The Impact of Innovation on Employment in Europe – An Analysis using CIS Data

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Non Technical Summary

The Historical Challenge

Technological progress in western economies has contributed to an immense rise in productivity, incomes and goods available over the last hundred years. Though not to the same extent as productivity and wages, population and employment have risen as well. Nevertheless, innovations are often blamed for job destruction and unemployment, with workers historically fighting against technological progress.

The impact of innovation on employment today is not as clearcut as it used to be in times of the first factory or the first railroad. The pace of technological progress in an open world economy has accelerated compared to former times, resulting in a greater number of product and process innovations as well as processes related to these product and process innovations. The evolutionary nature of a dynamic, growing market economy results in the perpetual birth and death of firms and the perpetual creation and destruction of jobs -all within a single industry all at the same time. Moreover, since the short and long term impacts of innovation can be different, this does not necessarily imply a contradiction. Negative and positive employment effects occur in various industries at various skill levels.

Most members states of the European Union suffer from high unemployment. The European unemployment rate was 10.9% on average in 1996 and has not changed much since then. In contrast, the US unemployment rate averaged 5.4% in 1996, with a declining tendency since then. Of course, the unemployment rates in the member states of the European Union vary significantly: from 3.3% in Luxembourg to 22.2% in Spain. In Sweden and Germany, unemployment rates rose from November 1996 to March 1997, while in the United Kingdom and the Netherlands, the rates declined.

Nevertheless, unemployment in the European Union is too high and the economy is in a state of disequilibrium. To successfully fight unemployment, it is necessary to create additional jobs by fostering both investment and innovation. This innovation strategy plays a large role in aim of he Commission to create 15 millions new jobs in Europe by the end of the century. Furthermore, it is necessary to promote workers' regional and occupational mobility and skill levels to enhance their ability to deal with economic disequilibria. In addition, the Commission as well as the governments of the member states influence labour and product markets to a large degree and in various ways. The share of GNP controlled by the governments stands at approximately 48% in Europe. Therefore, government regulations as well government budgets have direct and indirect impacts on employment. Governments in Europe traditionally assume a high level of responsibility for education, training and scientific progress, which are major inputs into the process of research and technological development and into the implementation of product and process innovations in private enterprises.

However, little is known about the empirical relationship between technology, technological innovation, human capital, market forces and the employment impact in a market economy. Without a detailed empirical knowledge of how the economy works and about the links between innovation and job creation, targeted policy action is not possible. This study aims at shedding empirical light on these links und helping to optimize government policies.

How can the governments and the Commission fulfill their role in creating the best possible employment situation? Do traditional policies have to be changed? Is it necessary to think about new priorities and how labour market policies can best be integrated in research and development programs? Answers have to be found for the national policies of the 15 member states and for the Commission as well.

This study concentrates on the economic impact of innovation on employment. It presents an overview of what economists think about the relationship between technological change and employment and what they empirically have found about this relationship. In a second step, the impact of innovation on employment is investigated for eight member states, building on a unique dataset: the Community Innovation Survey (CIS). The CIS was created in order to give the Commission a strong analytical tool for improving policy measures. The CIS dataset was compiled in 1993 and was supplied for the current study by EUROSTAT. Furthermore, to obtain insights into the dynamic nature of the relationship between innovation and employment, the study uses firm-level, panel data for the manufacturing sector of Germany covering the time period from 1993 to 1995 and for the manufacturing and service sector of the Netherlands covering the period from 1988 to 1992.

Strategies to fight unemployment

The study suggest four strategies to fight high unemployment in Europe:

- Innovations, in the form of improved processes, improved or totally new products, are one important key to more employment in the short and long run.
- The second key is improved competition in the product and labour market.
- Promotion of growth through the promotion of investment and enhanced macroeconomic demand is the third key.
- The fourth key involves strengthening the labour supply by education and training and improving the functioning of the labour market institution.

The four strategies are, in fact, interdependent. To give just one example: if firms sucessfully introduce new products and demand for these new products rises, investment will also rise and thereby stimulate growth. The process of creating new markets and raising the productivity of technology will have a larger positive impact on employment, if workers have the necessary skills. The Schumpeterian process of creative destruction will be less harmful to employment, if the burden of the adjustment processes in the market economy, stemming from competition and technological innovation, is better equilibrated between workers, labour time, and workers' and capital compensation. The interaction between technology, technological change, markets, institutions and individual behaviour has to be optimized in order to put more people to work. This is the real challenge for politicians, unions and employers.

