FLEXIBLE SPECIALIZATION, NEW TECHNOLOGIES AND FUTURE INDUSTRIALIZATION IN DEVELOPING COUNTRIES

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Developing countries increasingly recognize that in the future far more attention will need to be paid to firms located outside the modern or formal sector. In this context, the complex of recent microelectronics and organizational innovations seems highly attractive for these are often said to be capable of facilitating a pattern of industrialization based on flexible, small-scale production, rather than on the more typical large-scale technology of mass production. This article, accordingly, seeks to evaluate the various mechanisms through which the new technologies—and the more general possibilities implied by the various definitions of 'flexible specialization'—may in fact contribute to such an alternative model of industrialization.

Post-war patterns of industrialization in developing countries have generally been based on promotion—via a strategy of import substitution—of a modern sector using advanced technologies imported from the industrialized countries. On the whole this strategy has not succeeded in absorbing the vast numbers of those wishing to leave the non-modern (or traditional) sector, in which productivity and incomes are typically much lower.

This rather disappointing outcome reflects in part the highly capital-intensive character of the technology used in the modern sector and partly also the small initial size of this sector at the time when many developing countries first embarked on their strategies of industrialization. Furthermore, rapid rates of population growth in many developing countries (of 2–3% per annum) mean that the absolute numbers employed outside the modern sector are likely to continue growing well into the future. Indeed, for some countries the point at which the

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non-modern sector ceases to grow in absolute terms (the so-called Lewis turning point), may not occur until the middle of the next century. By that time, the sector could be as high as eight or nine times its present size.

This type of vision of the future has led in a number of developing countries, to the recognition that far more attention needs to be paid to the problems of (small and medium) firms located outside the modern or formal sector. For, without some means of improving the productivity of the (mostly traditional) technologies in this non-modern sector, the incomes of the growing numbers that will be reliant on these relatively unproductive technologies are unlikely to improve to any significant extent. From this point of view, the complex of microelectronics and organizational innovations (that form part of the so-called new industrial revolution) seems attractive, because they are often said to be capable of facilitating a pattern of industrialization based on flexible, small-scale production, rather than on the large-scale, capital-intensive technology of mass production. Such a transition, it is argued, would permit the benefits of recent technical change to accrue to small and medium, rather than, or in addition to, the large and often foreign-owned firms that comprise the modern sector of many developing countries.

To a large extent, this prospect resides in the 'descaling' properties of the new technologies—that would allow efficient production at small scales of output—but it is also based on other characteristics of what goes under the term 'flexible specialization', such as the ability of the new technologies to tap rapidly changing niche markets. Our concern in this article is to assess these and other mechanisms through which the new technologies (and the more general possibilities implied by the various definitions of 'flexible specialization') may be capable of bringing about an alternative and more egalitarian pattern of industrial development in the Third World.

What we find, tentatively, is that adoption of the new technologies and organizational innovations has so far been confined largely to the more developed of the developing countries and to certain types of firms within those countries, most notably firms that possess well developed technological capabilities and a strong orientation to international competition. As we see it, diffusion of the complex of new technologies to the majority of firms in the industrial sector of most developing countries is likely to be only a long-term phenomenon. One should not be particularly surprised by this conclusion; after all, most previous waves of innovation have taken numerous decades to spread widely, even in the countries for which the changes were originally designed. At the same time, it is important to recognize that the speed at which the most recent wave of innovations will spread in developing countries depends rather heavily on what the governments of these countries themselves do. We argue in this respect that much can currently be undertaken by governments, especially, but not only, in cases where markets work imperfectly or fail altogether.

Our analysis is based mainly, though not exclusively, on three particular types of microelectronics-based technologies, namely computer-aided design (CAD), computer-numerically controlled (CNC) machine tools, and microcomputers. And we focus largely on the *direct* mechanisms through which industrial enterprises may benefit from these technologies—that is, mechanisms that lead to actual adoption by these enterprises. In so doing, however, we by no means wish to deny that there may also be a variety of *indirect* mechanisms.

The first part of the article argues that from the point of view of what is *actually* happening in these countries, the framework provided in the choice of technology literature is best suited to answering this question. The following two sections, on the other hand, deal—mostly from a *normative* point of view—with other approaches (flexible specialization and decentralization) that cannot (or at least not easily) be fitted into the choice of technology framework. On the basis of the discussion in these two sections, the final part compares and hopefully clarifies the manifold mechanisms through which the benefits of the new microelectronics technologies are encouraging, or might encourage in the future, a more flexible smaller-scale industrialization in the Third World.

The choice of technology framework

The general question that needs to be posed under this heading is how firm size *influences the rate of adoption of the new technologies.*[1] This relationship, as we shall see, depends not only on the characteristics of the new technologies themselves but also on a number of institutional variables as well as on the nature of the industry considered. To begin with, though, let us consider the simplest textbook version of the choice of technology, according to which the individual firm is confronted with a range of alternatives and a choice is made at a particular point in time. In this version of the model, the new technology will be chosen on the basis of whether or not it reduces the costs of production in comparison with existing techniques.

The efficiency issue

Perhaps especially in the economics literature, a great deal has been made of the 'miniaturization' possibilities that are said to be associated with some of the new microelectronics technologies (most notably CAD and CNC machine tools (CNCMTs) technologies). The specific claim is that these technologies permit both efficient production and a small scale of output, a combination that automation has hitherto generally precluded.[2]

Unfortunately, however, there are as yet remarkably few studies that would enable one to assess this claim empirically. There are, that is to say, few studies that actually examine the comparative costs of conventional and new technologies at different scales of output in developing countries.[3] One of these studies, by Amiya Bagchi,[4] is concerned with the impact of microelectronics-based technologies in India. It includes a detailed set of cost calculations for different types of printing technologies in that country. The calculations suggest that for the firms producing small batches, the low wages and low initial investment costs that are associated with the letterpress method, mean that this technology retains a cost advantage over the new microelectronics-based techniques. On the other hand, at larger scales of output, it is these latter technologies that appear to attain a cost advantage.

