HODGSON G.M. and SCREPANTI E. (eds) (1991), Rethinking Economics. Market, Technology and Economic Evolution, Edward Elgar, Aldershot.

# 5. Production Flexibility

**Mario Morroni**[1]

## 1. INTRODUCTION

Particular attention will be devoted in this chapter to one aspect of flexibility which in recent years has aroused increasing interest: *the flexibility of production processes.* With the rapid evolution of market conditions, efficacy – which indicates the ability to meet consumer demand – becomes a complex goal and assumes a predominant role in affecting the competitiveness of a firm. In the presence of uncertainty, efficacy requires production flexibility.

As will become clear, production flexibility is not an exclusive prerogative either of small or of large firms (or production units) and the need for flexibility greatly differs from one sector to another. Production flexibility is even independent of the technology adopted, since it can be achieved in firms through the flexible organization of rigid equipment or production units. Nevertheless, the new information technology is proving a formidable tool for cutting flexibility costs, and thus for encouraging further development of flexible organizational systems. Hence the potentialities offered by this technology will undoubtedly be a strong incentive to apply flexible organizational systems to large as well as small production units.

The implementation of flexible production systems leads to a drastic reduction in the duration of the production process, response times, and the quantity of goods lying in inventories and goods in progress. Consequently, the analysis of production flexibility needs a representation of the production process which takes account of the organizational and temporal dimensions of production.

The chapter consists of four sections. In the second section the different meanings of production flexibility are discussed and a taxonomy devised. Section 3 deals with the link between uncertainty and production flexibility, and analyses briefly the organizational aspects of production flexibility. Section 4 examines the main effects of computer-based technology on production flexibility. Information technology reduces set-up times, which makes economies of scale compatible with economies of scope. Notably, sections 3 and 4 involve applications of the analysis to recent developments in industrial capitalism. Finally, some general conclusions are drawn in the last section.

## 2. PRELIMINARY DEFINITIONS

Flexibility expresses the capacity for adjustment to variations in external conditions; in other words, it is the ability to learn from experience and change plans over time. The greater the uncertainty, the greater, of course, is the need for flexibility. 'True uncertainty' depends upon the inability or

*Table 5.1: Flexible production systems: a taxonomy*

**Flexible production systems**

(A) **Adaptability** – the ability to change the quantity produced of an individual commodity. It may be achieved by:

(1) Numerical flexibility, changes in the number of employees (external numerical flexibility) or hours per employee (internal numerical flexibility);
(2) functional flexibility (workers' mobility across tasks);
(3) hiring of equipment;
(4) keeping inventories;
(5) keeping old machines, brought into use in certain periods only;
(6) employing sub-contractors.

(B) **Production flexibility** in a mix of outputs

(i) **Strategic flexibility** – the ability to change processes and goods, modifying quantities and qualities of outputs mix. It implies the capacity to modify the production process in order:
(a) to change the productive capacities of single production lines (ALTERABILITY);
(b) to produce new goods (CONVERTIBILITY).

(ii) **Operational flexibility** – the ability to vary the quantities produced within a mix. It refers to the characteristics of a given productive structure and implies adaptability of production lines. It can take the following forms:
(a) ORGANIZATIONAL FLEXIBILITY – the capacity to organize machines and equipment in 'a flexible way';
(b) TECHNICAL FLEXIBILITY – the flexibility of individual machines.

impossibility of considering all future contingencies and their probability distribution.[2] Hence, in the presence of uncertainty, a *flexible action* tends to reduce the degree of irreversibility of economic decisions, facilitating an improved reaction if something unforeseen or unforeseeable occurs.[3]

*Production flexibility* permits output flows to be regulated in line with the evolution of market conditions. Within this general definition, it may be useful to distinguish between flexibility in relation to absorbing quantitative variations in the demand for a *single* commodity, and flexibility in relation to a *mix* of outputs. For the sake of simplicity I call the former adaptability and the latter production flexibility (see Table 5.1).

