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Product versus process innovation:  
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## INTRODUCTION

The OECD *Jobs Study* (1994a) argues that it is necessary to develop a more detailed and differentiated understanding of the relation between 'growth' and employment, since some kinds of growth destroy jobs while others create jobs. At the same time, the Commission of the European Communities (1994, pp. 57–60) suggests the 'employment intensity of growth' differs between various kinds of productivity and economic growth, and the source and content of growth has significant employment implications. At the core of these studies is the crucial question: Which kinds of growth lead to more jobs and which do not?

The effects of innovations on the generation and destruction of jobs form an especially complicated part of the relations between growth and employment. The relationships between innovation and employment are seldom direct and are usually mediated by a number of offsetting factors (Vivarelli, 1995, ch. 4). These include 'multiplier' effects on demand in other industries and sectors, 'real income' effects influencing the level of demand and 'adjustment' effects in labour markets (wage movements) that partly compensate for the substitution of labour by other factors – all of which are affected by macro-economic conditions and institutional characteristics. Thus unemployment rates have been shown to differ substantially across countries which share similar levels of technological development and similar rates of growth. For example, the OECD

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(1994b, pp. 53–5) reports that during the most recent recession member countries commonly experiencing an initially 'weak rebound' in output growth performed very differently in terms of employment growth.<sup>1</sup> In Europe unemployment is much higher (12 per cent) than in Japan (3 per cent) and the USA (5 per cent).

On the basis of recent work within the so-called systems-of-innovation approach, this chapter proposes an analytical framework for the study of the relationships between innovations and employment.<sup>2</sup> The systems-of-innovation approach is mainly about the determinants of innovation and technical change (Edquist, 1997a). As such, it informs the key distinctions we make between product and process innovations, and, with respect to the latter, between technological and organizational innovations. The first distinction is well-established in the literature, having originated with Joseph Schumpeter, who defined product innovation as 'the introduction of a new good . . . or a new quality of a good' and process innovation as 'the introduction of a new method of production . . . [or] a new way of handling a commodity commercially' (Schumpeter, 1911; compare Archibugi *et al.*, 1994, p. 7). The second distinction, which points to the difference between technological and organizational process innovations, is a more recent development but flows naturally from the first. Utterback and Abernathy (1975), in their studies of the product life-cycle, demonstrate this continuity with a model of development in which transformations in a firm's organizational structure are related to the changing emphasis a firm places on product and process innovation.

Taking our point of entry to be the distinction between product and process innovations and the identification of organizational innovations as an important class of process innovations, we shall deal not only with the production of industrial goods but also with the production of services. The theoretical discussion will be of an 'appreciative' kind (Nelson, 1994, pp. 292–3): that is, we shall try to stay relatively close to empirical substance and shall argue in verbal terms. This discussion will lead to three summarizing propositions that can be tested or answered only through empirical work. Specific hypotheses, questions and systematic analyses of existing empirical studies have been more fully developed elsewhere (Edquist *et al.*, 1997).<sup>3</sup> Where possible in this brief chapter, we shall indicate whether existing empirical work provides a basis for answering the questions raised and give some illustrative empirical examples. Beyond that, we have no systematic empirical ambitions here. Rather, this chapter is a conceptually orientated review of existing theory and research conducted with the aim of developing a framework for assessing the employment effects of different types of innovations.

## SPECIFICATION OF BASIC CONCEPTS

Many economists argue that it would be highly advantageous to deal with the employment impact of innovation in a general equilibrium framework. That would mean looking at an economic system as a whole and dealing with the simultaneous determination of all prices and quantities of all goods and services, including the consequences of innovation for employment. To our knowledge, no one has ever attempted to conduct such an analysis, and it seems that a general equilibrium analysis of innovations and employment is not possible to carry out for the time being. One reason is that mainstream economic models have problems in dealing with product innovation (Lundvall, 1985; Pasinetti, 1981; Vivarelli, 1995): in that framework the terms 'innovation' or 'technical change' normally refer only to technological process innovations. Another reason is that technical change and innovation are evolutionary processes which tend to preclude equilibrium situations (Dosi, 1982, 1988).

In contrast, the systems-of-innovation approach can include product innovations as well as technological and organizational process innovations. Moreover, this chapter will discuss material goods as well as intangible services. Ideally, the analysis would identify not only the most important (direct) consequences of innovation for employment but also second- and third-order effects. Our attempt to do this will gradually take us closer to what the term 'general' in 'general equilibrium analysis' essentially means: an approach acknowledging that everything is tied together with everything. This, however, has nothing to do with the term 'equilibrium', since innovation is its opposite.

*Product innovations* are what is produced and sold in terms of new, or better, products (or product varieties). The products may be brand new to the world, or they may be new to a firm or country, that is, diffused to these units. In his original definition Schumpeter (1911) referred to goods or qualities of goods 'with which consumers are not familiar'. The category of product innovations, however, can include both new goods and new services. While new goods are product innovations in manufacturing and the primary sectors, new services are intangible, often consumed simultaneously to their production, and capable of creating values that satisfy non-physical needs of the user (Hauknes, 1994, pp. 8–9).<sup>4</sup> Examples of product innovations in goods include the automobile at the turn of the century, industrial robots in the 1960s and high-definition television (HDTV) in the 1990s. In services, product innovations include the (first) offer of a curly hairstyle, heart transplants in the 1960s, a new insurance payment plan for drivers who lose their licences, video-on-demand over the telecom network, education with regard to the European Union legal system, and the design and maintenance of computer systems in firms.