It is probably at least partly on account of this scale factor that the rate of adoption of CNC machines tools often appears to be relatively low, even in the more advanced regions of the developing world. For example, a detailed study by Edquist and Jacobsson of the engineering industry in the newly industrializing countries, concludes that 'with the exception of Argentina, it appears as if it is mainly the larger firms which adopt NCMTs'.[5]

In the early 1980s, it appeared to some of those who were working on the topic that there were also issues of scale in the selection of CAD techniques. In

1983, for example, Kaplinsky calculated that 'CAD design systems based upon minicomputers are unlikely to be profitable (in relation to the choice of technique, rather than the design of product) with fewer than 10 designers; those based upon mainframe have even greater effective economies of scale'.[6] Since then, however, personal computers began to be used in CAD systems with profound implications for costs and presumably also for scale (in the sense just mentioned of a reduction in the number of workers to make the systems profitable).

Whether the scale factor will be less important in the future industrialization of developing countries will depend in part on the nature of the industry and the product-mix, and in part on whether scale refers to batch or plant size.[7] Whether new technological developments are likely to give rise to an increase in CAD adoption rates by small firms in developing countries also remains unclear. Much will depend, apart from the scale factor, on the evolution of relative factor prices, the cost of acquiring new technologies, and the terms and conditions at which these technologies are likely to be available to Third World countries, particularly those which do not produce these technologies themselves.

To an important degree, the issues relating to the demand rather than the supply side of the choice of technology are likely to be significant. It is to these issues that we turn next.

The demand side: products and markets

Much of the standard choice of technology debate tends to focus on questions of efficiency and costs, that is, on the *supply* side of the issues. Yet, when it is viewed from the standpoint of the characteristics that are embodied in products, the *demand* side may also have a major influence on the returns that can be expected from a new (process) technology. The reason is that changes in technology often cause changes in the product and these in turn may shift the firm's demand curve to the right.

In the case of many new microelectronics technologies, these product changes often seem to be of overriding importance to the choice-of-technique decisions. Consider in this regard Table 1 which mainly contains a summary of the results of a series of studies conducted by/for the International Labour Office (ILO) World Employment Programme (WEP) on the adoption of a variety of the new technologies. A number of other case-studies have also been included in the table. In each case demand factors appear to be decisive to adoption decisions, whereas factors related to costs of production on the other hand were regarded as not being influential.

The demand dimension of technology choice is likely to have different implications for large-scale as against small-scale firms in developing countries. In general, small-scale firms in industry tend to serve particular and fragmented markets. Thus, whereas 'Large units tend to sell mainly to high-income markets ... most small units mainly sell low-income products to the informal sector'.[8] By 'low-income' products is meant essentially products embodying a relatively high proportion of essential (eg food nutrients) characteristics and a relatively low proportion of inessential characteristics (or what are sometimes referred to as 'frills'). Yet, it is precisely the opposite combination of characteristics that may often define the products associated with microelectronics innovations, such as CAD and CNC machine tools. The reason is that these innovations comprise part of what histori-

TABLE 1. THE ROLE OF DEMAND IN THE CHOICE OF MICROELECTRONICS INNOVATIONS IN SELECTED DEVELOPING COUNTRIES

Author (year)	Country	Sectors	New technologies	Determinants of the choice of technology
1. Onn (1989)	Malaysia/ Singapore	General machine manufacturing; electrical and electronics; automobile assembly and component manufacturing; computer and computer component manufacturing	NC machine tools, CAD/ CAM, robots	'Despite the much feared labour-displacement potentials of the new technology, labour saving was by no means a major motive of its adoption. Of the 24 Malaysian firms . . . 14 reported that their main objective had been to improve the quality of their products or work, while another 12 had introduced the new technology to enhance their competitiveness'. (p 53)
2. Pyo (1986)	Republic of Korea	Automobile, electronics, industrial machinery and shipbuilding	NCMTs, robots, CAD/ CAM	'The firms in our survey introduced it (FA machinery) for three main reasons: for better quality control (22 out of a total of 30 firms), to compete in export markets (18 firms); and due to product standard imposed by domestic buyers (15 firms)'. (pp 94–95)
3. Dominguez-Villalobos (1988)	Mexico	Electrical; electronics; automobile; machinery and tool	CNC machine tools, CAD, robots, machining centres	'By far the most frequent purpose of using NCMTs . . . was to attain a higher or more regular quality of work . . . followed by a higher speed of production/ reduced downtime. Flexibility was the third important consideration'. (p 24)
4. Fleury (1988)	Brazil	Metal engineering	Electronic data processing equipment; CAD, NCMTs, programmable logic controllers	'Although the degree of emphasis varied from one industry to another, the adoption of FA equipment was primarily motivated by the desire to improve the quality of products or work and to increase productivity for the purpose of strengthening the firm's competitive position in export markets'. (p 81)
5. Tauile (1987)	Brazil	Automobiles	CNC machine tools	'Motivation for introducing NC machine tools is . . . quality control, flexibility in production and the characteristics of certain products'. (p 171)

TABLE 1. THE ROLE OF DEMAND IN THE CHOICE OF MICROELECTRONICS INNOVATIONS IN SELECTED DEVELOPING COUNTRIES (continued)

Author (year)	Country	Sectors	New technologies	Determinants of the choice of technology
6. Boon (1986)	Colombia	Bottling plant	CNC machine tools	'The adoption of the CNC machine took place to achieve a better quality in order to maintain and enlarge export markets. In addition the size of the lots (fluctuating between 25 and 200 pieces) facilitated the adoption of the machines'. (p 38)
7. Boon (1986)	Peru	Metalworking industry	CNC machine tools	'The acquisition reasons which the seven (adopting) firms gave, were as follows: to reduce costs, to improve quality, precision, piece complexity, increment in production and volume'. (pp 36–37)

Sources: For 1 to 4, see Susumu Watanabe (ed), *Microelectronics and Third World Industries* (London, Macmillan, 1993); for 5, see Susumu Watanabe (ed), *Microelectronics, Automation and Employment in the Automobile Industry* (Chichester, John Wiley and Sons, 1987); for 6 and 7, see G. K. Boon, *Computer-based Techniques: Diffusion, Impact, Trade and Policy in Global Perspective* (Noordwijk, the Netherlands, Technology Scientific Foundation, June 1986).

cally (in the industrialized countries) has been a close relationship between innovations in products and innovations in processes.[9]

That these (historically determined) relationships help to explain the differential rates of adoption of some of today's new technologies, can be shown in relation to the Indian machine tool industry. For, on the one hand, the smaller firms in that industry 'often catered to customers who demanded low quality but cheap products',[10] while on the other hand, the larger firms would supply customers with more stringent quality requirements. And since CNC machine tools tend (as we saw above) to be associated with high (or at least more precise) standards of quality, they are demanded to a correspondingly greater extent by the large, rather than the small-scale firms in the industry.

