-based training reflects partly a concern for a more "relevant" type of training than in public institutions alone, but it also shows state concern that youth labour may be denied access to work experience, with potentially damaging long-term results in motivation, confidence and work discipline. At the same time even governments which prefer to slant youth training towards private employment have been forced to provide public facilities for the disadvantaged slice of the youth market whose prospects of appealing to employers remain low. Since 1980 the West German government has provided training places in public institutions for youths unable to secure placement in the private sector (Sellin, 1983); while in Britain the government has reluctantly maintained a substantial provision of places in the Youth Training Scheme for Mode B2, located wholly apart from employment and slanted heavily towards disadvantaged youth.

The spread of IT may intensify concern about inequality in the distribution of access to training opportunities. Should the pace of restructuring increase, whether in overall volume or simply in the degree of discontinuity between old and new skills, the problems of retraining adults will become more rather than less intense. Dramatic examples have arisen in Scotland, where the decline in skilled manual work in industries such as shipbuilding has been partly offset by a rise in manual semiskilled work in expanding "high tech" firms. Retraining of the redundant adult male for the latter jobs has however proven negligible, reflecting both the gap between the jobs in question in terms of skill content and working conditions and the sexual segregation of employment. The plight of displaced adult workers has been eased elsewhere by union bargaining activity, notably in North America. The United States automobile industry in particular has seen in recent years the institution of employer-based funds dedicated largely to the retraining of redundant employees in skills likely to be of help in finding jobs in the external labour market (Nollen, 1984; Business Week, 1984). Public policy has however proved less than over-active in this area. Although most OECD governments provide public retraining services whose funding grew rapidly in the 1970s, growth has been restricted in the 1980s by preoccupation with the problems of youth and general curbs on public expenditure. In Britain in particular, the expansion of adult training provision in Skill Centres, which was planned in the 1970s, has been reversed in the 1980s -- while the objectives of commercialisation and privatisation of retraining services suggest tht further contraction is to be expected in this area in the future (Ryan, 1984b). Indeed, while some have called for an expansion of retraining provision under public funding (Sengenberger and Mendius, 1983), the inadequancy of adult access to training opportunities constitutes a durable source of social concern which stands only to be intensified as a result of the effects of IT.

On the side of initial training, IT may exert some secondary influence upon problems of inequitable access. To the extent that occupational upgrading shrinks still further, the set of jobs for which little or no vocational training is required, and to the extent that computerisation requires enhanced capabilities for abstract and logical thinking in intermediate level jobs, the difficulties facing the children from lower-class families in obtaining access to skills and rewarding employment are likely to increase still further. An amalgam of lesser opportunities, lesser motivation and lesser ability means that they generallly derive little benefit from schooling -- and to the extent that the skills taught in school become more important for employment, their prospects will be accordingly diminished. One of the brighter spots in training policy in Britain at present is the large number of ITECs (Information Technology Centres) set up recently by the state to develop computer-related skills in a setting apart from the state school system and oriented in part towards the needs of disadvantaged youngsters (GB Manpower Services Commission, 1983a).

Indeed, it may be that considerations of equity may justify a policy of universal training, whether for young workers alone or for adults as well. We noted above the limitations of an efficiency-oriented justification for universality: as long as jobs are incapable of using the skills produced by universal training -- whether because the jobs are not there, as with mass unemployment, or because the content of many jobs is too impoverished to put skills to proper use -- much skill will inevitably go to waste. The social desirability of providing access to skills for those who are excluded from employer selection for training is however another matter. The lack of opportunity facing the less advantaged segment of youth has resulted in a set of social problems which has already generated support for remedial action.

Current training policies have indeed responded to the lack of opportunity in fairly explicit fashion. The political leaders of the member states of the EEC in 1982 declared collectively in favour of a social guarantee of a two-year course of continuing training for all young people, to be implemented during the subsequent five years (Sellin, 1983). In Britain the government has during the last four years guaranteed to all unemployed early school-leavers a place on the relevant programme of work experience or training (YOP or YTS) by Christmas of the year in which they leave school. Such guarantees cannot be justified on narrow efficiency criteria; they respond instead to the political desire to improve the opportunities facing disadvantaged young people (Lindley, 1983). At the adult level public action is rarer, but the desire to improve adult opportunities led to the institution of rights to educational leave of absence in France as a direct result of the social unrest of the late 1960s (OECD, 1973b). Similar provisions are to be seen in Italy, Belgium and Sweden; while in 1973 the ILO advocated paid educational leave as a right for workers (OECD, 1976).

However the problem of jobs dogs an opportunity-oriented justification for universality of training just as it did an efficiency-based one. If jobs in which the ex-trainee can put to use what is learned during training are subsequently denied to disadvantaged young people, then they will tend to view the training "opportunity" itself with cynicism. The limited takeup of places available to unemployed young workers in Britain under the Youth Training Scheme reflects a strong current of scepticism about not only the quality of the training on offer in many schemes but also the likelihood of finding a job in which to put to use whatever is learned while on the scheme (Raffe, 1984). The reaction to such problems is not necessarily to counsel inactivity until unemployment has been reduced and menial work eliminated, despite the logical priority and desirability of such objectives. In the meantime, the case for universal initial training can be rescued by emphasizing the importance of equity and opportunity, but with the focus shifted towards education and away from training. If training has strong educational and developmental components, in accordance with the ideals of those who advocate personal development through vocationalism (Taylor, 1981, Ch. 1), then the opportunity may be valued by young people quite apart from its effect on their subsequent employment prospects. The activity has then at least a chance of being value for itself if not for what it may lead to in work. It is clearly difficult to devise an appropriate programme of vocational education for disadvantaged young people, most of whom have by the time they leave school little regard for education as presented to them in state schools. But it is not impossible. The possibility of a strong educational component can be illustrated by some of the more expensive and better thought-out projects developed under the umbrella of the much criticised Youth Opportunities Programme of 1978-83 in Britain. In one showpiece project, a group of young school-leavers spent a year building a light aircraft, receiving at the same time instruction in navigation, meteorology and general education; in another, a group set up by Ford Motor Company built from scratch a small car of their own design. In each case many of the trainees will subsequently have experienced considerable difficulty finding work -- and particularly work in which they could use what they had learned. Such projects can nevertheless provide opportunities of value for life in general, whatever subsequently befalls them in the labour market.