*Process innovations* are new ways of producing goods and services; they are defined by how existing products are produced. Schumpeter's (1911) original definition referred to a 'method of production' or 'way of handling a commodity' that is 'not yet tested by experience in the branch of manufacture concerned'. In that we are discussing methods, process innovations may be technological or organizational.

*Technological process innovations* are units of real capital (material goods) that have been improved through technical change and that lead to productivity growth in their use. Some of these goods may once have been product innovations that were sold as commodities to other firms.<sup>5</sup> In other words, they can appear in two 'incarnations' in the economic system, where an industrial robot is a product innovation when produced by ABB in Västerås and a process technology when used by Volvo in Göteborg.

In addition to this relation between material product and process innovations at different stages, other important kinds of relationships exist within the sphere of production. Generally, empirical studies have shown a strong interrelation between product and process innovation at the firm level (Archibugi *et al.*, 1987; Kraft, 1990; Lunn, 1986). However, this relationship is neither simple nor deterministic (Rosenberg, 1976, ch. 8), and requires clear specification. In some cases the production of new products requires the modification of process technologies. In other cases, product innovations do not require new process technologies. A third case is when the same – or a very similar – product is produced with radically different process technologies. An example is human growth hormone, which was previously extracted from human pituitary glands and is now produced through genetically engineered cells.<sup>6</sup>

*Organizational process innovations* are more productive ways to organize work; a new organizational form is introduced. These innovations are intangibles, that is, they are non-material. Examples are just-in-time production, total quality management (TQM) and lean production. Organizational changes are normally developed through processes of trial-and-error and learning-by-doing within the innovating firms; they are not based on formal R&D activities.<sup>7</sup> Other firms generally copy the vanguard firms; this means of diffusion is facilitated by there normally being no property rights associated with organizational innovations. This differs considerably from the legal environment of most technological innovations. None the less, the process of copying is sometimes facilitated by organization consultants, who act as 'social carriers' of organizational knowledge. Thus the knowledge basis of organizational innovations may sometimes be sold as consultancy services, in which case organizational innovations are commodified.

There can be a link between services and organizational process innovations, but it is probably weak.<sup>8</sup> Only a tiny share of all service products

become organizational innovations, and conversely, most organizational innovations are not services in that they are not products sold on markets.<sup>9</sup> In other words, the categories of services and organizational innovations are fairly independent of each other, although they have some similar characteristics.

While organizational innovations are not always included in discussions of product versus process innovations, there are at least three important reasons for doing so. First, organizational changes are important sources of productivity growth and competitiveness which may also strongly influence employment.<sup>10</sup> Secondly, organizational and technological changes are closely related and intertwined, with organizational change often being a requirement for successful technological process innovation (Nyholm, 1995). Thirdly, as all technologies are created by human beings, they are 'socially shaped', and this is achieved within a framework of specific organizational forms (Edquist, 1997a).

## RELATIONSHIPS BETWEEN INNOVATIONS AND EMPLOYMENT

In order to analyse the different consequences that different types of innovations have for employment and growth, we propose six arguments for distinguishing between product and process innovations and between technological and organizational process innovations. The rather complex relationships between productivity growth, economic growth and (un)employment are addressed and later delineated as three propositions. The six arguments and the evidence adduced to support them are as follows:

1. Different types of innovations exist, with potentially different effects on productivity and employment. Process innovations may be technological as well as organizational, while product innovations may be goods or services.
2. The patterns of diffusion of technological product and process innovations are very different. For example, Swedish industry does well at diffusing process innovations but poorly at diffusing product innovations. The pattern is the reverse of the USA, while Japan is good at both product and process diffusion (Edquist, 1989; Edquist and Jacobsson, 1988).
3. The determinants that explain the differing patterns of diffusion are radically different for technological process and product innovations (Edquist and McKelvey, 1992, 1998). Determinants for diffusing process innovations include industry structure, relative factor prices,

regional wage differentials, rate of unemployment and union attitudes (Edquist, 1989, pp. 4–5). Determinants for diffusing product innovations include the propensity of firms to stay locked into 'core business' activities and the orientation of government policies (Edquist and McKelvey, 1992, pp. 52–63). Thus any action or policy to influence innovations must be based on a more detailed understanding of how and why different categories of innovations are made and diffused.