From a practical point of view, the strategies are interrelated and cannot be assessed separately. From a policy point of view, it is important to know which strategies help each other in raising employment, and which are neutral or even detrimental to that goal. Furthermore, in the age of globalisation and information, innovation from abroad is a challenge for the national economies, if trade leads to substitution through superior foreign goods or processes. Globalisation increases competition, but also the possibility of cooperation between different social and economic systems. Europe, with its long tradition in science and technology and its cultural history, should take a **leading, active and open attitude towards worldwide market**.

The promotion of innovation by the Commission and the member states may result in a higher competition between firms in some product markets, since new or improved products may be superior in relation to older ones. If the degree of substitution is high, it is likely that there will be no net employment gain from innovation at the firm or the industry level. Firms producing old products or using poor technology will disappear from the market. New firms with new products or improved technology will take their place. It is important to recognize that **product innovations do not automatically ensure more employment**. Whether there is a net gain in employment depends on the nature of the new products and overall demand. If **new products are complementary to old ones, the net impact is likely to be positive**. In addition, if new products generate new income, then this new income will induce positive demand effects in the aggregate economy as well, thereby, increasing employment.

A similar line of arguments hold for process innovation. If firms improve their productivity, they are able to produce the same amount of goods at lower costs, that is, with less input factors. Firms then are able to reduce output prices and sell more of their products, which in turn has a positive effect on factor demand. Moreover, lower prices will enable downstream firms to lower costs and prices, so that there can be additional positive employment effects. If lower production costs induce a higher output level at the innovative company, upstream supplier will increase their business, enhancing employment. Whether there is a net gain in employment depends on the rise in demand and the reaction of competitors. In any case, firms who are not able to keep pace with technological progress will disappear from the market, in turn, impacting both upstream and downstream firms. This arguments imply that **process innovation can have positive employment effects** as well as product innovations at the micro as well as at the macro level.

Product and process innovations are crucial elements in the dynamics of market economies. Innovation continually generates, destroys and reallocates jobs. **Competition, in the product, labour and capital markets is therefore, a necessary, though not sufficient precondition for innovation to have a positive impact on employment.**

In some European countries, wages are nearly inflexible downwards and -- seen from an international perspective -- wage and, more importantly, non-wage labour costs are relatively high. Unions and employers are responsible for wages, while governments are responsible for non-wage labour costs. New products and new firms producing new products are only introduced if the high labour costs, including social transfers, can be paid. Therefore, labour intensive production methods, especially in personal services, exibit weak growth in many of Europe's economies.

Labour-saving, process innovations are rather attractive for economizing on the cost of labour. In times of labour shortage or high wages, technological change is directed at automatisation and rationalization. This process is skill-biassed. It **favours high-skilled over low-skilled**

labour since more complex technologies need more highly skilled and often scientifically educated labour. This process is part of the strength of the European manufacturing sector and is nessesary to survive in the age of globalisation. The traditional manufacturing sectors will remain a domain of high wages and high productivity. **It is unlikely that the jobs lost in the past decades will ever return**.

The seminal shift of labour demand in favour of high-skilled workers and high-quality jobs is fostered by information and communication technologies. This process is not restricted to manufacturing. It is even more prevalent in the service sector, especially in banking and insurance, where further productivity jumps through information technologies can be expected to take place.

Educational policy will become more important in the future than they were in the past. **On-the-job training and life-long, continuous learning are necessary precondition for increasing the ability of workers to master economic change**. Off-the-job training seems to be less effective than on-the-job-training. Therefore, bringing the unemployed as well as the young people back to work is critical. In times of high unemployment among the low skilled as well as young, inexperienced people, it is necessary to expand markets and industries with more labour intensive production.

Adequate wage policy would be a necessary complement for an employment-enhancing innovation policy. Unemployment among the persons with low skills cannot be successfully reduced by innovation policies alone. Fostering innovation is necessary for international competiveness. However, it will not directly help the unskilled among the unemployed. Furthermore, intra- and interindustry shifts in labour demand can be supported by a credible government policy to lower the non-wage cost of labour. To avoid the problem of creating a working poor, flexibility in wage and non-wage labour costs in the low wage groups should be corrected by incentive compatible, social policy measures, like the negative income tax.