The case for lifelong access to education and training for adults runs into similar problems when the problem of jobs is considered. The take-up of rights to educational leave in France has remained pitifully low, partly because of the lack of provision for income while on leave, but also because employees who exercise their rights may earn the disfavour of their employers and thereby put their jobs and careers in jeopardy (OECD, 1976; Jallade, 1982). Moreover, it is difficult for a person's interest in self-development through education to be kept alive when everyday work experience in routinised and strictly supervised jobs militates strongly against it (Meissner, 1971). Here, as elsewhere, the problem of jobs dominates the issues of education and training. Adult education is indeed capable of significant expansion but its value to the redundant is attenuated by the lack of gainful employment.

The arguments for universal training and lifelong training therefore receive at most partial support from consideration of the likely consequences of the adoption of IT. If a solid justification for them is to be found, it lies not in considerations of efficiency but rather in the "old-fashioned" ones of equity and opportunity. The predominance of efficiency over opportunity in contemporary policy discussions centred around IT can be explained only in terms of the greater political role of appeals to the postulated needs of efficiency in the technocratic culture of modern capitalism (Offe, 1976). Justifications in terms of opportunity carry some weight politically, particularly for young people. In an era of renascent conservatism they fail to carry the legitimacy more generally that attaches to appeals to efficiency, however partial and even spurious the latter prove upon detailed analysis. Such adverse political developments do not however alter the logic of the argument.

4. Human Resources and the Utilisation of IT

If the implications of IT for skills, education and training are subject to considerable uncertainty, the same cannot be said for the reverse relationship. The quality of the human resources in an economy exerts a powerful influence upon both the speed of adoption of IT and the degree of success attained in its utilisation.

The availability of craft, technician and professional skills is restricted to varying degrees by the constraints upon the willingness of employers and governments to incur the costs of the relevant vocational education and training, as outlined in section 6.1 above. Companies, industries and even whole economies may find their ability to innovate restricted by limited availability of the requisite technical skills. According to one assessment, the shortage of high-level skills in particular "may be the greatest single impediment to the development of microelectronics both in Canada and worldwide" (Science Council of Canada, 1980, p. 35).

The outstanding example of virtue and success in this respect is the large Japanese corporation, whose commitment to the development of employee skills has impressed many observers (Ball, 1979; Senker, 1984a; Hayes *et al*., 1984). As much as five per cent of gross revenues may be spent upon human resources in general, while substantial funds are specifically earmarked for IT-related training. A survey of Japanese manufacturing in 1983 found that nearly two-thirds of all plants had set up training programmes for applications of IT (Okamoto, 1983). Many British firms, by contrast, frequently exhibit not only low levels of background training but also ad hoc and unplanned responses to the training needs of new technology. In many cases no particular training plans are drawn up; even where they are, they often slip badly and then get downgraded as the pressure for rapid implementation builds up (Rothwell and Davidson, 1983; Rothwell, 1984).

It is not surprising to find therefore that the implementation of new technology in Britain has been hampered, sometimes seriously, by shortages of the relevant technical skills. A study of installations of robots in manufacturing gave pride of place amongst the reasons for both slow rates of diffusion and alarmingly high rates of failure to skill shortages in maintenance, on top of inadequate technical education and training in general (Fleck, 1983). For maintenance work in process industry, nearly one-half (15 out of 36) cases indicated that a lack of relevant skills had proven a "major barrier" to the introduction of new technology (Cross, 1983). More generally still, 45 per cent of manufacturing plants using microelectronics reported "the lack of people with microelectronic expertise" as a "very important" disadvantage when it came to IT utilisation -- a source of difficulty whose only rival in frequency was the "general economic situation" (Northcott and Rogers, 1984, Table 21).

The constraints imposed upon innovation by inadequate human resource development are more important still at the level of managerial competence and attitudes. The extent of planning for the training requirements of IT is clearly a managerial decision, as is the degree of preparation for other aspects of IT installation. In one outstanding example drawn from Japan, 100 000 employee hours were devoted over two years (i.e. roughly 50 full-time employees) to the design and preparation of an 18-machine FMS system (Arnold, 1983). The scrupulosity of corporate planning for IT in Japan may have much to do with the lead attained by Japan not only in installations of sophisticated manifestations of IT such as FMS but also in their successful operation (Senker, 1984b).

Perhaps the key constraint imposed by human resources upon the utilisation of new technology involves the skills of management itself. Successful use of such advanced forms of IT as CAD/CAM, FMS and corporate information systems requires the rethinking of methods and procedures, as in the shift from simple hierarchy towards "matrix" forms of organisation (Winch, 1983a). Simply tacking IT-based equipment onto existing facilities and structures is a recipe for failure. The demands upon management competence and creativity are correspondingly great. As one comparison of the relative importance of management and operator development put it in the context of the computerisation of design, "management learning is more complex and crucially affects the rate of operator learning" (Arnold, 1983, p. 37).

Here again, substantial differences between corporations and countries stand out. The training of management in both Japan and West Germany stands on a strong engineering foundation, in contrast to the greater importance of liberal arts, accounting and finance in Britain and the United States. The organisation of the management function in Germany and Japan stands out also for the deliberate integration of staff into line functions, relying on manager rotation and low staffing of ancillary departments to restrict the development of parochial perspectives and ensure the fusion of marketing, engineering and finance perspectives amongst decision makers. In Britain and France, by contrast, more strictly departmentalised corporate structures make the assessment and implementatin of IT particularly difficult (Sorge and Warner, 1980; Maurice, Sellier and Silvestre, 1984). The usage made of the skills of engineers may thus be more important than their numerical frequency (Lutz, 1981). In the eyes of some observers these problems are compounded in both Britain and the United States by the dominance of short-term financial criteria in corporate decision making. The organisational diffuseness and long-term nature of the benefits of much IT-based innovation means that they tend to evade capture by standard discounted cash-flow techniques, leaving the accountant-dominated firm at a disadvantage relative to its product and engineering-dominated rivals (Frohman, 1982; Gerwin, 1982; Gold, 1982; Senker, 1984a, Chapter 12). The extent of such differences between firms and countries requires further research but their prospective influence upon IT outcomes is undoubtedly great.

A further attribute of managerial quality concerns the propensity to use IT for building rather than undermining skills amongst employees. In cases where the efficient utilisation of new technology is promoted by skill-intensive job structures (section 5.3, above), ability to recognise the fact and avoid Tayloristic, low-trust approaches constitutes a crucial -- and in Britain, at least, still scarce -- aspect of the quality of management. There are signs that the message is getting through to managements in the hitherto less rapid and successful areas of innovation. One large British firm whose survival was in doubt in recent years (Lucas) recently sent its top management off for a one-week course in information technology. The problem is however likely to endure, as the attitudes of management are one of the least readily altered attributes of national work organisation.