4. Some product innovations become process innovations at a later stage of the economic cycle. More specifically, consumer products only take the form of product innovations, whereas investment goods can change over time from being product innovations (when sold) to being process innovations (when used). This holds for some goods products which become technological process innovations and for some service products which become organizational process innovations. This dynamic is important because product innovations that become process innovations have second-order effects which can reduce the overall positive employment consequences of product innovations.
5. The consequences for productivity of the various kinds of innovations differ and work through different mechanisms. While process innovations tend to enhance productivity by reducing labour inputs (Vivarelli, 1995), some organizational process innovations are an exception (Dreher, 1996; Nyholm, 1995). In contrast to process innovations, the increased productivity growth associated with new products (particularly new goods) has to do with changes in labour productivity – the nominator of the ratio (Assarsson, 1991; Hansson, 1991). In this sense, the productivity increase (associated with new goods) is not 'real' in the sense of physical output but is rather an increase in productivity 'as measured'.<sup>11</sup> (See, 'Conclusions and policy implications', pp. 142–5.)
6. An analytical distinction between product and process innovation is necessary to make possible the study of the relations between the two. The tendency of mainstream economic theory to assume that all innovations are forms of process innovation ignores product innovations as the main mechanism behind structural economic change (Pasinetti, 1981). While technological process innovation normally has the net effect of reducing employment (Vivarelli, 1995), 'If we abstract from product innovation, we abstract from the most important of factors counteracting stagnation and unemployment' (Lundvall, 1985). This reasoning draws attention to the special character of product innovation as a 'differentiating mechanism' (Katsoulacos, 1984) and to the argument that 'in determining the effect of product innovation on the level of employment, the primary factor involved is the "welfare effect" implying generation of employment' (ibid., p. 83).

These six points clearly indicate that analysis of the relations between innovations, employment and growth depends on a more nuanced discussion of different types of innovations. Our conceptual framework helps to identify which types of innovations, sectors and industries may be more beneficial for employment than others. It suggests that the type and locality of economic and productivity growth is vital for understanding the pattern of employment generation and destruction. Clearly, the consequences of product and process innovations for employment differ sharply between these two major categories and between our three sub-categories of (a) technological and organizational process innovations; (b) product innovations in services and goods; and (c) investment, intermediate and consumer products. With these distinctions made, blanket statements such as 'technology destroys jobs' are nonsense.

Our main arguments and observations about the relationships between different types of innovations and employment can now be summarized in the form of three general propositions.

### Propositions

*Proposition 1* The balance between product and process innovation differs sharply between industrial sectors and also between different service sectors.<sup>12</sup>

Technological process innovations can cumulatively lead to 'technological trajectories' or 'growth patterns' that are either labour-saving or employment-generating (Freeman and Soete, 1987, p. 46). National growth patterns with a relatively low employment intensity reflect the predominance of industrial sectors characterized by a labour-saving technological trajectory in which there is a primary concentration on process, rather than product, innovations (Pianta *et al.*, 1996, p. 13). The evidence comes from a variety of sources. Both comparative studies of national technology specialization (Pianta, 1996; Pianta and Melicana, 1994) and national studies of sectors of employment growth and decline (Edquist and Texier, 1996; Greenan and Guellec, 1996; Meyer-Krahmer, 1992, 1996) indicate that R&D-intensive manufacturing sectors with high levels of product innovation have also experienced net employment growth. In broad terms, there is greater emphasis on developing new products in the more R&D-intensive industries while there is greater emphasis on process improvements in the less R&D-intensive industries, largely through the acquisition of investment products (Calvert *et al.*, 1996; Papaconstantinou *et al.*, 1995; Pollack, 1991). Within the manufacturing sector, a clear divi-

sion has thus emerged between the 'high-tech' (R&D-intensive) industries and 'traditional' manufacturing industries (OECD, 1996b, pp. 64-71).

Similar national and international evidence supports similar patterns of employment growth and decline in the service sector (Denmark Ministry of Business and Industry and OECD, 1996; McKinsey Global Institute, 1994). However, it is much harder to identify service industries with a high level of R&D. Because formal R&D is less important for the development of new services, conventional measures of R&D intensity are less applicable within the service sector (Lee and Has, 1995). Moreover, it is more difficult to distinguish between product and process innovation in the service industries. Nevertheless, on the basis of trial survey results, Evangelista and Sirilli (1995) have argued that 'the distinction between product (service) and process innovations (including delivery innovations), even if less clear-cut compared to the manufacturing sector, is still useful in identifying different firms' innovative objectives and strategies'. We have adopted a similar position. Given these analytical difficulties, we treat the introduction of new process technologies in service industries as an indicator of both process innovation and (possible) product innovation (Barass, 1986, 1990).

Just as there is diversity within different industrial sectors, so too there is diversity within service sectors; and just as there are R&D-intensive and low R&D-intensive industrial sectors, so too there are 'dynamic' and 'traditional' services (Economic Council of Canada, 1991, p. 93). Traditional services have a primary focus on incremental product innovation based on improvements to human capital, while dynamic services exhibit a stronger emphasis on the development of new products based on 'enhancements to all the factors of production' (Baldwin, 1995, p. 23). In 'dynamic' services, therefore, the pattern of product innovation is based on quality-enhancing and diversifying uses of new process technology combined with complementary improvements to human capital. This has been the case, for example, in the financial, insurance, real estate and business services industries (Fincham *et al.*, 1994), the second most important segment of services in terms of employment creation for OECD countries (OECD, 1996b, pp. 73-5, 88-91; Sakurai, 1995).

Despite this close relation between process and product in the service sector, there are also segments of services where product and process innovations are not as closely related as first thought. On the one hand, there appears to have been extensive product innovation which has not relied primarily on technological process innovations. For example, the community, social and personal services sector has been a primary source of employment growth throughout OECD countries (OECD, 1996b, p. 73) but most of this growth cannot be attributed to technological change: rather, it is due to increases in final demand (Sakurai, 1995).