A mono-product plant is more adaptable the less its unit costs vary with the quantity produced (that is, the lower the elasticity of unit costs is in relation to the volume of production). It is generally assumed that there is a trade-off between adaptability and efficiency. Since greater adaptability makes plant more efficient over a large range of products, it reduces efficiency at the optimum technical output level.[4]

The indivisibility of production elements and sunk-cost irreversibility of investment in capital goods generally imply a low adaptability level. Hence, firms pursue adaptability by increasing the divisibility of plants and by reducing their fixed cost. In short, adaptability may be obtained by:

(a) numerical flexibility that involves changes in the number of employees (external numerical flexibility), or of working hours per employee (internal numerical flexibility);
(b) functional flexibility which refers to the capacity to adjust workers' skills in order to change the required tasks (mobility across tasks, changing job assignment, retraining);
(c) hiring of equipment;
(d) keeping inventories that serve to compensate for quantitative fluctuations in demand;
(e) keeping in-house old machines and equipment, which are already fully amortized and which are brought back into use only when the demand is particularly high;
(f) employing sub-contractors, so that variability of demand is largely transferred to suppliers.

If we take into consideration the production of a mix of goods, *production flexibility* may refer to, first, the capability for modifying the mix, changing processes and goods produced (strategic flexibility); or secondly, the possibility of varying the quantities produced within a given mix, using a given productive structure (operational flexibility).[5]

*Strategic flexibility* implies an innovative capacity; that is to say, the ability to change production processes, production element endowment and the qualities of outputs in relation to changes in environmental conditions. Strategic flexibility may involve widening the mix of products and variations in product quality. Thus, strategic flexibility implies alterability, that is, the ability to modify the productive capacity of single production lines; and convertibility; the ability to introduce new products. In a changing environment a certain degree of strategic flexibility may be achieved, for instance, by buying less-durable equipment.[6]

In contrast, what is termed *operational flexibility* is related only to the characteristics of a given productive structure in relation to the possibility of adjusting the quantities of various outputs within the same range. Hence, operational flexibility depends on the degree of adaptability in the single processes belonging to the production mix. Operational flexibility includes both organizational flexibility and technical flexibility. The former refers to the capability for organizing rigid machines in a 'flexible way'; the latter refers to the degree of flexibility of individual machines, in order to guarantee variability in the quantitative composition of the mix of outputs.

It should be noted that the need for production flexibility may differ greatly from one industry to another. On the other hand, no deterministic relationship exists between technical flexibility and organizational flexibility, in the sense that technical flexibility does not require organizational flexibility, because it is conceivable that versatile machines or plants may be utilized within a rigid organizational structure. Conversely, a production unit can achieve a degree of organizational flexibility through the combination and organization of inflexible (highly standardized mono-use) machines. Likewise, a firm can secure organizational flexibility by arranging the activity of several (mono-product) production units (or firms). In conclusion, the analysis of flexible production systems requires the technical aspects of production processes to be considered together with the organizational dimension.

## 3. UNCERTAINTY AND FLEXIBLE ORGANIZATION

Consider the particular relevance of this issue to the evolution of industrial systems. During the 1950s and 1960s the economic development of industrialized countries was based on stability and a highly standardized demand, ready availability of unskilled labour, and technical changes allowing large economies of scale, through the application of *rigid automation* in the production process. These first two decades after the Second World War were characterized by mass production and corporate development at the microeconomic level, and by what were labelled Keynesian policies, at the macroeconomic level.[7] During the 1970s these conditions were progressively transformed. Market structures and production organization were influenced by a number of factors, which gave rise to uncertainty in many industries.[8] Among these factors, the following may be mentioned:

(a) increasing instability of demand and increasing product differentiation;
(b) notable increases in the prices of raw materials and wages;
(c) floating exchange rates and recurrent financial disturbances;
(d) labour unrest; in particular, variations in expectations over levels of skill and job satisfaction;
(e) increased competitiveness of developing countries in mass production;
(f) the spread, since the late 1970s, of computer-based technology.

All these changes have certainly induced many enterprises operating in industrialized countries to seek greater production flexibility. In fact, as already noted, production flexibility is required if environmental conditions change rapidly and if there is a low degree of predictability with regard to the direction and magnitude of changes (bounded rationality). If there is a trade-off between production flexibility and efficiency, the firm's choice (as to which plant and organizational scheme to adopt) depends on the level of flexibility required by the environmental conditions in relation to flexibility costs.

Furthermore, the saturation of mass markets (which have increasingly become substitution markets) and the associated evolution of consumption models lead to the spread of more and more personalized and differentiated commodities, with a larger service component. Consequently many firms become more market orientated. Efficacy, linked to the capacity to evolve in response to changed market conditions, begins to be an increasingly important aspect of competitiveness for many firms.

The need to produce differentiated goods may also derive from reasons of international competitiveness. Standardized production, based on rigid automation technologies, becomes less and less competitive in industrialized countries as it spreads among developing countries, which often have considerably lower direct costs. In these mature sectors, international competitiveness is maintained only in those market segments where the differentiation of the product is very important, and where the products have a large service content, with the capacity to respond to the evolution and growing differentiation of consumption models.