It is certainly difficult to assess the precise importance of deficiencies in human resource development and utilisation as constraints upon the usage of IT. There are other potentially restrictive influences -- notably, low profitability and economic stagnation. However, low profitability and economic stagnation cut two ways. The adoption of IT is certainly discouraged by pessimistic expectations of demand and low levels of cash flow. But, by the same token, economic crisis intensifies the pressure to innovate or perish, making recourse to IT for many firms essential for long-term survival. At the same time, the links between human resources and the adoption of IT are so numerous and underlined by so many studies that the major determinant of the extent and success of IT usage in firms and economies must be seen as the quality of their human resources -- those of employees in general and those of corporate management in particular.

As final issue, it might be urged that a tendency for the diffusion of IT to be slowed down by the limitations of human resources is no bad thing. The social costs of economic change are high -- and incompletely internalised to the individuals and institutions whose decisions determine the rate of change. Might not a slower pace reduce the disruption of individual lives and patterns of community, thereby more than compensating for the loss of marketable output? The importance of the question is undeniable -- and, while a major study would be needed to attempt an answer, a positive response is a distinct possibility for the world economy as a whole. That possibility is however of solely academic interest from the standpoint of national policy. The lack of international institutions capable of influencing the pace of technical innovation reduces the choice set at the national level to the simple "sink or swim" dichotomy -- i.e. to match the pace of innovation attained by one's rivals or suffer still further disruption of the lives of individuals and communities as a result of intensified redundancy and unemployment.

5. Conclusions

The introduction of new technology has already served to highlight deficiencies in the provision of skill in certain advanced economies. The intensity and rapidity of the growth of IT's requirements for such skills as those of electronics engineers, technicians and maintenance craftworkers has resulted in shortages in economies where human resource development was already defective. The severity of the problem has been considerably moderated by the endemic state of excess supply in the labour market as a whole. But it is clear that any significant general economic revival or any selective acceleration in the rate of growth of IT utilisation would result in serious shortages of such costly transferable skills in a range of contexts, and notably in Britain.

Conversely, national systems of human resource development and utilisation have already exerted considerable influence over the speed and success of application of IT to both products and processes. The issue is more general when causality is examined from this side. It is no longer simply the difficulty of provision for costly transferable skills which hampers the diffusion of IT. There is also the quality of management and the organisation of human resources more generally. The ability to comprehend the potential of IT within the firm, together with the willingness to approach job design with sufficient openness of mind and to provide sufficient time and resources to planning and training for IT -- these are the crucial managerial characteristics which have led already to considerable differentiation between companies and countries in the vital race to implement new technology.

At the same time too many commentators have claimed too much for IT in the area of education and training. The effects of IT are multidimensional. They are intrinsically difficult to foretell but easy to dramatise. Certain dramatisations cannot be sustained. The attempt to develop from IT alone a case for universal and lifelong vocational training founders in the face of the durability of both mass unemployment and the low-skill segment of national job structures. The problem of jobs is prior, both logically and politically, to that of training. It promises not only to survive the advent of IT but even to intensify as a result, given the labour-saving potential of the technology and government restrictiveness towards aggregate demand.

The futures of information technology and human resources are closely tied the one to the other. Perhaps the most important linkage between the two concerns the implications of current patterns of skill development and utilisation for the progress of information technology itself. IT <u>is</u> different in a way that other new technologies have not been: it stands to remould fundamentally the structure and procedures of the modern organisation, and in particular those of the modern manufacturing firm. The desirability of increased interactions between the different specialities and departments within the firm reflects the integrating effects of the pooling of databases made possible by flexible computerisation. Corporate functioning is optimised increasingly not by traditional, unidimensional hierarchies but by the flexible, cross-linked "matrix" forms of organisation. Instantaneous worldwide transmission of data makes possible superior centralised access to information about corporate activities while improving the prospects for decentralised and flexible administration. In order to respond to such changes in the menu of organisational possibilities, the quality of managerial resources must be considerable. Countries and firms whose managements have the requisite technical competence and breadth of vision will be in a particularly good position to exploit the potential of IT to the hilt -- to the increasing detriment of those rivals who have not.

The implications of IT for lower levels of the corporate hierarchy are less readily determined. Indeed, as these implications depend crucially upon the decisions made at the top, they too are influenced by management quality. The use of IT to promote or undermine skill depends not so much upon the characteristics of the technology, which are at most a secondary influence upon skill requirements in most applications. Perhaps the most important influence is the policy of management towards skills and training within the organisation. All too many firms elect to develop IT-based systems around strict hierarchical controls over labour and reductions in the skill requirements of jobs -- with immediate and negative implications for education and training requirements. Undoubtedly a correspondence exists between the two levels of organisational effects of IT. Managements which are ill prepared to perceive and exploit the opportunities opened up by IT at the level of the organisation as a whole are particularly likely to prefer low-trust, deskilling applications of IT to particular processes and occupations within the enterprise. To the extent that superior results can be attained by a policy of skill-enhancement, as is often the case where quality of product or service is important to customers, such policies will be punished by the verdict of the marketplace. There have already been many failures amongst non-innovative firms during the current crisis. It is true that not all sectors are totally exposed to the icy blast of international competition in the way that manufacturing firms are; while even in competitive product markets it may take some considerable time for the removal of the inefficient. Nevertheless, the intensification of international competition in manufacturing, together with its emergence in areas of services which had hitherto been largely immune from it, will mean in practice an increasing penalty upon firms and economies whose human resources fail to capture the potential of new technology.

At the same time the implications of IT applications at the workplace for education and training are less radical than is commonly thought. Attempts to justify policies of universal and lifelong training in terms of the requirements of IT have some force, but in view of the limits to the speed and extent of the diffusion of IT, they err in converting an uncertain and quantitative change into a deterministic and qualitative one. To say this is not to say that such policies are without merit. Indeed, IT may well prove a useful peg upon which to hang such politically long-standing issues as inadequacy in vocational education anbd training, in terms of both levels of provision and equity of access.