Further, there is much evidence to link these increases in demand to extensive product innovation (Illeris, 1996, ch. 4). This indicates a primary emphasis on investment in human capital, rather than capital equipment, as a basis for product innovations. To the extent that these product innovations involve, or are related to, 'process innovation', this may be predominantly 'organizational innovation', which can have capital-saving and neutral employment effects (Dreher, 1996; Nyholm, 1995). On the other hand, some service sectors concentrate more exclusively on process innovation without a complementary emphasis on product innovation. This appears to be the case in high-productivity service industries that are strong consumers of new process technologies, and which have expanding markets but stable or declining levels of employment. An example is the transportation, communication and storage sector in services, which has been a heavy investor in new process technology (Papaconstantinou *et al.*, 1995, table 5), yet has not made any large contribution to employment growth in services (OECD, 1994b, p. 159).

Significantly, the service sector, where the great bulk of employment and job creation in OECD countries has been located for several decades (OECD, 1996a, 1996b, p. 73), has few industries based on investment products. Thus negative employment effects of the 'second incarnation' are less likely to characterize the development of new services. Instead, the positive, first-order effects tend to remain at full strength. In addition, because new services are more likely to complement than to compete with new goods, this relationship between goods and services will have positive effects on employment. The case of (non-public) community, social and personal services is instructive. This sector accounted for 30 per cent of all OECD employment in 1991 and its rate of employment growth was ranked among the top five employment sectors in nine out of ten OECD countries (Sakurai, 1995). It has been demonstrated empirically that its growth has been due to the development of services that cannot be replaced by goods (Illeris, 1996, ch. 4).

*Proposition 2* The employment effects of innovation differ between sectors.<sup>13</sup>

As argued above, in both manufacturing and services, sectors in which there is a strong emphasis on process innovation tend to be characterized by labour-saving trajectories, while sectors with high levels of product innovation tend to have employment-generating trajectories. The relative mix of sectors of these two types will have a major effect on the overall national pattern of employment creation and destruction.

In manufacturing across the OECD world, there has been a growing divergence between industries with high levels of product innovation and those concentrating on process innovation. The former industries, which are the most R&D intensive, are clearly the 'growth industries', and have experienced net gains in employment; the latter, which are not R&D intensive, tend to be 'declining' industries with net employment losses (Pianta *et al.*, 1996). Recent German research (Meyer-Krahmer, 1992) reviewed in Meyer-Krahmer (1996) offers some particularly illuminating results. This research found that R&D-intensive sectors of West German industry enjoyed 'outstanding growth' during the 1980s, increasing their share in industrial employment from 39.5 per cent to 44 per cent by 1990. Since 1984, moreover, the net additional jobs created in industry were all in the R&D-intensive sector. Despite a slight reversal of this dynamic suffered in the early 1990s, these industries continued to expand while others contracted. 'The non-R&D-intensive sectors stagnated in comparison to the shrunken level reached during the recession' (Meyer-Krahmer, 1996, p. 217).

The body of argument and evidence indicating that there is a strong positive association between product innovation and employment growth provides the basis for a more complete explanation of why the labour-saving effects of technological process innovations tend to vary widely between sectors and within both goods-producing and services-producing sectors. Process innovations generally have a net negative effect on employment. Although compensation effects exist, such as increased demand resulting from lower production costs or from rising incomes and consumption – which may result from productivity-enhancing process innovations – these are not normally large enough to make the net employment effect of process innovation positive (Johnson, 1995, p. 56). In this connection, the most crucial issue for employment is generally the size of price elasticities, which is usually not large enough to compensate for the immediate decreases in employment caused by process innovation (Bosworth, 1987).

None the less, there has been extremely wide variation in the pattern of employment growth, or decline, among sectors that have experienced comparable levels of productivity improvement due to labour-saving process innovations (Blazecjak, 1991; Freeman and Soete, 1987; Johnson, 1995; Levy *et al.*, 1984). This variation cannot be explained solely in terms of the compensation mechanisms linked to process innovation, but must also take into consideration the positive employment effects of product innovation.

In the services sector, the pattern is similar to manufacturing, although it is much less clearly defined. For manufacturing, product innovation is positively associated with R&D intensity (Calvert *et al.*, 1996, p. 8;

Papaconstantinou *et al.*, 1995, p. 3). There is a similar positive relationship between employment growth and product innovation (Edquist and Texier, 1996). For services, 'formal R&D' is less important to product innovation (Baldwin, 1995), and alternative measures of 'R&D intensity' such as education of employees are necessary (Lee and Has, 1995). Even when reviewing research using such proxy measures, it has remained more difficult to establish clear linkages between R&D intensity, product innovation and employment growth for the services sector.

Against this background, we have observed that both a (knowledge-intensive) R&D-intensive segment (finance, insurance, real estate and business services) and a relatively non-R&D-intensive segment (community, social and personal services) have acted as the main engines of employment growth (OECD, 1996b, p. 73). However, it must also be recognized that one of the most R&D-intensive industries within the community, social and personal services sector – health care – has been this segment's main force of employment growth (OECD, 1994b, p. 52). Therefore, if R&D intensity is correlated with a higher performance of product innovation, it is possible to discern in the services a pattern somewhat similar to that observed for manufacturing, although differences are less easily identified.