There is a possibility that the speed and flexibility of many new microelectronics technologies may be much more important to Western markets (such as textiles and automobiles) where change in demand is rapid and continuous, than to the relatively stable patterns of demand that characterize many 'low-income' markets on which many developing-country industries depend.

Supply and demand combined: a technology decision matrix

The discussion so far has dealt for the most part separately with the demand and supply sides of the choice of technology decision. Before going further with these issues, however, it is worth emphasizing that, in practice, the decision to select one technology over another is based on a *combination* of both supply and demand factors.

In fact, since both costs (supply) and demand may increase, decrease or remain unchanged following the adoption of a new technology, the decision can

TABLE 2. COMBINING SUPPLY AND DEMAND DETERMINANTS OF ADOPTION

		Demand increases	remains constant	falls
	Costs fall	+	+	–
Supply	Costs remain constant	+	X	X
	Costs increase	–	X	X

+ = the new technique is adopted.
X = the new technique is not adopted.
– = the outcome is indeterminate, depending on the relative influences of supply and demand on the profits of the firm.

be depicted in terms of the nine cells shown in Table 2. Thus, whereas some combinations give rise to an unambiguous decision about whether to accept or reject the new technology, others are indeterminate and depend on the relative strengths of the opposing influences on profitability. These indeterminate cases appear in the upper right and lower left cells of the matrix.

The lumpiness problem

In the previous section, we suggested that there are factors on both the supply and demand sides that may frequently make it unprofitable for many industrial enterprises (particularly small-scale ones) to adopt technologies such as CAD/CAM and CNC machine tools. One of the most important of these factors, as a number of case-studies clearly demonstrate, is the price of the capital equipment itself. Onn's study of microelectronic industrial machinery in Malaysia and Singapore, for example, shows that the high cost of equipment was cited more than twice as frequently as any other perceived constraint on adoption.[11] Similarly, in Tauile's study of the diffusion of CNC machine tools in the Brazilian automobile industry, the high cost of this technology was cited by the firms that he interviewed as the major constraint on adoption.[12]

Capital cost does not, however, bear only on the profitability of the new technologies. For, even if this factor does not render the new technology unprofitable (in terms of the decision matrix shown in Table 2), a formidable problem of indivisibility or 'lumpiness' may nevertheless still confront the small-scale (though perhaps not as much large-scale) enterprises.

The special case of microcomputers

Much less has been written in the economics literature about the use of computers for managerial functions (such as inventory control and accounting) than for purposes of production (as in the case of CAD or CNC machine tools). The comparative neglect of the former is unfortunate in part because the two functions may, in practice, be difficult to separate. Indeed, managerial changes may facilitate those in production. This neglect is also especially unfortunate from the point of view of the small-scale firm in developing countries, because the use of the computer (and especially the microcomputer) as a tool of management suffers to a much less pronounced extent from the problem of lumpiness, that so pervades the use of the new technologies in production (and which is most marked in the case of industrial robots).

An effective use of microcomputers in the industrial growth of developing countries raises the issue of the role of domestic technological capabilities. On the one hand, such capabilities may facilitate the diffusion of cheaper forms of these technologies. On the other hand, to the extent that domestic capabilities are acquired under conditions of protection against competing imports, the gains from design innovations may be partially or more than fully offset by correspondingly higher (than world) prices. In the case of microcomputers produced in Brazil, for example, although the products are said to be 'more appropriate to the local needs because they are designed to match local requirements',[13] their prices are higher than those of microcomputers imported from the industrialized countries.

So far we have considered the hardware aspects of technology. However, it is important to emphasize that innovations designed to ameliorate the problem of lumpiness can also take an institutional form—that is, a form in which it is institutions rather than technologies that are adapted.

In countries such as the Philippines, rental markets appear to be highly developed, as evidenced by the fact that 'harvesting and threshing equipment, tractors, and motor vehicles, are used on about five to seven times as many farms as those who own them'.[14] In an analogous manner, institutions such as service bureaux could play an equally important role in the adoption and diffusion of some of the new microelectronics technologies (such as CAD). Existing service bureaux in the garment industries of a number of relatively advanced countries offer one specific institutional model that may be of relevance to the developing countries in the future when expanding markets and globalization of production and trade might make it particularly suitable. What these service bureaux offer is microelectronics-based equipment which performs all functions up to marker making on behalf of garment producers, thereby reducing their investment, maintenance and managerial costs.[15] All that the manufacturers have to do is to supply the bureau with a sketch of the garment to be produced. The case of Borås in Sweden (a district with the highest concentration of garment producers) illustrates the functioning of the concept of the service bureau in practice. The Borås bureau services about 200 customers out of a total of 300 firms (in 1985). The 10 bigger firms possessed their own pre-assembly equipment, which suggests that the bureau customers were mainly small firms which could not afford to install this equipment. Similar bureaux are in operation in the USA and Japan.

Institutional innovations need not, however, be confined to one or another form of rental market. They may involve in addition a change in the *level* at which choice of technique decisions are made, and more specifically a change from individual to communal patterns of ownership. The latter are in fact already prevalent in areas such as irrigation and sanitation where adoption decisions necessarily involve the community as a whole. And the experience with these decisions (especially the pronounced problems that they have so frequently encountered), offers much that may be relevant to a 'communally oriented' approach to the diffusion of microelectronics innovations among small-scale enterprises (including, as we note below, the flexible specialization approach). In any case, however, what is clear is that choice-of-technique decisions made at the community level cannot be understood in terms of the traditional choice of technology model, which generally presupposes the existence of a *single* decision maker.[16] Instead, an analytical framework is needed, which, on the one hand incorporates a variety of possible modes of individual interaction and which, on the other hand, makes it possible to understand how conflicts between individuals arise and ultimately get resolved.