A related issue raised in new form by IT concerns the linkage of learning and working. Despite optimistic interpretations of the modern firm as a form of vocational school, the reality of too many enterprises is the degree to which they not only under-utilise human potential, but even stunt its development. A policy of continuous and unlimited development of employee potential is certainly expensive. More to the point, it threatens the hierarchical assumptions and values which characterise most organisations: viz., that the supply of the ability and willingness to work hard and learn is strictly limited, and that it is better to reduce rather than intensify demands upon employees. The Japanese, and to some extent the West Germans, reject this view of human resources. Even in the apparently hostile environment of Britain, Japanese management techniques appear to have produced good results. Some large corporations in other countries have in recent years become conspicuous converts to the developmental approach to human resources. Time might be expected to bring others round to this way of thinking. In practice, however, it will take more than simply time to undermine the values and assumptions underlying the standard hierarchy of work and training. The narrowness of vision of many employers will continue to slant work organisation towards low- rather than high-skill profiles; to limit rather than to expand the encouragement offered to employees for their personal development; and to frustrate the interest of society in the fusion of work and learning between the school and the enterprise. The concerns that have emerged around the issue of information technology are at most a secondary influence upon these long-standing social issues. But they can in their turn become part of a political process which attempts to erect in advanced economies systems of vocational education and training of which society can be proud, on grounds of personal development as well as economic efficiency.

Adler, P. (1983), "Does Automation Raise Skill Requirements? What, Again?", paper presented to Conference on Microelectronics in Transition: Industrial Transformation and Social Change, University of California, Santa Cruz, May.

Arnold, E. (1983), "Information Technology as a Technological Fix: Computer-Aided Design in the United Kingdom", in Winch, G. (1983).

Arnold, E. (1984), "The Draughtsman's Contract", CADCAM International, February 20-1.

Arnold, E., Huggett, C., Senker, P., Swords-Isherwood, N. and Shannon, C.Z. (1982), Microelectronics and Women's Employment in Britain, Occasional Paper No. 17, Science Policy Research Unit, University of Sussex (Brighton, England).

Arrow, K.J. and Capron, W.M. (1959), "Dynamic Shortages and Price Rises: The Engineer-Scientist Casse", Qtly. Jnl. Econ.; 73, 2; 292-308.

Atkinson, J. (1982), "Maintaining Apprentice Intakes: do Public Policies Work?", Manpower Studies, Spring; 4; 5-9.

Atkinson, W.R. (1980), "The Employment Consequences of Computers: A User View", in Forester (1980).

Ball, G.F. (1979), Report on Vocational Education and Training for Employment in Engineering in Japan (mimeo), Engineering Industry Training Board, Watford, England.

Barras, R. and Swann, J. (1983), The Adoption and Impact of Information Technology in the UK Insurance Industry (Technical Change Centre, London).

Becker, S. (1964), Human Capital (NBER, New York).

Benson, I. and Lloyd, J. (1983), New Technology and Industrial Change, (Koran Page, London).

Berg, I. (1970), Education and Jobs: The Great Training Robbery, (Praeger, New York).

Bessant, J.R., Bowen, J.A.E., Dickson, K.E. and Marsh, J. (1981), The Impact of Microelectronics: a Review of the Literature, Frances Pinter, London.

Bessant, J. (1983), "Management and Manufacturing Innovation: the Case of Information Technology", in Winch, G. (1983).

Blaug, M. (1972), An Introduction to the Economics of Education, Penguin, Hammondsworth, England.

Brady, T. and Liff, S. (1983), Monitoring New Technology and Employment, (GB Manpower Services Commission, London).

Braverman, H. (1974), Labor and Monopoly Capital, Monthly Review, New York.

Bright, J.R. (1958), "Does Automation Raise Skill Requirements?", Harvard Business Review, July; 36, 4; 85-98.

Bright, J.R. (1958), Automation and Management, Harvard University Press, Boston.

Brooks, H. (1983), "Technology, Competition and Employment", Annals of the American Academy of Political and Social Science, Nov; 470.

Brown, W. (1973), Piecework Bargaining, Heinemann, London.

Brusco, S. and Sabel, C. (1981), "Artisan Production and Economic Growth", in Wilkinson, F. (Ed.), Dynamics of Labour Market Segmentation, Academic Press, London.

Buchanan, D. (1983), "Technological Imperatives and Strategic Choice", in Winch, G. (1983).

Buchanan, D. and Boddy, D. (1982), "Advanced Technology and the Quality of Working Life: the Effects of Word Processing on Video Typists", Jnl. of Occupational Psychology, 55; 1-11.

Burns, A., Feickert, D., Newby, M. and Winterton, J. (1983), "The Miners and New Technology", Industrial Relations Journal, Winter; 14, 4; 7-20.

Business Week (1984), "New Blueprints in the Drive for Job Security", 9 January, 77-78.

Buss, M. (1982), "Managing International Information Systems", Harvard Business Review, Sept.-Oct.; 60, 5; 153-62.

Caves, R.C. (1980), "Productivity Differences Among Industries", in Caves, R.C. and Krause, L., Britain's Economic Performance (Brookings, Washington, DC).

CEDEFOP: European Centre for the Development of Vocational Training (1981), Youth Unemployment and Alternance Training in the EEC: Conference Report (Berlin).

Child, J., Loveridge, R., Harvey, J. and Spencer, A. (1984), "Microelectronics and the Quality of Employment in Services", in Marstrand, P. (1984).

Cockburn, C. (1983), "New Technology in Print: Men's Work and Women's Chances", in G. Winch (1983).

Colasanto, M. (1983), "Alternance: Assumptions, Conditions, Advantages", Vocational Training, Sept; 12; 8-12.

Commission of the European Communities (1982), The FAST Programme, Vol. 1, Results and Recommendations (Brussels).

Commission of the European Communities (1983), "Social Change and Technology in Europe: Robotics", Information Bulletin No. 10, European Pool of Studies, Brussels.

Commission of the European Communities (1983), Mismatch between Machine Representations and Human Concepts: Dangers and Remedies (FAST Series No. 9, Luxembourg).

Council for Science and Society (1981), New Technology: Society, Employment and Skill, CSS, London.

Crompton, R. and Reid, S. (1982), "The Deskilling of Clerical Work", in Wood, S. (1982).

Crompton, R. and Jones, G. (1984), White Collar Proletariat: Deskilling and Gender in Clerical Work, Macmillan, London.

Cross, M. (1983), "Changing Requirements for Craftsmen in the Process Industries", Interim Report; Technical Change Centre, London.

Daniel, W.W. and Milward, N. (1984), Workplace Industrial Relations in Britain, Heinemann, London.

Davies, D.S. (1980), "The Computer Revolution, Industry and People", in Forester (1980).

Dav' , L.E., Canter, R.R. and Hoffman, J.F. (1955), "Current Job Design Criteria", Jnl. Indl. Eng., March; VI, 2; 5-8.

Dickson, K. (1980), "Petfoods by Computer: a Case Study of Automation", in Forester (1980).

Doeringer, P. and Piore, M. (1971), Internal Labour Market and Manpower Analysis, D.C. Heath, Lexington, Massachusetts.