In many cases this flexibility was obtained even before the advent of new information technology, through the adoption of various organizational structures able to adapt to a differentiated and rapidly evolving market. A certain degree of operational flexibility is obtainable by increasing the adaptability of single production lines, without recourse to computer-based technology. In this case, production flexibility is mainly achieved through:

(a) in-house organizational systems, such as:
  (i) multi-production by juxtaposing many production units within the same firm and or several product lines within the same production unit;
  (ii) just-in-time method of production;
(b) agreements between specialized firms (groups or constellations of independent firms, subcontracting, etc.).[9]

Consequently, flexibility can be increased, while still using rigid technologies, by combining individual, inflexible machines and organizing them in a 'flexible way'. With rigid automation technology, agreements between independent firms and/or in-house multi-production involve simply the sum of specialized elements that produce the different goods.

The just-in-time method of production can be seen as a production philosophy aimed at achieving production flexibility while still using inflexible technology. A certain level of flexibility is obtained, on the one hand, by trying to reduce set-up times, and on the other hand by producing small batches using the Kanban system.[10]

The just-in-time production model is not applicable to all operations. In fact, it requires a particular set of technical and organizational environmental conditions. For example, suppliers must be near at hand, because delays in delivery would make it advisable to have large reserve stocks despite the costs of locked-up semi-finished products. Another important condition is a stable demand – sudden changes can create a crisis for a production system with no reserves. Lastly, there should be no bottlenecks in the flow of production, which means that the productive capacity must be well-proportioned along the various intermediate stages.

The spread of computer-based technology helps to remove some of the constraints limiting the diffusion of the just-in-time production model. In fact, new technology, by cutting down set-up times and providing an information network from the final consumers to the suppliers of materials and semi-finished goods, through the different units which go to make up the production *filière*, reduces the volume of the minimum economic batch and hence the need for intermediate warehouses.

Flow-fund models, based on Nicholas Georgescu-Roegen's production analysis, provide a useful applied research tool into the economic effects of changing degrees of organizational flexibility. These models address the time profile of production processes and the quantities of intermediate goods lying in inventories.[11]

## 4. THE ECONOMIC IMPACT OF COMPUTER-BASED TECHNOLOGY

The development and promulgation of computer-based technology provides another useful set of examples to which the above analysis and taxonomy may be addressed. The main property of computer-based technology is the *automation of information processes*. This has several important consequences:

(a) increased flexibility and efficiency of organizational processes by reducing the specificity and complexity of information management;[12]
(b) changes not only in the quantity of inputs in relation to output, but especially in their quality. In particular, with regard to the labour market, skill requirements and work patterns (shifts, hours of work, and so on) undergo a drastic change.[13] In many industrialized countries, the growth of service employment leads to a displacement of the demand for labour from traditional industrial occupations to new service occupations even within the manufacturing sector itself;
(c) increased (technical) flexibility of equipment through cutting down the duration of the production process, response time and set-up times (hence reduced quantities of goods held in warehouses and reduced working capital).

The following pages focus on the effects of computer-based technology on *technical flexibility*, in particular on the shortening of production processes and their set-up times, and on the associated removal of the trade-off between economies of scale and economies of scope.

The duration of the production process has a double nature: it can be seen on the one hand as a *sort of input*, objectified in the quantity of stocks and semi-finished goods in process, and on the other as a contributory factor in determining the quality of the goods. The influence of process duration on product quality can be understood in two different ways. In the first place, response time (based on the process duration) is generally included among the qualitative characteristics of the product. Duration also affects the degree of strategic flexibility in qualitative changes of the product mix. In fact, the shorter the production process duration, the easier it is to vary the output qualitative characteristics in relation to market changes. For example, CAD/CAM can drastically reduce the time required for planning, design and production of a given product.

In certain industrial sectors that are strongly influenced by fashion (where the evolution of design plays a crucial role in orientating demand), as well as in service sectors, the overall process duration and response times are particularly important in determining the efficacy and efficiency of a production unit. Hence they have a decisive influence on its competitiveness.

Differentiation involves a cost when it leads to a loss of *economies of scale* inherent in standardized productions. Basically, differentiated production is more costly than standardized production when the loss of *economies of scale* is greater than the *economies of scope* that can be obtained when the different processes are carried on within the same firm or production unit. There are economies of scope when it is less costly to 'combine' the productions of two or more commodities than to perform them 'separately';[14] in other words, if it is possible to economize on some shareable production element or intermediate stages by saturating their production capacities.