Moreover, our proposed proxy of a high proportion of highly educated people as a measure of R&D intensity in services may require further specification in terms of how these human resources are actually employed. Their work might involve creating new products with positive effects on employment, but conceivably they could be engaged in forms of technological process innovation whose overall effects on employment are negative. Examples of this labour-saving trajectory in service sectors with relatively high R&D intensity are found in the air, rail and pipeline transportation, communication and utilities industries which have always been among the most capital-intensive sectors (Quinn, 1987), but have not been leaders in the creation of service employment (OECD, 1994b, p. 159). In other instances, a dual focus on process and product innovation might have mixed employment effects, as appears to be the case in the finance, insurance, real estate and business services sector (Barass, 1990). The pattern of innovation underpinning this sector's rise as a leading generator of employment has been one in which labour-saving process technologies have eliminated many 'back-office' jobs while later expanding 'front-office' employment based on product innovation, namely the development of 'new services and operations' (Fincham *et al.*, 1994, p. 7).

The community, social and personal services sector has been a leading source of job creation throughout OECD countries, both within services and among all sectors of the economy (Sakurai, 1995). The focus of inno-

vation in this sector has been on the development of new products that are primarily, if not exclusively, consumer products with the least potential for reducing employment through a 'second incarnation' as process innovations. They are also, contrary to the 'self-service society' thesis, resilient to the employment-reducing effects of replacement by new consumer goods (Gershuny and Miles, 1983; Illeris, 1996, ch. 4). Many of these service products have been developed to complement goods innovations that originally threatened to replace them, and this complementarity often involves the creation of highly skilled employment (Gadrey, 1988, 1992). For these reasons, the type of 'final demand' involved in product innovations should be taken into account in analyses of their employment effects. For both manufacturing and services, products that do not replace existing ones have a larger effect on employment creation than those that do, and consumer and intermediate products can have a larger overall positive effect than investment products.

*Proposition 3* It is too blunt to argue that industrial employment is decreasing and that only 'the service sector' can save the world from massive unemployment.<sup>14</sup>

Certain service and manufacturing sectors will be of far greater strategic importance to job creation than others. These sectors are R&D intensive and engage most heavily in product innovation. Knowledge-intensive industries, in both manufacturing and services, have dramatically higher rates of employment growth and have made a disproportionately large contribution to total employment growth (Department of Finance, 1992; OECD, 1994b, pp. 152–4). Our findings also point to the importance of interactions between R&D- (or knowledge-) intensive goods and services-producing sectors for employment growth. In other words, goods-producing and services-producing sectors have become increasingly interlinked.<sup>15</sup>

The sectors most important for the creation of employment are those engaged in the creation of new products and new markets. This has been shown most recently in an analysis of employment changes in the manufacturing sectors of the six largest OECD countries, where it was found that innovation, production and employment opportunities are concentrated in a few highly R&D-intensive industries (Pianta *et al.*, 1996). From a more detailed analysis of the dynamics of employment growth by sector in one country, the same study concluded that '[a] labour increasing pattern has been found only in sectors characterized by higher design and engineering expenditure and higher shares of product innovations' (Pianta *et al.*, 1996, p. 13). With respect to service industries, the most innovative and rapidly growing ones are those where there is a close cor-

relation between manufacturing and services (OECD, 1996b, p. 77). Since service industries in general will continue to be the main source of employment growth in the OECD world, it is appropriate to dwell briefly on the importance of the interaction between new goods and new services for the development of new jobs.

We have shown that the community, social and personal services segment has been a main source of new employment in services throughout the OECD. Further, we have argued that employment growth in this segment has greatly depended on the development of new service products and, in turn, on complex interactions between consumer goods and consumer services. These interactions have predominantly taken the form of complementarity, rather than competition, between goods and services (Gadrey, 1988, 1992).

New service products are also based on the acquisition of new process technologies, particularly equipment incorporating information and communications technology, which are produced in the capital goods sector. This type of product innovation has been pronounced in the financial, insurance, real estate and banking services sector (Fincham *et al.*, 1994), which is the second main area of service employment growth in OECD countries (OECD, 1996b, p. 73). As argued above, much of the employment growth in this sector can be attributed to the employment-generating effects of product innovation which counteracts the normally employment-reducing effects of process innovation. However, this type of product innovation would not have been possible without the initial process innovations. There can thus be a dynamic of 'virtuous interaction' between R&D-intensive manufacturing and service sectors, even when it is based on the initial application of labour-saving investment goods in services (OECD, 1996b, ch. 2).

The development of the mobile telecommunications industry is an example of a virtuous interaction between new consumer goods and new consumer services (Miles, 1996). With over 44 million subscribers within OECD countries at the end of 1994, and with more than 1.2 million subscribers being added per month, its rate of growth in 1994 was double that of 1992 (OECD/ICCP, 1996). The innovation profile for mobile communications, as for the communication industry in general, is also extremely high (Kelly, 1995; Mercer Management Consultants, 1994). The country of Finland provides further indications of this segment's rapid growth. The Finnish telecommunications sector is the first major knowledge-based industrial development block in Finland and the fastest growing, expected to become soon the second most important block (after the historically dominant 'forest' block) in that country's economy (Rouvinen, 1996, pp. 39–40).<sup>16</sup> Finland is a major telecommunications

equipment exporter, and its most significant products in this sector – in terms of export value, share of total exports and share of OECD markets – are mobile and fixed networks as well as mobile telephones. Mobile telephones, moreover, have experienced particularly rapid growth during the 1990s (*ibid.*, pp. 84–9).