Imperfect information

The availability of information is generally recognized to be an important determinant of why one technology is chosen rather than another. In fact, most empirical studies suggest that information is available for only a limited portion of the range of available techniques. From the standpoint of small-scale enterprises and in relation to new technologies, imperfect information is likely to present a particularly acute problem, in terms of availability and cost of search.

In part, this is a question of the demand for information and, in particular, the differential extent to which industrial firms of different size find it profitable to search for information about new technologies. In the context of agricultural innovations, an argument along these lines has been used to account for the tendency for larger farms to adopt new technologies earlier than small farms, even when the innovations themselves are scale-neutral.[17] Specifically, the argument is that larger farms have more of an incentive to search for innovations than small farms because the expected (absolute) gains to the former are greater. Similar reasoning may help to account for the tendency noted above, for many of the new microelectronics techniques to be adopted mainly by relatively large-scale industrial firms in developing countries.

Another explanation of this tendency, however, has to do with the supply of, rather than the demand for, information about the new technologies. For what Edquist and Jacobsson emphasize in their study of the engineering industry in the newly industrializing countries, is that what (little) information is supplied to firms in these countries, tends to reach mainly relatively large-scale enterprises with some kind of connection (eg through licensing) to foreign firms. It appears to be largely through such connections that information about new technologies is transmitted. For other firms, especially those of medium or small-scale, the problem is often that 'Local suppliers do not exist and distributors of foreign made machines may not be represented in the country. If they are, they may very well not put a great deal of emphasis on marketing etc'.[18] This problem, one might add, is likely to be especially pronounced in the small and least developed countries of the Third World.

Aggregate adoption of new technologies

In the developed countries, empirical evidence on the adoption of new technologies by size of firm (measured by numbers employed) tends to conform to what one might expect, namely, that the larger firms, because of their greater technical and financial resources, know-how and information, have adopted these technologies to a greater extent than relatively small-scale enterprises. The Policy Studies Institute, London, for example, undertook a detailed survey of a total of more than 3800 factories in France, Germany and the UK to 'measure across the whole range of manufacturing industry, the form, extent and effects of the use of microelectronics in products and production processes'.[19] The study noted that the microelectronics applications (eg CAD/CAM, CNC machine tools and robots) were concentrated mainly in mechanical and electrical engineering and automobile industries.

Evidence on patterns of adoption by firm size in developing countries is more difficult to attain. Some of this evidence conforms broadly to the developed-country patterns noted above. We have already cited the study by Edquist and Jacobsson of the engineering industry in the newly industrializing countries, which found that with few exceptions it is mainly the larger firms which adopt CNC machine tools in these countries. Fleury's study of the adoption of microelectronics technologies in the Brazilian metal-engineering industry appears to come to a similiar conclusion.[20]

On the other hand, not all the evidence from developing countries conforms to this conventional pattern. One study of Mexico, for example, examined the use of flexible automation (FA) equipment in the following industries—automobiles and parts, electrical appliances and machine tools. It found that 'at the beginning of the 1980s over 80 per cent of the FA machines were used by small and medium-sized firms, but their share fell to 45 per cent in 1983 and to 28 per cent by mid-1987'.[21] At the same time, the share of large firms using the technology actually increased, thus widening the gap between large and small firms. This situation in Mexico is in sharp contrast with that of the UK industry noted above. What explains this rather unusual Mexican experience?

The rapid growth of the domestic market for machinery and consumer durables during the first subperiod is noted by the author to be a possible explanation for the small-scale adopters. During the second subperiod, the liquidity problem of the small firms (with little access to export markets) is proposed as a factor explaining a decline in their share among the adopters. The larger firms adopted FA equipment to compete in export markets. Other factors explaining a decline in the share of small adopters in Mexico may be the fact that most new technology equipment is imported from abroad. The increasing debt crisis and the erosion of the national currency must have made these imports extremely expensive, with the result that the large firms alone could afford them.[22]

Flexible specialization paradigm

The first part of the article showed that a number of the mechanisms through which the benefits of the new microelectronics technologies are transmitted to industrial enterprises can adequately be viewed from the perspective of the choice of technology approach. At the same time, however, there are other mechanisms that cannot (or can less easily) be fitted into this framework. Some of the most important of these arise in relation to what is known as flexible specialization.

Associated most closely with the work of Piore and Sabel,[23] flexible specialization represents a new paradigm of industrial organization, which,

> In contrast to mass production ... uses a series of general resources to produce a constantly shifting mix of specialized products. It depends upon the increasing generality of the resource base: finding new uses for existing skills and equipment and extending the range of products which the economy can produce. This form of production was typical of the craft communities which existed throughout Western Europe and North America in the first half of the nineteenth century.[24]

New microelectronics technology is one of the factors that has given rise—in the 'new dynamic' form that is known as flexible specialization—to the revival of craft production. These technologies are flexible in the sense that they allow a greater range of output to be produced, as well as in the sense that they permit a more rapid response to changes in consumer demand (a form of flexibility that is especially relevant to industries such as textiles, footwear and automobiles, which are prone to demand changes). Piore and Sabel are at pains to emphasize, however, that although it has increased the flexibility of production, the computer *alone* cannot account for this revival (partly because computers can be used in a 'rigid' manner and partly because Piore and Sabel cite cases where flexible production does not depend on computers). Nor are the new technologies (in the hardware sense) the only form of innovation that is emphasized by the concept of flexible specialization.

On the contrary, one can find in the literature a variety of different forms of innovation that are subsumed under the term.[25] Flexibility is often used, for example, to refer to changes in working practices that are required by flexibility of output 'to minimise downtime during changeovers and to generate a faster rate of technical progress'.[26] A second meaning that attaches to the concept of flexibility has to do with labour markets, both internal and external. For example, 'task flexibility can be facilitated by greater use of internal labour markets, reducing labour turnover, increasing training in a range of skills, winning flexible working practices and willingness to move within the firm in return for job security'.[27] Still another meaning of flexibility refers to organizational innovations within and between firms. Within firms, for example,

> Factory outlets need to alter, from mass production's dedicated lines and functional layouts to flexible production cells. 'Families of parts' need to be composed, each family being allocated a separate 'factory' to itself; these are based on the principle of modular-designs and involve a process of what has come to be called 'design for manufacture'.[28]

Changes in the nature of the relationships between firms are frequently also discussed; some of these discussions focus on the relationships between small-scale firms (notably in industrial districts) while others are concerned with the relationships between large- and small-scale firms (often in the context of subcontracting relationships).