Dore, R. (1973), British Factory; Japanese Factory, University of California Press, Berkeley.

Drake, K. (1982), "The Cost-Effectiveness of Vocational Training: a Survey of British Studies", Economics of Education Review, Spring; 2, 2; 103-125.

Edding (1974), Commission on the Cost and Financing of Vocational Training, The Cost and Finance of Non-School-Based Vocational Training, (Bielefeld).

Edwards, R.C. (1976), "Individual traits and organisational incentives: what makes a 'good' worker?" Journal of Human Resources, Winter; XI, 1; 51-68.

Edwards, R.C. (1979), Contested Terrain, Basic Books, New York.

Eliasson, G. (1981), "Electronics, Economic Growth and Employment -- Revolution or Evolution?", in Giersch, H. (Ed.), Emerging Technologies: Consequences for Economic Growth, Structural Change and Employment, Mohr, Tübingen.

Elsasser, B. and Lindvall, J. (1983), "Impact of NC Machine Tools on Employment and Skill Levels", Department of Economics, University of Linköping, Sweden (Mimeographed summary).

Finniston (1980), GB Committee of Inquiry into the Engineering Profession, Engineering our Future, Report; Cmnd 7794 (HMSO, London).

Flanders, A. (1964), The Fawley Productivity Agreements, Faber, London.

Fleck, J. (1983), "Robotics in Manufacturing Organisations", in Winch, G. (1983).

Forester, T. (1980) (Ed.), The Microelectronics Revolution, Basil Blackwell, Oxford; MIT Press, Cambridge, Massachusetts.

Fox, A. (1974), Beyond Contract: Work, Power and Trust Relations, Faber, London.

Freeman, R.B. (1971), The Market for College-Trained Manpower, Harvard University Press, Cambridge, Massachusetts.

Freeman, R.B. (1976), The Over-Educated American, Academic Press, New York.

Friedman, A. (1977), Industry and Labour, Macmillan, London.

Frohman, A. (1982), "Technology as a Competitive Weapon", Harvard Business Review, Jan; 60; 97-104.

Gallie, D. (1978), In Search of the New Working Class, CUP; Cambridge, England.

Gerwin, D. (1982), "Do's and Dont's of Computerised Manufacturing", Harvard Business Review, March; 60; 107-116.

Ginzberg, E. (1979), Good Jobs, Bad Jobs, No Jobs, Harvard University Press, Cambridge, Massachusetts.

Gintis, H. (1971), "Education, Technology and the Characteristics of Worker Productivity", American Economic Review, May; 61, 2; 266-279.

Gold, B. (1982), "CAM sets new rules for Production", Harvard Business Review, Nov; 60; 88-94.

GB Department of Employment (1981), A New Training Initiative: a Programme for Action, Cmnd 8455; HMSO, London.

GB Engineering Industry Training Board (1981), Maintenance Skills in the Engineering Industry: the Influence of Technological Change, Occasional Paper No. 8, Watford, England.

GB Engineering Industry Training Board (1982), Designing the Future -- the Implications of CAD Interactive Graphics for Employment and Skills in the British Engineering Industry, Occasional Paper No. 9, EITB, Watford.

GB Engineering Industry Training Board (1984), Economic and Industry Monitor, Nov; 17; Watford, England.

GB Manpower Services Commission (1982), Youth Task Group Report, MSC, London.

GB Manpower Services Commission (1983a), Towards an Adult Training Strategy, MSC, London.

GB Manpower Services Commission (1983b), Annual Report 82/83, MSC, London.

GB National Economic Development Office (1977), Engineering Craftsman: Shortages and Related Problems, London.

GB National Economic Development Office (1982), Policy for the UK Information Technology Industry, NEDO, London.

Griffin, A. (1984), "Technological Change and Craft Control in the Newspaper Industry: an International Companion", Cambridge Jnl. Econ., March; 8, 1; 41-62.

Guiliano, V.E. (1982), "The Mechanization of Office Work", Scientific American, Sept; 247, 3; 125-134.

Gustavson, P. and Taylor, J.C. (1983), "New Modes of Work: Sociotechnical Design of Wafer Fabrication", paper presented to Conference on Microelectronics in Transition, University of California, Santa Cruz; May.

Hartley, K. (1972), "The Economics of Training: Theory and Evidence", European Training, Summer; 1, 2; 159-170.

Hayes, C. (1981), "Trends in Apprenticeship in the EEC", pp. 59-86 of CEDEFOP (1981).

Hayes, C., Anderson, A. and Fonda, N. (1984), Competence and Competition, Report to NEDO and MSC, Institute of Manpower Studies, Brighton, UK.

Hingel, A. (1984), "A Promethean Change of Industrial Relations: a Comparative Study of Western European Unions and Technological Developments", in Warner, M. (1984).

Hodge, R.W. and Siegel, P.M. (1966), "The Classification of Occupations: Some Problems of Interpretation", American Statistical Association, Proceedings of the Social Science Section, 176-192.

Horowitz, M.A. and Herrnstadt, I.L. (1966), "Changes in the Skill Requirements of Occupations in Selected Industries" in US National Commission on Technology, Automation and Economic Progress, Technology and the American Economy, appendix, Vol. VI, 227-287, GPO, Washington.

Horowitz, M.A. and Herrnstadt, I.L. (1969), "The Training of Tool and Die Makers", Northeastern University, Boston, Massachusetts (mimeo).

Howard, R. (1981), "How AT&T's Workers are Drugged, Bugged and Coming Unplugged", Mother Jones, August.

Howard, R. (1983), "High Technology and the Re-enchantment of the Workplace", paper presented to Conference on "Microelectronics in Transition: Industrial Transformation and Social Change", University of California, Santa Cruz.

Incomes Data Services, Ltd. (1983), "Draughtsmen and CAD", Study 302, November, London.

Incomes Data Services, Ltd. (1984), "Craft Flexibility", Study 322, September, London.

d'Iribarne, A. (1981), "New Technologies and the Structure of Qualifications: an Approach Based on French Experience", Commission of the European Communities, CEC/DG-XII/DG-V, Brussels.

d'Iribarne, A. (1982), "Vocational Education and Training and the New Technologies: the Key Role of the Enterprise", OECD, Paris (CERI/CW/82.02, mimeo).

Jahoda, M. (1982), Employment and Unemployment, CUP, Cambridge, England.

Jallade, J.-P. (1982), Alternance Training for Young People: Guidelines for Action, CEDEFOP, Berlin.

Japan Ministry of Labour (1980), Bureau of Vocational Training, Report of a Survey of Occupational Capacity Development, Tokyo.