Moreover, the development of communication infrastructures has been identified as one of the most strategically important bases for job creation in several OECD countries – notably, the USA and Japan (Imai, 1996). For example, Japanese authorities estimate that 2.43 million jobs can be created in network-based service employment in the multi-media market by 2010 (Ministry of Posts and Telecommunications, 1994). Similarly, estimates in France project an increase in this type of employment between 2.5 and 5 times the 1993 level (OECD, 1996b, p. 110). In addition to its potential for explosive growth, this indicates that the growth in communication service employment will be closely tied to growth in the infrastructure of telecommunications goods.

As this example suggests, it is necessary to develop a more discriminating analysis of innovation–employment dynamics in particular sectors and industries than available data now permit. In some manufacturing sectors employment increases rapidly. In some service sectors, employment is decreasing. For empirical research and analysis to be fruitful, manufacturing as well as service production will have to be disaggregated. This crucial point raises two questions to be addressed in later empirical research, before we summarize our arguments:

1. In which disaggregated goods and service sectors does employment decrease or increase? What is the relation to productivity growth and various kinds of innovation?
2. What are the immediate as well as the indirect effects of various kinds of innovation for employment at a disaggregated level?

To summarize, this section has concentrated on refining a conceptual framework for the type of disaggregated empirical analysis recommended above. The distinctions between process and product innovations and between three subcategories of innovation – (a) technological and organizational process innovations; (b) product innovations in services and goods; and (c) investment, intermediary and consumer products – have been posed here, although more conceptual specification could be done. These categories have been quite useful for analysing the effects of different types of innovations on productivity growth and on employment, enabling us to make some observations about which types of manufacturing and service sectors will tend to lead national growth patterns into

either labour-saving or employment-generating trajectories. These observations will now be used in the final section of this chapter to draw conclusions and policy implications.

## CONCLUSIONS AND POLICY IMPLICATIONS

Politicians and mainstream economists often argue that 'more rapid growth' would solve or mitigate the unemployment problem. However, the relation between 'growth' and 'employment' is by no means simple and mechanical. Some kinds of growth create jobs, other kinds destroy jobs, and there is the phenomenon of 'jobless growth'. Economic growth and productivity growth do not automatically or always lead to employment growth. Therefore a general policy of growth will not necessarily create more jobs. Moreover, specialization at the firm, industry and national levels will influence future ability either to continue along or to shift between labour-saving and employment-generating trajectories. On the basis of arguments presented here, this concluding section will try to outline a more detailed and differentiated understanding of the relations between 'growth' and 'employment' with reference to innovations.

There are many problems associated with measuring productivity growth. Analytically it is important to distinguish between quality changes in products and increased output, and determine which is associated with demand growth. The importance of these differences has led us to try to further clarify and distinguish productivity and economic growth and their relationships to employment, as summarized in the following points.

First, productivity growth which is associated with more of the *same* kind of output and produced by the same amount of input leads to a reduction in the number of jobs (per unit of output). Labour productivity is the ratio between production value (value added) and amount of employment. Thus if output (production value) is constant, this kind of productivity growth means that the *denominator* (amount of employment) in this ratio decreases. The most important source of this kind of productivity growth are technological or organizational *process innovations*. While compensation mechanisms can mitigate job losses, they can promote net employment gains only when growth in production (that is, demand) outstrips productivity growth.

If the general level of demand is kept constant and if the price elasticity of demand for the product is below 1, jobs (in the world economy as a whole, that is, in a closed economy) will be lost in the sector of production where the process innovation occurred. If the elasticity is above 1, the number of jobs will increase in that sector (in the world economy as a whole) in spite of the process innovation. The price elasticity is, however,

normally below 1. Thus, on the whole, labour productivity growth associated with process innovations is labour saving. If there is an exogenous demand increase for the product, jobs are of course created.<sup>17</sup> However, this is not the result of productivity growth but of economic growth, that is, increased output. Output and the number of jobs are increasing, but the number of jobs *per unit of output* is not increasing.

Secondly, productivity growth which is associated with *new* kinds of output leads to job creation.<sup>18</sup> This is the case of *product innovation*. Productivity growth of this kind reflects the quality improvements of output as well as the monopolism often associated with new products. It influences the *nominator* in the ratio between production value (value added) and amount of employment (that is, labour productivity), resulting in a higher price paid for the new products.<sup>19</sup> The denominator (employment), however, is not directly influenced by productivity growth associated with product innovations. In other words, the amount of labour needed per unit of output does not decrease; labour is not saved through product innovation.