Economies of scope make multi-production within a single microeconomic unit desirable, but they do not determine its degree of flexibility. This is determined by the adaptability of the production processes of single goods. On the other hand, it is possible to produce, in a 'flexible way', a vast range of outputs without enjoying economies of scope. In fact, a wide mix of products may be obtained by using subcontractors rather than by producing all the commodities in-house. We have seen that in some cases the use of subcontractors reduces fixed costs and hence increases the adaptability of the processes.

Cutting down set-up times is a key element in reducing the cost of producing differentiated goods with the same equipment. Greatest flexibility is obtained when the same degree of economies of scale can be enjoyed in producing single-unit lots (that is, one-of-a-kind) as in producing a single homogeneous product. In this case, it is possible to enjoy economies of scope and economies of scale at the same time.[15]

With the spread of information technology, industrial production acquired some of the elements typical of traditional artisan production (high flexibility and trade specialization). This has been brought out by the literature on flexible specialization.[16] Alongside these *similarities*, however, there are two important *differences* between artisan production and flexible industrial production. These are due to the fact that the latter, unlike the former, permits a reduction in idle time, and allows economies of scale. Artisan production has three basic characteristics: high flexibility, long idle time for tools, and long training time for workers (high specialization). The long idle time for tools is due to the fact that the craftsman moves from one operation to the other, using his tools one at a time. The more operations performed by one craftsman, the longer the idle time of the tools will be. Generally the craftsman's tools are simple and the incidence of idle time on total unit costs is relatively low. The great advantage of handicraft production is, of course, its flexibility, which allows very small batches, or indeed single units, to be produced. The importance of this advantage is such that in many activities handicraft has never been completely supplanted by cheaper industrial production, but has survived alongside the latter. On the other hand, industrial production, based on the factory system, permits the excess of equipment productive capacity to be reduced. In particular, this may involve a decrease in the time that individual machines and tools lie idle.[17]

The possibility of reconciling economies of scope with those of scale is leading to the spread of a new model of industrial organization for firms and markets: *large-scale flexible production*. In fact, 'on-line' linkages between markets and producers, and flexible technology, allow 'custom-made' production in large establishments.[18]

Large-scale flexible production is destined to coexist with other forms of production and market organization: small-scale flexible industrial production, industrial production based on rigid technologies and flexible organizational systems, mass production, traditional artisan production. The prevalence of one form of production over another in a geographical area or sector of activity depends on the interaction of environmental and institutional elements.

Microelectronics may reduce the minimum investment cost. This lowering of the entry barriers, which allows new firms access, is essential but is not sufficient for the formation and development of a large number of small, flexible, specialized firms. Other determining factors are: the characteristics of financial markets and financial availability; the spread of entrepreneurial abilities; trade-union regulations and industrial relations; central and local governments' industrial policies; and laws on taxation and social security contributions.[19]

However, flexible automation production systems usually require high investment per operator, which makes it indispensable to keep the plants running 24 hours a day.[20] Therefore the production process tends to be organized according to principles similar to those in the continuous-process industries, such as the iron, steel, chemical and paper industries (ECE, 1986, p. 135). With increased capital intensity, idle time must be reduced through flexible utilization of working hours and shifts.

In small and medium companies, the application of flexible automation production systems still faces considerable difficulties. In particular, the diffusion of computer-integrated manufacturing (CIM) or computer-aided manufacturing (CAM) involve the following main problems:

(a) higher investment cost per employee than old technologies based on rigid automation;[21]
(b) the need to produce a large total volume of differentiated products in order to benefit from the economies of scale allowed by flexible equipment;
(c) in-house technical expertise;

(d) resistance to modifying the existing organization and distribution of skills;
(e) the technical difficulty of making compatible the software used in different areas.

The spread of computer-based technology within firms usually begins with islands of automation with very little interconnection between them. The search for a common language permitting communication between different areas of automation may prove technically difficult, and therefore economically burdensome. At the present stage of software development this difficulty may discourage the planning and realization of computer-integrated manufacturing (CIM).

The application of information technology within firms through islands of automation and the coexistence of a variety of organizational and technical solutions correspond to the nature of the technical change highlighted in the works of Christopher Freeman (1974), Nathan Rosenberg (1976, 1982), Richard Nelson and Sidney Winter (1982) and Giovanni Dosi (1984, 1988). The capacities of the workers in a firm develop gradually with the introduction of new techniques, according to the way in which these new techniques are translated into practical knowledge. All these capacities together determine the specific nature of the firm itself, which is more than the sum total of the different experiences and skills.