If there are, therefore, a variety of meanings attaching to the concept of flexible specialization, even further meanings (and one might add, in many cases, further confusion) are created by the numerous ways in which these dimensions can be combined. Some dimensions can of course exist separately from the others: adoption of the new technologies, for example, can be effected without changes in the other dimensions, and the same is true of organizational changes. On the other hand, there are a number of powerful complementarities between the various dimensions that are ascribed to the concept of flexible specialization.[29]

Whatever the definition of the concept of flexible specialization, in future production in both industrialized and developing countries, the pattern of industrialization is likely to be characterized by new forms of labour utilization, thanks partly to the greater use of new information technologies. A changing pattern of employment, its 'flexibilization', a shift between core and periphery workers, flexible working hours etc, are already becoming a reality in industrialized countries. These characteristics of the new flexible labour markets are likely to be a model of the future particularly for the newly industrializing countries (NICs). Their influence on industrial productivity, skill structures and human capital formation is bound to be of important concern for industrial firms facing the challenge of quality as well as price competition.

Innovational complementarities

The choice of technology literature tends to focus on a single innovation, which, typically, is an innovation in the hardware of technology. (This, of course, is a general observation and is not meant to deny the existence of untypical contributions.) Those who have contributed to the flexible specialization literature, in contrast, emphasize (as noted above) organizational as well as technological innovations, and some of them deal also with relationships (especially those of a complementary kind) between these innovations. It is widely recognized, for example, that organizational changes within an industrial enterprise are required if all the potential gains from the new technologies are actually to be realized. This recognition owes much to the Japanese experience. 'They have built on their already highly flexible production organization, to develop the management structure and practices necessary to extract the full benefit of flexible automation'.[30] In the industrialized countries, this recognition is supported by a large number of empirical studies; in developing countries, in contrast, such studies are relatively few, and, of these, the best documented is Kaplinsky's recent analysis of a medium-scale garments' firm in Cyprus.[31] He shows that through essentially three mechanisms—reorganization of the production line, the introduction of a computerized information processing system, and the closer integration of marketing and production—the firm has experienced a 'substantial enhancement' of its competitive position.

It bears emphasizing, though, that complementarity between innovations does not mean that they need to be *simultaneously* adopted.[32] In fact, there are several reasons why organizational change may be undertaken *prior* to the adoption of the new process technologies. One reason is that organizational change may stimulate or facilitate the adoption and effective operation of the latter forms of innovation. A second reason why organizational innovations may precede those of a technological kind is that, in certain circumstances—such as an acute scarcity of capital and foreign exchange—the former may be the only feasible option for small-scale enterprises in developing countries.[33] What occurred among small firms in the light engineering industry in Argentina during the economic crisis of the 1980s may be illustrative of just such a possibility. In particular, the '"Japanese" organisational model (of inventory minimisation, reduction in setting-up time of machinery etc) appears to have been combined with old, non-sophisticated physical technologies'; this experience, according to Roldan, suggests that 'the Japanese "classical model" may be successfully emulated by a small firm, in small batch or custom-made production, with traditional physical technologies, in a crisis situation'.[34]

The model of the industrial district

The concept of flexible specialization is perhaps most commonly understood to refer to regional clusters of small-scale enterprises. Within the scope of the concept thus delineated, however, it is still important to distinguish between two very different strands of literature.

One of them, associated mainly with the work of Hubert Schmitz, is concerned specifically with developing countries and, in particular, with the notion of 'collective efficiency', which denotes the various types of gains that accrue collectively to small-scale enterprises clustered 'around a set of related activities'.[35] Neither Schmitz nor those who have followed up his concept of collective efficiency[36] seek to link it to the adoption of new microelectronics technologies (or, for that matter, to any form of technical change). The absence of any link of this kind could be defended on the grounds that the new technologies do not in fact exist in actual regional clusters of small-scale enterprises in developing countries. At the same time, however, the neglect of these technologies renders the concept of flexible specialization employed by Schmitz and his followers open to the criticism that it lacks novelty. For without any such dimension, it is difficult to see what is in fact novel about this approach or to discern what new hope it offers to existing clusters of small-scale producers in developing countries who are reliant on traditional (and usually unproductive) technologies. After all, not only have regional clusters of small firms (such as at Kumasi in Ghana, an example that is frequently quoted by Schmitz) long been in existence, but they have also been actively promoted by governments in a wide variety of developing countries through the establishment of industrial estates and workshop clusters (see below).[37]

In sharp contrast to the concept of flexible specialization that has just been described, the second (albeit less extensive) strand of literature seeks explicitly to *incorporate* the new microelectronics technologies. This concept of flexible specialization, which can appropriately be described as 'high-technology cottage industry',[38] is much closer to the model of the industrial district that is found in the 'Third Italy' and especially to the many small firms in that region that make use of, for example, CAD and CNC machine-tool technologies. The concept of industrial district (in the context of Italy) is defined as 'a fragmented cycle of production' which 'can assume different forms, ranging from a pattern of decentralisation of production within larger firms to a constellation model of small firms'.[39] In the case of the 'Third Italy' the latter interpretation and experience has proved to be much more successful in responding 'to the ups and downs of demand and to the introduction of innovations'.[40]

From the standpoint of the concept of the industrial district, the key question takes a normative rather than a positive form, namely, whether 'high-technology cottage industry' represents a model of the industrial district that is capable of replication in the Third World context either now or in the future. The answer to this question in turn depends on what preconditions will need to be met.