Instead, the production of new products influences production value (value added). Product innovations often lead to the establishment of new units of production, which means new investments and structural change, and possibly more jobs *as well as* higher productivity. The new product which satisfies a completely new kind of demand or serves a new function contributes most to increased employment.<sup>20</sup> This statement holds whether the product is new to the world, or new to a country, region or company, that is, if the production of a product diffuses. Thus the 'immediate' effect of a product innovation is to increase employment.

However, employment generation caused by product innovation can be counteracted through (a) substitution between old and new products, and (b) new products that become process innovations in a later incarnation. If the new product functionally replaces an old one, either increased or decreased employment may result. The net employment effect depends on whether demand for satisfying the function changes when the new product replaces the old one, and whether there are changes in the labour intensity of the process used to produce the new product.

Some new products are transformed into process innovations in a second incarnation. These products generally lead to a net reduction in the number of jobs in the economy as a whole. However, only investment products can play this double role over time. Therefore, the net employment-generating effect of consumer products and intermediate products is larger than that of investment products. Because the proportion of investment products is smaller in services than in goods, the production of services destroys jobs to a lesser extent than goods production. Product innovation in services is, in this respect, more employment-generating than product innovation in goods production.



Thus, productivity growth associated with product innovations is not, on the whole, labour saving. On the contrary, new jobs are created, mostly through the development, production and use of new products which satisfy new needs and wants. Moreover, the demand for new products often grows more rapidly than for old products. This implies an increase in (production and) employment in some industrial sectors as well as in (some) service sectors.

On average, technological process innovations seems to increase labour productivity faster in goods production than in service production. Therefore process-related job destruction seems to be larger in manufacturing than in services. In both cases, however, the variation between subsectors is large. A net increase in employment can be expected in some industrial sectors and in some service sectors (due to product innovation).

The implications of these arguments are that the firms, regions and countries producing new products do so for markets that are often growing rapidly. Growing markets mean an increase in output (demand) which reinforces the intrinsic employment-creation effect of product innovations. Again, this effect is not associated with productivity growth, but with economic growth.

In summary, firms, industries and national economies that specialize in product innovations generally create more employment than those that specialize in process innovations. The overall extent of employment creation or destruction depends on factors such as changes in market growth and in demand (price elasticity) as well as dynamic effects within the economic system. Product innovations which neither substitute for an existing product nor are later used as process innovations have the greatest positive effect on employment creation. Both manufacturing and service sectors can be roughly divided into those that are more R&D- (knowledge-) intensive and product-innovation-orientated and those that concentrate less on R&D and are more process-innovation-orientated. The links between dynamic manufacturing and service sectors seem to offer the greatest potentials for employment growth.

The implications for government policy can be summarized in the following points:

1. Employment policies need to reflect the differences between sectors highly concentrated on process or product innovations. If a country (time period, firm or region) is characterized mainly by process innovations (technological or organizational) this constitutes a tendency to decrease employment. If product innovations dominate, there is an opposite tendency of increasing employment.<sup>21</sup>

2. A reallocation of resources from process to product innovation will have positive employment effects. An example is policy which identifies and strengthens those manufacturing and service sectors where product innovation dominates over process innovations, namely those with a high R&D (knowledge) intensity.<sup>22</sup> Such a policy would support structural change in the economy in the direction of new sectors.<sup>23</sup> Such a policy of structural change would increase employment in the long run.
3. However, technological and organizational process innovations should not be stopped or hindered in any firm, region or country. While employment problems can be solved by decreasing productivity in the short term, in the longer run such a policy would have devastating consequences. Productivity is the main source of increased material welfare, and competitiveness (of the firm, region or country) depends on productivity growth. Those that attempt to avoid process innovations will end up lagging behind, with worsened prospects for gaining material welfare.
4. Any policy that gives priority to employment generation over productivity growth by preventing process innovation will fail, partly because competition normally requires that potential increases in labour productivity be exploited in the long run.
5. Policies for increased employment should support more capital-saving types of organizational process innovations than labour-saving ones.

As Europe seems to have become locked into a technological trajectory or growth pattern that is predominantly labour saving, the employment intensity of growth is relatively low. For this reason, policy supporting structural change in the direction of more R&D-intensive and less process-innovation-orientated sectors is called for to a greater extent in Europe than in the USA and Japan. The present European trajectory will lead to an increasing competition with eastern Europe and advanced developing countries. This trend has continued for at least two decades without being corrected by market forces. There is thus a strong justification for considering policy intervention.

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## APPENDIX: TWENTY HYPOTHESES

*Hypothesis 1* The labour-saving effects of technological process innovations vary widely between sectors – in manufacturing as well as in service production.

*Hypothesis 2* The variation in labour saving caused by technological process innovations is larger between service sectors than between manufacturing sectors.

*Hypothesis 3* In some service sectors labour saving attributed to technological process innovations leads to very large productivity increases.

*Hypothesis 4* There are different kinds of organizational process innovations; one category is similar to technological process innovations with regard to the factor-saving bias; another class is capital saving without direct effects on employment levels.

*Hypothesis 5* Organizational process innovations require different kinds of investment than technological ones, and more directly affect the type of employment created.

*Hypothesis 6* New goods originate more often from R&D-intensive manufacturing sectors than from other sectors.

*Hypothesis 7* The pattern of diffusion of product innovations is different from that of process innovations, and so are the determinants.