## 5. CONCLUSIONS

In changing market conditions, efficacy, which indicates the ability to produce the right thing for the market, becomes a complex goal and assumes a predominant role in affecting the competitiveness of a firm. In the presence of uncertainty, efficacy requires production flexibility.

Production flexibility involves workers being subjected to turbulence and changes in productive activity, since it implies that workers are actively involved in the production process and are rapidly adapting their own skills to changes in products and processes. In many situations the demand for greater organizational flexibility is met by compensation mechanisms that make changes more acceptable to workers and to society. Thus it happens that some forms of flexibility are counterbalanced by forms of rigidity. For example, functional flexibility may be accompanied by a low numerical flexibility, so that functional flexibility is compensated (and limited) by the stability of the worker–firm links. This is the case in the large Japanese firms where there is a high degree of functional flexibility in the use of labour power, but little external mobility (employees are said to have 'a job for life') and with a strong dualistic flexibility in labour market. Moreover, in some contexts the workers' direct involvement may be achieved or simply encouraged by forms of participation, co-management and co-operation which can result in a reduction of external mobility. In yet other situations strategic and operational flexibility can be obtained through numerical flexibility, within the context of a social system that guarantees a network of protection (such as unemployment benefits and opportunities for retraining). In conclusion, *each specific context* features a combination of rigidities and flexibilities that varies according to the evolution of institutional conditions which differ enormously from one sector of activity to another (namely, the financial structure, economic policies, social security system, industrial relations and market characteristics).

The emphasis often placed on computer-based technology, and on the opportunities it provides for making production processes more flexible, may induce people to forget that flexibility can arise from the way in which the elements of production are organized, regardless of the technology being used. In fact, flexibility in production is first and foremost an economic phenomenon, which may even be independent of the technology adopted. The theoretical treatment of flexibility and applied studies of the phenomenon both need an analytical representation of production which takes account of organizational and temporal dimensions of production processes. Moreover, while there is no doubt that conditions of uncertainty demand greater flexibility, there is no close link between the pursuit of greater flexibility and the size of production units or firms. In fact, in some cases new technology allows a high degree of flexibility in large-scale production, while in other cases it favours the economic potential of small firms or production units. This encourages the coexistence of different technical and organizational structures.

## NOTES

1. This chapter discusses some arguments developed in Chapter 12 of the author's forthcoming book *Production Process and Technical Change* (Cambridge University Press). He is indebted to Cliff Pratten, Sandeep Kapur and the participants at the European Association for Evolutionary Political Economy (EAEPE) 1990 Annual Conference in Florence for useful comments. The research received financial support from the National Research Council (CNR, Rome, 89.05143ct10).
2. On true uncertainty and probability, see Keynes (1921, ch. 6; 1936, pp. 148, 152, 168, 316; 1937, pp. 112–14); Knight (1921); Carabelli (1988, pp. 47, 58–9, 199, 212–22).
3. On different meanings of flexibility see: Stigler (1939) who discusses flexibility in the context of static decision-making; Marschak and Nelson (1962) where flexibility makes subsequent actions less costly or preserves more choices; Koopmans (1964) on flexibility of future preference; Jones and Ostroy (1984) who consider flexibility in relation to the probability distributions of payoffs over time in a sequential decision context. See also

the interesting discussions in Merkhofer (1975), Mills (1986), Del Monte and Esposito (1989), Amendola *et al.* (1990).