Some of these preconditions are likely to involve precisely the types of problems that have so frequently undermined the efficacy of various forms of collective action in developing countries. The literature is replete, for example, with frustrated collective outcomes in areas such as irrigation and sanitation, while the historical experience with cooperatives on the whole provides a no less discouraging record.[41] Common to many of these disappointing experiences is an inherent and formidable problem that Mancur Olson described so forcefully many years ago, namely, the problem of the 'free-rider'.[42] One well known form that this problem takes is that when the community is large no single individual has an incentive to participate in a communal venture, 'For by definition, he cannot make a perceptible contribution to the group scheme, and since no one in the group will react if he fails to contribute, there is no economic incentive for him to do so'.[43] The industrial districts of the 'Third Italy' appear to have been able to overcome this type of problem largely through the countervailing pressure that is exerted by powerful communal ties. Piore and Sabel suggest, for example, that 'the fear of punishment by exclusion from the community is probably critical to the success of the explicit constraints on competition'[44] that seem to be so important in these districts. Comparable mechanisms are known to exist in some Third World communities,[45] but in general they cannot be relied on. Indeed, even in the Brazilian footwear industry that is so approvingly cited by Sabel, it is doubtful that anything like the strength of communal ties in the 'Third Italy' can be found. In fact, according to one recent description of this industry, smaller firms 'do not find in Brazil a propitious environment in which to operate, which seems to exist in the case of the Italian model . . . there exists a climate of *distrust* in the inter-industrial market'.[46]

Other types of precondition that need to be met if the Italian model is to be replicated are likely to revolve to an important extent around the role of government. For, as is frequently acknowledged in the literature on the 'Third Italy', government institutions have been key to the adoption and utilization of the new technologies (the use of CAD in Prato, the textile industry, is one of the clearest examples of this).[47] Whether governments in developing countries will be willing (and able) to emulate this behaviour depends, among numerous other factors, on how far they can overcome in Kaplinsky's words, 'their fixation with large-scale production'.[48] This form of production often appears to have been favoured directly and indirectly by governments, even when more profitable (in private as well as social terms) small-scale technological alternatives were available. Still, as Kaplinsky indicates, the governments of at least three relatively small developing countries—Cyprus, Jamaica and the Dominican Republic—have already modelled their industrial development strategies on the basis of the small-scale clusters found in the 'Third Italy'.[49] It is not clear, though, how representative these countries are of the Third World as a whole; nor is it clear to what extent these emulative efforts have actually succeeded in the implementation of the new approach.

Industrial districts v industrial estates

On the surface, the concept of the industrial district in the industrialized countries like Italy seems to be similar to that of industrial estates promoted in developing countries. They both represent a constellation or agglomeration of small firms. However, one important distinction between them concerns size: whereas the industrial districts of Italy typically comprise between 1000 and 3000 firms,[50] industrial estates are usually concerned with a much smaller number of firms. Moreover, while the industrial districts of Italy have developed more or less spontaneously, the industrial estates are by their very definition 'tracts of land and (possibly) buildings developed by the State, presumably on favourable terms, for industrialists . . .'.[51] In the Indian industrial estates, for example, several incentives were granted to attract small-scale firms—favourable terms for hire purchase, improved terms for small loans and the supply of equipment and materials and common facilities.

An important question is whether existing industrial estates in the developing countries can provide an appropriate model for the government to disseminate and promote the use of new technologies like CAD/CAM and CNC machines among small and medium firms. Our impression is that, to date, governments have not made wide use of the estates for the sake of improving small-scale technologies, reflecting perhaps the more general absence of a technological component in measures to promote small-scale industries in developing countries.[52] In at least some countries, however, this neglect is apparently being redressed[53] and to this extent, existing industrial estates could acquire a stronger technological component in general and in relation to the new technologies in particular. One form that this might usefully take is the introduction of service bureaux which we discussed above.

Decentralization

The spatial dimension of production is generally neglected in the standard choice of technology approach. Yet, as we have just seen, location, in the specific form of agglomerative clusters of small-scale firms, is central to the flexible specialization paradigm. Locational issues arise also in a different, but no less important way, in the notion that the new technologies might permit a more decentralized pattern of industrialization than has hitherto been possible on the basis of 'mass production'.

One way in which this might arise relies on the tendency towards diminished plant size and greater flexibility of production that is associated with some new technologies. These characteristics of the new technology, so the argument runs, may alter the regional concentration of production that has been so prevalent under import-substituting industrialization in developing countries. More specifically, what is envisaged is the alteration of a pattern of industrialization that has been characterized by production in a few large-scale (usually imported) plants, of goods embodying characteristics in proportions very similar to those found in the developed countries. The new technologies may be able to alter this pattern through the dispersed location of a larger number of small-scale plants which are able to serve the heterogeneous preferences of a much wider group of consumers. (Kaplinsky refers, in this context, to an 'ability to "niche" output to the specific conditions of individual markets, without sacrificing quality and price', which, he contends 'opens the prospect of developing appropriate products for developing country markets').[54]

The extent to which this type of locational change actually materializes, however, will depend (among other factors) on the numerous supply- and demand-side determinants of adoption of the new technologies described above. On the demand side, an especially important question arises as to whether effective demand will be sufficient in the decentralized (particularly rural) locations to make adoption profitable. More specifically, the question is whether the new products associated with the new technologies embody characteristics in proportions that are desirable and accessible from the point of view of low-income rural households. While this may indeed occur in some cases—thereby validating the view that the new technologies are able to produce 'low-income' or appropriate products—there are likely to be many other cases when the new products are suitable instead for 'high-income' markets. After all, many examples cited above suggested that the new technologies are often adopted precisely to be able to compete in the export markets of the industrialized countries.

This form of demand-side issue does not, however, apply to applications of micro-hydro power to rural areas, because a given demand (for energy) is here simply being met more cheaply. What has nevertheless still to be overcome in most such schemes is the problem of lumpiness of investment described above, since even relatively low-cost versions of this form of power will be inaccessible to most individual households in rural areas. If, on the other hand, adoption decisions can be made communally, micro-hydro projects appear to represent one important way in which the new technologies can promote a pattern of industrialization that is based on small-scale producers in rural areas. A project in a small rural village in central Colombia that used the power from a micro-hydro plant to establish a small sawmill illustrates this potential.[55] The community in that village was able (with the assistance of a non-governmental rural development organization) to commit itself not only to the joint ownership of the sawmill hydro plant, but also to planning and building the sawmill. Evidently, therefore, the problems of collective action are not insuperable and the incomes of even very isolated rural communities can, under the right conditions, be increased by the adoption of the new technologies.