Jones, B. (1982), "Destruction or Redistribution of Engineering Skills? The Case of Numerical Control", in Wood, S. (Ed.), The Degredation of Work? Skill Deskilling and the Labour Process, Hutchinson, London.

Jones, I. (1982), "The New Training Initiative -- An Evaluation", Nat. Inst. Econ. Rev., Feb; 99; 68-74.

Jones, I. and Hollenstein, H. (1983), "Trainee Wages and Training Deficiencies: an Economic Analysis of a 'British Problem'", Discussion Paper No. 58, National Institute of Economic and Social Research, London.

Kahn Freund, O. (1979), Labour Relations: Heritage and Adjustment, OUP, Oxford.

Kamata, S. (1984), _Japan in the Passing Lane_, Unwin, London.

Kanter, R.M. (1984), "Managerial Career Structures in High-Technology Firms", in Osterman, P. (1984).

Kaus, R.M. (1973), "Job Enrichment and Capitalist Hierarchy", Unpublished Seniors Honours Thesis, Harvard College.

Kendrick, J.W. (1976), _The Formation and Stocks of Total Capital_, NBER, New York.

Keynes, J.M. (1930), "Economic Possibilities for our Grandchildren", in _Essays in Persuasion_, Macmillan, London.

Kling, R. (1982), "Value Conflicts in Public-Oriented Computing Developments", Department of Information and Computer Science, University of California, Irvine (mimeo).

Kochan, T., McKersie, R.B. and Capelli, P. (1984), "Strategic Choice and Industrial Relations Theory", _Industrial Relations_, Winter; 23, 1; pp. 16 ff.

Krais, B. (1979), _Relationships between Education and Employment and Their Impact on Education and Labour Market Policies_, CEDEFOP, Berlin.

Lariccia, G. and Megarry, J. (1984), "Information Society and General Education", OECD, Paris (CERI/NT/84.07, mimeo).

Lawler, E.E. (1969), "Job Origin and Employee Motivation", _Personnel Psychology_, 22; 426-35.

Lee, D. (1972), "Very Small Firms and the Training of Engineering Craftmen -- Some Recent Findings", _British Jnl. of Industrial Relations_, July; 10, 1; 240-55.

Lees, D. and Chiplin, B. (1970), "The Economics of Industrial Training", _Lloyds Bank Review_, April; 29-41.

Lindley, R. (1983), "Active Manpower Policy", in Bain, G.S. (Ed.), _Industrial Relations in Britain_, Basil Blackwell, Oxford.

Littler, C. (1983), "A History of 'New Technology'", in Winch, G. (1983).

Long, R.J. (1984), "Microelectronics and Quality of Working Life in the Office: a Canadian Perspective", in Warner (1984).

Lorenz, E. (1983), "The Labour Process and Industrial Relations in the British and French Shipbuilding Industries from 1880 to 1970", Unpublished Ph.D. dissertation, University of Cambridge.

Lund, R.T., Sirbu, M.A. and Utterback, J.M. (1979), "Microprocessor Applications: Cases and Observations", Report, Centre for Policy Alternatives, Massachusetts Institute of Technology.

Lutz, B. (1981), "Education and Employment: Contrasting Evidence from France and the Federal Republic of Germany", European Journal of Education, 16, 1; 73-86.

Mace, J. (1979), "Internal Labour Markets for Engineers in British Industry", British Jnl. Indust. Rel., March; 17, 1; 50-63.

Magnum, G.L. (1968), MDTA: Foundation of Federal Manpower Policy, (Johns Hopkins, Baltimore).

Mansfield, E. (1961), "Technical Change and the Rate of Imitation", Econometrica, Oct; 29, 4; 741-66.

Manwaring, T. (1981), "The Trade Union Response to New Technology", Industrial Relations Journal, July; 12, 4; 7-26.

Marglin, S.A. (1974), "What do Bosses do? The Origins and Function of Hierarchy in Capitalist Production", Review of Radical Political Economics, Summer; 6, 2; 60-112.

Marsden, D. (1982), "Career Structures and Training in Internal Labour Markets", Manpower Studies, Spring; 4; 10-17.

Marsden, D. (1984), "Homo Economicus and the Labour Market", in Wiles, P. and Routh, G. (Eds.), Economics in Disarray, Basil Blackwell, Oxford.

Marstrand, P. (1984), New Technology and the Future of Work and Skills, Frances Pinter, London.

Martin, R. (1981), New Technology and Industrial Relations in Fleet Street, OUP, Oxford, England.

Martin, R. (1984), "New Technology and Industrial Relations in Fleet Street: 'New Technology will Make it Possible for Managers to Manage'", in Warner, M. (1984).

Maurice, M., Sellier, F. and Silvestre, J.-J. (1979), "La Production de la Hierarchie dans l'Entreprise : Recherche d'un Effet Sociétal", Revue Française de Sociologie, XX; 331-365.

Maurice, M., Sellier, F. and Silvestre, J.-J. (1984), "The Search for a Societal Effect in the Production of Company Hierarchy: a Comparison of France and Germany", in Osterman (1984).

Méhaut, P. (1983), "French Training Policies and the Structure of the Training System", paper presented to Annual Conference of International Working Group on Labour Market Segmentation, Aix-en-Provence.

Meissner, M. (1971), "The Long Arm of the Job: a Study of Work and Leisure", Industrial Relations, Oct; 10, 3; 239-60.

More, C. (1980), Skill and the English Working Class, 1870-1914, Croom Helm, London.

Murray, P. and Wickham, J. (1983), "Technical Training and Technical Knowledge in an Irish Electronics Factory", in G. Winch (1983).

Nicholas, I., Warner, M., Sorge, A. and Hartmann, G. (1983), "Computerised Machine Tools, Manpower Training and Skill Polarisation: a Study of British and West German Manufacturing Firms", in Winch, G. (1983).

Noble, D.F. (1979), "Social Choice in Machine Design: the Case of Automatically Controlled Machine Tools", in A. Zimbalist (Ed.) Case Studies in the Labour Process (Monthly Review, New York).

Nolan, R. (1982), "Managing Information Systems by Committee", Harvard Business Review, July; 60; 72-79.

Noll, I., Beicht, K., Böll, G., Malcher, W. and Wiederhold-Fritz, S. (1983), "The Net Cost of Firm-Based Vocational Training in the FRG", CEDEFOP, Berlin (mimeo).

Nollen, S. (1984), "The Development and Utilisation of Human Resources in the Context of Technological Change and Industrial Restructuring: Country Study - United States, OECD/CERI, Paris (CERI/CW/84.15, mimeo).