4. Stigler (1939) represents the trade-off between adaptability (flexibility in his terminology) and efficiency by the position and the slope of the short-period average-cost curves: the unit-cost curve of a more adaptable plant is flatter, but with the minimum point higher, than the unit-cost curve of a less adaptable plant. Generally the literature on production flexibility concentrates on adaptability (Marschak and Nelson, 1962, pp. 42ff.; Mills, 1986).
5. There is still no definitive taxonomy concerning flexibility in economics. Strategic flexibility is also called dynamic flexibility, while the concept of operational flexibility is similar, in many respects, to the definition of short-run flexibility or static flexibility (Cohendet and Llerena, 1988).
6. See Rosenberg (1982, p. 109).
7. Minsky (1982, 1985); Vercelli (1988, p. 105); Boyer (1988, pp. 84ff.); Duijn (1982).
8. For a thorough analysis of these factors see Piore and Sabel (1984); Boyer (1988); Barca and Magnani (1989).
9. On the development of industrial districts, the renaissance of small firms and inter-firm forms of collaboration, see Becattini (1989); Bellandi (1989); Brusco (1982, 1986); Mariti and Smiley (1983); Piore and Sabel (1984); Russo (1985); Vercelli (1988); Lorenzoni and Ornati (1988); Tinacci Mosello (1989); Goodman *et al.* (1989); Barca and Magnani (1989); Phillimore (1989); Storper (1989); Amin (1989a, 1989b); Capecchi (1989); Mariti (1991). On the role of small firms on innovative processes, see also Rothwell and Zegveld (1982); Oakey (1984); Oakey *et al.* (1988); Vercelli (1989).
10. The just-in-time model was tested by Toyota in car production at the beginning of the 1960s. The philosophy of just-in-time production could be summed up as 'the smallest possible quantity [of production elements] at the latest possible time'. Just-in-time is a system whereby materials are bought and components are built only at the moment when they are to be used, without any intervening storage period. Using special order-cards (Kanban system), various orders come from the market and pass successively back through the different work-cells of the production cycle to the suppliers of intermediate goods and raw materials (the pull system). The literature on this subject is vast; see, for example, Monden (1983); Lubben (1988); Hay (1988).
11. See Georgescu-Roegen (1966, 1971, 1976); Tani (1986, 1987, 1988, 1989); Scazzieri (1983); Zamagni (1987, 1989); Landesmann (1986); Leijonhufvud (1986); Piacentini (1987, 1989); and, for an attempt to apply a flow-fund model to empirical research, see Morroni (1992, Part II).
12. See Perez (1985, pp. 453–4), Rullani (1988, pp. 96–8).
13. A large body of literature examines the social and labour-market implications of computer-based technology. Among the main contributions, see Rothwell and Zegveld (1979); Blattern (1981); Stoneman (1987, ch. 14); Cooper and Clark (1982); Bosworth (1983); Freeman and Soete (1985, 1987); Leontief and Duchin (1986); ECE (1986); Cyert and Mowery (1988); OECD (1988). There is general agreement that, in analysing the impact of introducing computer-based technology, an approach that integrates the microeconomic and macroeconomic dimensions must be adopted.
14. Panzar and Willig (1981, p. 268). Given two output vectors $y_1$ and $y_2$, we have economies of scope if we can assume the following relation between the cost functions: $C(y_1, y_2)$ $C(y_1, 0) + C(0, y_2)$. See also Teece (1980, pp. 225ff.). On production diversification, see Grant (1988). Generally, the literature considers only the combination of different production lines within one firm. However, the economies of scope may operate not only at firm level but also at other operational levels, such as at production unit, plant and production line level.
15. On this point see Bailey and Friedlaender (1982, p. 1026); Del Monte and Esposito (1989, p. 23).
16. 'Flexible specialization leads back to those craft methods of production that lost out at the first industrial divide' (Piore and Sabel, 1984, pp. 6, 27–8, 124). For a critical analysis on flexible specialization, see, for instance, Minsky (1985); Landes (1987); Williams *et al.* (1987); Archibugi (1988); Hyman (1988); Amin (1989a).

17. Georgescu-Roegen (1976, p. 68) writes that the factory system, for this extraordinary property to achieve the maximum time economy, 'deserves to be placed side by side with money as the two most fateful economic innovations for mankind'. This innovation is 'economic' and not technological, 'because the economy of time achieved by the factory system is independent of technology. Nothing prevents us from using the most primitive technique of cloth weaving in a factory system'.
18. Perez (1985, p. 46, n. 23).
19. The impact of 'regional institutions' on the spread of new technological and organizational solutions is stressed, for instance, by Sabel and Piore (1984, pp. 264–5); while on the role of financial structure credit institutions, see Minsky (1982, 1985); Storey (1983); Vercelli (1988).
20. With the introduction of information technology, some large-scale production may become so capital-intensive that production in Europe will be competitive, even if the labour costs are higher than in developing countries.
21. Northcott and Walling (1988, p. 11), reporting the results of thorough empirical research on the impact of microelectronics in British industry, observe that more than one-fifth of the user factories have experienced economic difficulties due to high development costs (particularly for product application), and lack of finance for development. On diffusion of CIM, CAM and CAD see ECE (1986, pp. 24ff., 45ff.); Gaibisso *et al.* (1987); Edquist and Jacobsson (1988); OECD (1988); Vickery and Campbell (1989).