Still another way in which the new technologies might facilitate decentralization exploits the ability of (some of) these technologies to overcome long distances. Unlike the two previous possibilities which were based on 'stand-alone' adoption by individuals or communities, this third possibility involves communication *between* the geographically fragmented elements of a system of production or distribution of goods and services. In the context of public goods provided by governments, one can point to a variety of examples of this model in developing countries (eg the way in which computers at different levels of government are linked together in information systems). In the context of the privately owned enterprise, aspects of the Benetton experience provide probably the best example (especially when compared with the case of Prato, the Italian textile industry).

The Benetton retail shops are to be found in locations throughout the world. The Prato case, on the other hand, as noted above, comprises a cluster of large numbers of small-scale firms in one particular region. It would seem that the production structures of Benetton and Prato are similar, but not their distribution structures. For, while Benetton producers are, like their counterparts in Prato, centralized in a particular area, the retail outlets are widely dispersed. This dispersion is based on a telematics network (combining information processing and transmission) which Benetton introduced in 1978 to provide communications between the headquarters and the sales outlets. The network has proceeded through different stages of sophistication since then. In 1985, the basic telematics network was linked to the different Benetton agents through the provision of a personal computer to each. As a result, the agents are rapidly able to receive information about consumers, goods and prices. At the same time, 'The pattern of sales and extent of re-orders are regularly fed back from the shops to Benetton, and in this way the time required for the final decision of distribution among subcontractors is markedly reduced. This allows for an optimisation of the total production cycle and a better utilisation of capital equipment of the whole system'.[56]

As with Prato, it is difficult to conceive of Benetton as a model (for incorporating small-scale enterprises in the benefits of the new technologies) that is easily replicable in developing countries. On the supply side, for example, the latter requires a highly complex communications infrastructure, which, for many, if not most, developing countries simply does not exist. On the demand side, it is worth emphasizing that the complex information system is used by Benetton to communicate with retail outlets which are overwhelmingly concentrated in the developed countries. The reason is that the major markets for Benetton are found in these countries, and it is information about these markets (and changes therein) that the company requires (so precise is this information, in fact, that Benetton 'almost directly "interacts" with its customers').[57] Correspondingly few developing countries participate in the communications network of retailers; in fact, according to one study, the Benetton experience casts doubt 'on the general applicability of the thesis which suggests the progressive displacement of labour intensive "mature" products to LDCs'.[58]

TABLE 3. NEW TECHNOLOGIES AND SMALL-SCALE INDUSTRIALIZATION: ALTERNATIVE ECONOMIC AND INSTITUTIONAL MECHANISMS

	Choice of technology	Flexible specialization	Decentralization
Technological focus	New technology as an expansion of the existing range of techniques	New technology as part of the new flexible specialization paradigm	New technology as an expansion of spatial technological possibilities
Unit of analysis	Individual firm	Individual firm as part of well defined cluster of firms	Individual firm/community
Organizational change	Not major area	Innovational complementarities	May involve changed relationships between central and dispersed units of production (distribution)
Geographical focus	None	Agglomerative clusters	Dispersion
Inter- and intra-firm linkages	Only insofar as differential rates of adoption by small and large firms affect the competitive position	Central issue, competitive and cooperative relationships between small-scale firms and between large and of the former	Unimportant (with dispersed 'stand-alone' adoption), or important (where dispersed units interact with centrally located unit) small-scale
Benefits	Increased profits by individual adopting firms	'Collective efficiency', dynamic gains in export markets, externalities	Regional decentralization, increased equality
Main constraints	Factor prices, skills, information	Problems of collective action, 'government failures' to induce cooperative behaviour	Lack of infrastructure and effective demand in dispersed locations
Examples	CAD/CAM in NICs, microcomputers in Africa	Prato	Benetton, micro-hydro

Summary and conclusions

This article has examined the various economic and institutional mechanisms through which the benefits of the new microelectronics technologies are, or might be, transmitted to small-scale enterprises in developing countries. We have suggested that although there is a tendency in the literature on this topic to emphasize the 'newness' of these technologies, many instances of adoption can be understood with reference to the received choice of technology framework (albeit one that differs in some ways from the neo-classical model). There are, for example, a number of similarities between the patterns of adoption and diffusion of agricultural innovations and those that are associated with the new microelectronics technologies.

On the other hand, there are numerous other mechanisms through which the benefits of the latter might be transmitted to small-scale enterprises that cannot (or at least not easily) be fitted into the choice of technology framework. This was shown to be mainly because the framework tends to focus on the individual rather than the group or community; because it neglects relationships between and within enterprises; because it tends to deal with the hardware rather than the organizational dimensions of technology; and because it lacks a spatial dimension. In each of these areas, we have compared the choice of technology with two other analytical frameworks, namely, those associated with flexible specialization on the one hand and with decentralization on the other. The outcome of these comparisons is contained in summary form in Table 3. We wish to emphasize, however, that our approach to these alternatives has been essentially comparative rather than exhaustive; by no means, therefore, does our discussion purport to review the substantial literature on them that already exists.

None of the mechanisms we have considered suggests that the complex of new technologies is likely to constitute a major alternative to previous patterns of industrialization, at least in the short run (although particular types of small firms have and will benefit from these technologies). This conclusion should not, however, be interpreted to imply that governments have no role to play; on the contrary, we have indicated much that can be done by government, especially but not exclusively in instances of market imperfections and failures.