Northcott, J. and Rodgers, P. (1984), Microelectronics in British Industry: the Pattern of Change, Policy Studies Institute, No. 625, London.

OECD (1973a), Review of Manpower and Social Policies: Japan, Paris.

OECD (1973b), Review of Manpower and Social Policies: France, Paris.

OECD (1979a), "Manpower and Employment Measures for Positive Adjustment", Manpower and Social Affairs Committee, Paris (mimeo).

OECD (1979b), Policies for Apprenticeship, Paris.

OECD (1979c), Interfutures: Facing the Future, Paris.

OECD (1979d), "Recurrent Education and Industrial Democracy", CERI, Paris (mimeo).

OECD (1980), "Review of Youth Employment Policies: Federal Republic of Germany", CERI, Paris (mimeo).

OECD (1984a), "The Introduction of the New Information Technology in Education: Policy Trends and Developments in Member Countries", Paris (CERI/NT/84.02, mimeo).

OECD (1984b), "Education in Changing Social, Economic and Technological Conditions", Education Committee, [ED(84)5, mimeo].

Offe, C. (1976), Industry and Equality, E. Arnold, London.

Okamoto, H. (1983), "New Technology, Workshop Organisation, Education and Training", OECD/CERI, Paris (CERI/CW/83.09, mimeo).

Osterman, P. (1982), "Employment Structures within Firms", British Jnl. Indust. Rel., Nov; 20, 3; 349-361.

Osterman, P. (1984), Internal Labour Markets, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Parmagenta, P. and Overy, R. (1984), All Our Working Lives, BBC Publications, London.

Pescarollo, D. (1981), "The Alternation of School and Work in Italy", Vocational Training, 4; 19-25.

Piore, M.J. (1968), "On-the-Job Training and Adjustment of Technological Change", Jnl. Hum. Res., Fall; III, 4; 435-449.

Piore, M.J. (1973), "The Importance of Human Capital Theory to Labor Economics: a Dissenting View", Industrial Relations Research Association, 26th Annual Meeting, Proceedings, 251-258.

Piore, M. (1982), "American Labour and the Industrial Crisis", Challenge, March; 25, 1; 5-11.

Piore, M. (1982), "Fissure and Discontinuity in US Labour Management Relations", paper presented to the Annual Conference of the International Working Group on Labour Market Segmentation, Aix-en-Provence.

Prais, S.J. (1981), Productivity and Industrial Structure, CUP, Cambridge, England.

Raffe, D. (1984), "Small Expectations: the First Year of the Youth Training Scheme", paper presented to Conference on the Young Persons' Labour Market, Institute for Employment Research, University of Warwick, England.

Ray, G.F. (1984), The Diffusion of Mature Technologies, CUP, Cambridge, England.

Robey, D. (1980), "Computers and Management Structure", in D. Katz, R. Kahn and J. Adams, The Study of Organisations, Jossey-Bass San Francisco.

Robins, K. and Webster, F. (1982), "New Technology: a Survey of Trade Union Response in Great Britain", Industrial Relations Journal, 13, 1; 7-26.

Rosenbrock, H. (1984), "Designing Automated Systems: Need Skill be Lost?" in P. Marstrand (1984).

Rosenfeld, M. and Thornton, R.F. (1976), "A Case Study in Job Analysis Methodology", Educational Testing Service report, Princeton, New Jersey.

Rothwell, S. and Davidson, D. (1983), "Training for New Technology", in Winch G. (1983).

Rothwell, S. (1984), "Company Employment Policies and New Technology in Manufacturing and Service Sectors", in Warner, M. (1984).

Rumberger, R.W. (1981), "The Changing Skill Requirements of Jobs in the US Economy", Ind. Lab. Rel. Rev., July; 34, 4; 578-590.

Rumberger, R.W. (1983), "A Conceptual Framework for Analysing Work Skills", Project Report No. 83-A8, Institute for Research on Educational Finance and Governance, School of Education, Stanford University.

Ryan, P. (1977), "Job Training", unpublished Ph.D. dissertation, Harvard University.

Ryan, P. (1980), "The Costs of Job Training for a Transferable Skill", Brit. Jnl. Indust. Rel., Nov; 18, 3; 334-352.

Ryan, P. (1981), "Human Resources, Job Training and Industrial Restructuring in OECD Countries", paper presented to Conference on Changes in Work Patterns: Educational Implications, OECD/CERI, Paris, November.

Ryan, P. (1983), "Youth Labour, Trade Unionism and State Policy in Contemporary Britain", paper presented to Fifth Conference of the International Working Group on Labour Market Segmentation, Aix-en-Provence, July.

Ryan, P. (1984a), "Job Training, Employment Practices and the Large Enterprise: the Case of Costly Transferable Skills", in P. Osterman (1984).

Ryan, P. (1984b), "The New Training Initiative after Two Years", Lloyds Bank Review, April; 152; 31-45.

Ryan, P. (1984c), "Do Trade Unions Raise the Pay of Young Workers?", paper presented to Conference on the Young Persons' Labour Market, Institute of Employment Research, University of Warwick, November.

Sabel, C. (1982), Work and Politics: the Division of Labour in Industry, CUP, Cambridge, England.

Sadowski, D. (1981), "Finance and Government of the German Apprenticeship System", Journal of Institutional and Theoretical Economics, July; 137, 2; 234-251.

Schlesinger, R.J. (1984), "Industrial Robots, Work and Industry: Past, Present and Future", in Warner, M. (1984).

Schonberger, R.J. (1982), Japanese Manufacturing Techniques, Free Press, New York City.

Schuller, T. (1983), "The Process of Skill Change: Outline of a Multilinear Approach", OECD, Paris (CERI/CW/83.07, mimeo).

Science Council of Canada (1980), The Impact of the Microelectronics Revolution on Work and Working, Ottawa.

Scoville, G. (1966), "Education and Training Requirements for Occupations", Review of Economics and Statistics, Nov; 387-393.

Scoville, J.G. (1969), "A Theory of Jobs and Training", *Industrial Relations*, Oct; 9, 1; 36-53.

Sellin, B. (1983), "The Development of Alternance Training for Young People in the European Community", *Vocational Training*, September; 12; 73-83.

Sengenberger, W. and Mendius, H.G. (1983), "Training in the Enterprise and the Development of the Labour Market -- a Plea for Forward-looking Personnel Policies and Increased Public Labour Promotion", OECD/CERI (CERI/CW/83.06, mimeo).