*Hypothesis 8* There is a strong association between the production of R&D-intensive goods and new goods, on the one hand, and high labour productivity, high productivity growth and rapid market growth, on the other.

*Hypothesis 9* Employment grows faster in R&D-intensive industrial sectors than in other sectors.

*Hypothesis 10* The increased productivity (growth) associated with new goods does not mean decreased employment (per unit of output), but relates to changes in labour productivity – the nominator of the ratio.

*Hypothesis 11* The productivity increase related to goods innovation is not 'real' but matters to the welfare of the members of the unit producing the innovation.

*Hypothesis 12* The production of new goods might lead to more jobs as well as higher productivity (as measured).

*Hypothesis 13* Service sectors with a large proportion of highly educated people can be classified as 'R&D intensive'.

*Hypothesis 14* Formal R&D is not important for the development of new services.

*Hypothesis 15* There is a correlation between 'R&D-intensive' service

sectors and service sectors with high levels of product innovation.

*Hypothesis 16* Service sectors characterized by high levels of product innovation are also characterized by rapid market growth.

*Hypothesis 17* The service sectors where there is a close relation between a new good and a new service are, generally speaking, more innovative and growing faster than others.

*Hypothesis 18* There is also rapid growth and a high level of innovation in service sectors where there is a close relation between new process technologies and new service products.

*Hypothesis 19* Only a small part of the services produced are investment products.

*Hypothesis 20* Product innovation generates more employment in the service sector on the whole than in the manufacturing sector. Moreover, service industries are less susceptible to employment-reducing substitution effects than are manufacturing industries.

## NOTES

1. These differences are described in OECD, (1994b) ch. 2.
2. This framework is partly based upon Edquist (1997b).
3. The hypotheses are listed in the appendix.
4. Because the focus of this chapter is on employment in the sense of wage labour, only products produced for the market (commodities) are addressed here, excluding goods and services produced for direct use by the producer (within the household or the internal market of the firm).
5. For reasons of simplification we are including only material elements in the concept of technological process innovation, thereby obviously excluding services. When the conceptual basis of technological process innovations has become more solid, non-material elements (like skills and knowledge) might also be introduced – although they may fit best in the category of organizational process innovations.
6. The growth hormone example is analysed in detail in McKelvey (1996).
7. Hence original organizational process innovations normally emerge within the using firm; unlike technological process innovations, they are seldom sold and bought on the market.
8. More research should be done to establish empirically the strength of this link, and whether or how it grows stronger under different circumstances.
9. Nevertheless, these innovations may have important effects on both production costs and the delivery of products, and so may have a significant impact on products and product markets.
10. Thus 're-engineering' techniques have been shown to result in significant productivity increases and reductions in employment. See the example in Hammer and Champy (1993, pp. 36–9).
11. The usual convention of national accounting is to split the output at current prices of a new product into two components: a volume effect, which reflects the improved quality, and the price effect (the residual).

12. Evidence and arguments supporting proposition 1 can be found in hypotheses 3-6, 8, 9, 12-18 and 20 in Edquist *et al.* (1997).
13. Evidence and arguments supporting proposition 2 can be found in hypotheses 1-3, 6-16 and 18-20 in Edquist *et al.* (1997).
14. Evidence and arguments supporting proposition 3 can be found in hypotheses 6-12 and 15-20 in Edquist *et al.* (1997).
15. Thus the future development of business services is, to a large extent, dependent on the further 'unbundling' of vertically integrated firms, particularly in the manufacturing sector. 'Outsourcing' could proceed along either a low-skill or a high-skill path, with important consequences for both manufacturing and service industries, not only in terms of the quality of employment, but also in terms of its quality (Abraham and Taylor, 1993).
16. The term development block refers to a set of enterprises and industries coupled together by strong quantitative and qualitative linkages of interactive learning and commodities flows (McKelvey, 1994).
17. The case of increases in exogenous demand points to the crucial importance of co-ordination between innovation policies and macro-economic policies, including fiscal, monetary and exchange rate policies. A reasonable degree of macro-economic stability is important for innovation processes and for investment more generally - and therefore for economic growth and employment creation. However, it seems extremely difficult to solve the problems of low growth and high unemployment in western Europe through innovation policy if macro-economic policies remain excessively strict. Fiscal and monetary policies in Europe might become less restrictive once the European Monetary Union has been established - and national governments may thereby avoid the contractionist grip of the Maastricht convergence criteria (of low public debt, low government deficit, low inflation, low interest rates and a stable exchange rate).
18. This refers to productivity growth as it is measured. See note 11.
19. This kind of productivity growth (measured at constant prices) is not 'real' (in physical terms), but it matters to the welfare of the members of the unit producing the innovation.
20. The size of employment generation is related to the size and growth of demand.
21. Although there are counteracting forces.
22. However, this does not mean that it is easy to start new sectors within a country. McKelvey (1996) and references discussed there analyse the importance of trajectories which tend to lock firms into a set of technological choices whereas the systems-of-innovation literature argues for national specialization trajectories.
23. On the whole, these sectors are characterized by higher productivity and higher productivity growth, and therefore can carry higher wages and profits. They are also characterized by more rapid market growth than other products.

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## Part V

# Dynamics of Government Policy and Firm Strategy