Notes and references

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2. Kaplinsky has rightly emphasized that scale economies have several dimensions, namely, product, plant and firm. He also argues that these dimensions are changing in different ways; some are growing, others are falling, while yet others are static. See R. Kaplinsky, *The Economies of Small* (London, IT Publications, 1990).
3. There are, however, some estimates at relatively large scales of output. See M. Dodgson, *Advanced Manufacturing Technology in the Small Firm* (London, Technical Change Centre, 1985).
4. A. Bagchi, 'The impact of microelectronics-based technologies', *ILO World Employment Programme Research Working Papers No 169* (Geneva, September 1986).
5. C. Edquist and S. Jacobsson, *Flexible Automation: The Global Diffusion of New Technology in the Engineering Industry* (Oxford, Basil Blackwell, 1988) page 132.
6. R. Kaplinsky, 'Computer aided design—electronics and the technological gap between DCs and LDCs', in S. Jacobsson and J. Sigurdson (editors), *Technological Trends and Challenges in Electronics* (Lund, Research Policy Institute, University of Lund, Sweden, 1983).
7. A detailed recent survey by Alcorta concludes that although the new technologies 'may have a significant scale reduction effect at product level, it is not clear they would have a similar impact at plant level. Furthermore, the impact at firm level may be "scaling-up" rather than "descaling"'. See L. Alcorta, 'The impact of new technologies on scale in manufacturing industry: issues and evidence', UNU/INTECH, Working Paper 5, Maastricht, 1992.
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13. P. Tigre, *Technology and Competition in the Brazilian Computer Industry* (London, Frances Pinter, 1983), page 173.
14. H. Binswanger, 'Agricultural mechanization: a comparative historical perspective', Research Unit, Agriculture and Rural Development Department, World Bank (Washington, DC, 1982), page 16. For a review of public tractor hire and equipment hire services in the Sub-Saharan African context see P. Pingali, Y. Bigot and H. Binswanger, *Agricultural Mechanization and the Evolution of Farming Systems Research in Sub-Saharan Africa* (Baltimore, MD, Johns Hopkins University Press, 1987).
15. B. Tulsi, *The Blending of Emerging and Traditional Garment Technologies: An Examination of the Swedish Experience and General Implications for the Third World Industry*, paper prepared for a Meeting of the UNCSTD/UNACSTD on the Blending of Emerging and Traditional Technologies (San Miniato, Italy, 28–30 November, 1985).
16. There have, however, been some attempts to relax this assumption. See, for example, J. Enos, 'A

game theoretic approach to choice of technology in developing countries', in J. James and S. Watanabe (editors), *Technology, Institutions and Government Policies* (London, Macmillan Press, 1985); and J. James, 'Bureaucratic, engineering and economic men: decision making for technology in Tanzania's state-owned enterprises', in S. Lall and F. Stewart (editors), *Theory and Reality in Development* (London, Macmillan Press, 1985).

17. Feder, Just and Zilberman, *op cit*, reference 1.
18. Edquist and Jacobsson, *op cit*, reference 5, pages 136–137.
19. J. Northcott with Petra Rogers, *Microelectronics in Industry: An International Comparison: Britain, Germany, France* (London, Policy Studies Institute, 1985).
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24. M. Piore, 'Outline for a research agenda for "The New Industrial Organization"', Memorandum for the Director of the Institute of Labour Studies of the ILO, Geneva.
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26. R. Kaplinsky, 'From mass production to flexible specialization: micro-level restructuring in a British engineering firm', IDS, Sussex, 1991, page 5 (mimeo).
27. Sayer, *op cit*, reference 25, page 671.
28. R. Kaplinsky, 'Direct foreign investment in Third World manufacturing: is the future an extension of the past?', *IDS Bulletin, 22*(2), 1991, page 25.
29. Some of them are described in K. Hoffman, 'Technological advance and organizational innovation in the engineering industry', Industry and Energy Department Working Paper, Industry Series Paper No 4 The World Bank (Washington, DC, The World Bank, 1989); and R. Kaplinsky, 'A case study of industrial restructuring: from mass production to flexible specialisation', IDS, Sussex, 1991 (mimeo).
30. Hoffman, *op cit*, reference 29, page 27.
31. Kaplinsky, *op cit*, reference 29.
32. A point made by Feder, Just and Zilberman, *op cit*, reference 1.
33. Kaplinsky, *op cit*, reference 28, notes, however, that these changes are often human-resource intensive, and this may pose an especially acute constraint on Sub-Saharan African countries.
34. M. Roldan, 'JIT (just in time) technological innovations, industrial restructuring and gender relations', International Workshop on Women Organizing in the Process of Industrialization, Institute of Social Studies, the Hague, April 1991, page 19.
35. H. Schmitz, 'Flexible specialization in Third World industry: prospects and research requirements', Industrialization Seminar, Institute of Social Studies, the Hague, 20 April 1990.
36. See, for example, the papers prepared for the EADI Workshop on Flexible Specialization and Industrialization in the Third World, Copenhagen, June 1991. One exception to this collection however, is a study by Cho on the Republic of Korea which classifies clusters of firms by three technological levels: upper (referring to microelectronics), middle and lower. He says that in Korea, three regional clusters have been emerging in line with three different levels of techology. Cho concludes: 'Given that each cluster has its own pattern of inter-firm relations and resultant flexibility, the sum of three flexible techno-spatial clusters gives rise to a flexible regime of accumulation . . . There is no single pathway to a flexible specialisation industrial paradigm'. *Source*: Myung-Rae Cho, 'Weaving flexibility: large–small firm relations, flexibility and regional clusters in South Korea', paper prepared for EADI Industrialization Stategies Working Group Workshop on New Approaches to Industrialization: Flexible Production and Innovation Networks in the South, Lund, Research Policy Institute, 26–27 June 1992.
37. See, for example, UNIDO, *The Effectiveness of Industrial Estates in Developing Countries* (New York, UNIDO, 1978). Moreover, the idea itself, as Schmitz himself acknowledges, can be traced back to Marshall.
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45. James, *op cit*, reference 43, emphasizes the role of this in the context of diffusion of communal innovations.
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48. Kaplinsky, *op cit*, reference 2, page 183.
49. Kaplinsky, *op cit*, reference 28.
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52. See for example, I. Livingstone, 'A reassessment of Kenya's rural and urban informal sector', *World Development*, *19*(6), June 1991 pages 651–670.
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55. See *Appropriate Technology*, *10*(3), 1983.
56. F. Belussi, 'Benetton: information technology in production and distribution: a case study of the innovative potential of traditional sectors', *Occasional Paper Series*, No 25, Science Policy Research Unit, University of Sussex, 1987, page 49.
57. *Ibid*, page 65.
58. *Ibid*, page 16.