Senker, P., Swords-Isherwood, N., Brady, T. and Huggett, C. (1981), *Maintenance Skills in the Engineering Industry: the Influence of Technological Change*, Occasional Paper No. 8, GB Engineering Industry Training Board, Watford, England.

Senker, P. (1984a) (Ed.), "Learning to Use Microelectronics: a Review of Empirical Research on the Implications of Microelectronics for Work Organisation, Skills and Industrial Relations", Science Policy Research Unit, University of Sussex, Brighton, England (mimeo).

Senker, P. (1984b), "Training for Automation", in Warner, M. (1984).

Sorge, A. and Warner, M. (1980), "Manpower Training, Manufacturing Organisation and Workplace Relations in Britain and West Germany", *Brit. Jnl. Indust. Rel.*, Nov; 18, 3. 318-333.

Sorge, A., Hartmann, G., Warner, M. and Nicholas, I. (1983), *Microelectronics and Manpower in Manufacturing*, Gower, Aldershot, UK.

Sorge, A. (1984), *Technological Change, Employment, Qualifications and Training*, CEDEFOP, Berlin.

Spence, M. (1973), "Job Market Signalling", *Qtly. Jnl. Econ.*, Aug; 87, 3; 355-74.

Stinchcombe, A.L. (1959), "Bureaucratic and Craft Administration of Production: a Comparative Study", *Administrative Science Quarterly*, Sept; 4, 2; 168-187.

Stone, K. (1973), "The Origins of Job Structures in the Steel Industry", *Radical America*, Nov-Dec; 7, 6; 19-66.

Strauss, G. (1965), "Apprenticeship: an Evaluation of the Need", pp. 299-332 of Ross, A.M. (Ed.), *Employment Policy and the Labour Market*, University of California, Berkeley.

Strauss, G. (1984), "Industrial Relations: a Time of Change", *Industrial Relations*, Winter; 23, 1; 1-15.

Swords-Isherwood, N. and Senker, P. (1980a), *Microelectronics and the Engineering Industry*, Frances Pinter, London.

Swords-Isherwood, N. and Senker, P. (1980b), "Management Resistance to New Technology", in Forester (1980).

Tarsh, J. (1984), "Graduate Shortages in Science and Engineering", Department of Employment, Gazette, August; 92, 8; 354-60.

Taylor, B. and Lewis, P. (1973), "Informal Learning, Training and Industrial Relations", European Training; 2, 2; 160-79.

Taylor, F.W. (1967), The Principles of Scientific Management, Norton, New York.

Taylor, M.E. (1981), Education and Work in the Federal Republic of Germany, Anglo-German Foundation for the Study of Industrial Society, London.

Taylor, R. and Piore, M. (1971), "Federal Training Programmes for Dispersed Employment Occupations", in Jacks, S.M. (Ed.), Issues in Labour Policy, MIT, Cambridge, Massachusetts.

Thatcher, A.R. (1978), "Labour Supply and Employment Trends", pp. 26-48 of Blackaby, Frank (Ed.), De-Industrialisation, Heinemann, London.

Thomas, B., Moxham, J. and Jones, J.A.G. (1969), "A Cost Benefit Analysis of Industrial Training", Brit. Jnl. Ind. Rel., July; VII, 2; 231-264.

Thurley, K. (1982), "Utilisation of Human Resources: a Proposed Approach", OECD, Paris (CERI/CW/82.04, mimeo).

Tipton, B. (1982), "The Quality of Training and the Design of Work", Industrial Relations Journal, Spring; 13, 1; 27-42.

Trades Union Congress (1979), Employment and Technology, TUC, London.

Turner, H.A. (1962), Trade Union Growth, Structure and Policy, Allen and Unwin, London.

US Department of Labor, Bureau of Labor Statistics (1970), Outlook for Computer Process Control, Bulletin 1658 GPO, Washington, DC.

US Department of Labor, Bureau of Labor Statistics (1974), Technical Change and Manpower Trends in Six Industries, Bulletin 1817.

US Department of Labor, Bureau of Labor Statistics (1975), Technical Change and Manpower Trends in Five Industries, Bulletin 1856.

US Department of Labor, Bureau of Labor Statistics (1977), Technical Change and its Labor Impact in Five Industries, Bulletin 1961.

US Department of Labor, Bureau of Labor Statistics (1979a), Technical Change and its Labor Impact in Five Energy Industries, Bulletin 2005.

US Department of Labor, Bureau of Labor Statistics (1979b), Impact of Technology on Labor in Five Industries, Bulletin 2033.

US Department of Labor, Bureau of Labor Statistics (1982), Impact of Technology on Labor in Five Industries, Bulletin 2137.

US Department of Labor Manpower Administration (1964), Office of Manpower, Automation and Training, Formal Occupational Training of Adult Workers, Manpower/Automation Research Monograph No. 2, GPO, Washington, DC.

US Federal Trade Commission (1976), Bureau of Consumer Protection, Proprietary, Vocational and Home Study Schools, Staff Report, Washington, DC.

Useem, Elizabeth and Kimball, L.M. (1983), "High Technology and Challenges to Education: Policies, Dilemmas and Social Inequities", paper presented to Conference on Microelectronics in Transition, University of California, Santa Cruz, May.

Weir, M. (1977), "Are Computer Systems and Humanised Work Compatible?" in R. Ottoway (Ed.), Humanising the Workplace, Croom Helm, London.

Werneke, D. (1983), Microelectronics and Office Jobs, ILO, Geneva.

White, M. and Trevor, M. (1983), Under Japanese Management, Heinemann, London.

Whyte, W.F. (1955), Money and Motivation, Harper, New York.

Wilkinson, B. (1983), The Shopfloor Politics of New Technology, Heinemann, London.

Williams, R. and Moseley, R. (1982), "The Trade Union Response to Information Technology", paper presented to EEC/FAST Conference on the Transition to an Information Society, London, January.

Winch, G. (1983), Information Technology in Manufacturing Processes, Rossendale, London.

Winch, G. (1983a), "Organisation Design for CAD/CAM" in G. Winch (1983).

Wood, S. (1982), The Degredation of Work?, Hutchinson, London.

Woodward, N. (1974), "The Feasibility of Evaluating Apprentice Training", European Training; 3, 3; 226-35.

Wyles, C. (1984), "People -- the Forgotten Factor in Automation", Works Management, March; 37, 3; 17-20.

Ziderman, A. (1978), Manpower Training: Theory and Policy, Macmillan, London.

Zuboff, S. (1982), "New Worlds of Computer-Mediated Work", Harvard Business Review, Sept-Oct; 60, 5; 142-152.