Furthermore, innovation policy should be directed towards those new products with a high likelihood of not acting as substitutes for existing products but of satisfying new customer needs. In addition, if new (intermediate) products will help to increase the efficiency of downstream firms, the positive employment effect in the product innovation sector must be related to the process innovative sector which uses the more efficient product to improve production technology and, hence, probably reduce employment. Although our estimates imply that promotion of product innovation would be a preferable strategy, this seems impossible to implement in practice and doubtful when seen from the broad perspective of the whole economy.

Process innovations have a negative impact on employment if turnover stays constant. However, process innovations are necessary for firms to stay or to become competitive. **Discriminating against process innovations while promoting product innovations, can, therefore, have a negative effect on the global competitiveness of Europe's enterprises in the medium and long run.** Furthermore, even in shrinking sectors, process innovation is called for to slow the otherwise more rapid output and, hence, employment decline.

Globalisation hits Europe's large enterprises harder than SME operating in market niches or local markets. Therefore, large firms are forced to make large efforts in rationalisation. They, furthermore, globalise their production activities to become more competitive in the world market, to profit from international differences in labour costs and to realize gains by being nearer to their markets. Process innovation, therefore, seems to be an important tool for improving Europe's advantage as an industrial production location.

Given the large labour costs differences across Europe, intra-European shifts of production facilities will be persistent in the future. Although this regional reallocation of labour within Europe will hurt the countries from which production is moving out, reallocation is efficient from an European point of view. Additional demand created in the 'new home' country of the production facility will also help to increase aggregate European demand.

Increasing the flexibility in the labour market will be a complementary strategy for the creation of new jobs because it encourages the intra- and intersectoral shifts of employment caused by innovation as well as the interregional employment shifts. **Lowering effective costs for firms will foster labour demand for the unskilled, most likey in the service sector.** In addition, flexibility in the labour market can be enhance by putting more weight on education and training, especially for the young generation and for the young unskilled. Government expenditures on human capital formation and the conservation and rebuilding of human capital should be regarded as a long run strategy and as an investment in the future. The quality of vocational training has to be enhanced and the training curriculi should be improved to master technological and economic change. To build a broad foundation of human capital, professional, vocational training for medium skilled jobs in all areas of the economy, and in the information and communication technologies in particular, should be enhanced in Europe.

To get more employment through innovation in Europe, **the complicated net of regulation in its economies has to be either simplified or managed more efficiently by governments**. In

1997, the European Union had 15 members, with the eastward enlargement on the political agenda. Critics are right in pointing to the fact that the analysis of 1993 data is only of historical value. The crucial question, however, is whether there are regularities in the complex economic system which are still valid today. It is the task of empirical economics to find such regularities. While it is true that some parameters of the economic system clearly have changed since 1993, it is not as obvious that the structure of the economies, the complex system of thousands and millions of relationships, formal and informal rules and patterns governing individual, firm and government behaviour, have changed that much in four years. The CIS data are necessary to uncover such regularities connected to innovation processes at the firm level. In future surveys, it is appropriate to cover the service sector, which was the most dynamic in the economy during the last decade..

The study furthermore concentrates on direct impacts of innovation on employment on the micro level. Indirect impacts on the micro or macro level, which often occur with a lag, and long run impacts have not investigated. In this sense, the study should be viewed as a starting point, not as the final result of a research program. The role of fiscal and monetary policies, which are responsible for macroeconomic development, for stability and, therefore, for employment, are not addressed. Likewise, the effect of regulation on innovation is not covered by our approach, but is surely of a crucial importance for stimulating growth in Europe's economies. Macroeconomic framework conditions and regulation are important for the labour market, since they play a major role in firms' investment decision and exchange rates.

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Content

1 Introduction

Technological progress in western economies has contributed to an immense rise in productivity, goods and income over the last hundred years. Though not to the same extent as productivity and wages, population and employment have risen as well. In this perspective employment has not fallen. Nevertheless, innovations are often blamed for job destruction and unemployment with workers historically fighting against technological progress. Since the short and long term impacts of innovation can be different this does not necessarily mean a contradiction- negative and positive employment effects occur in various industries at various levels of skill.

The impact of innovation on employment today is not as clearcut as it used to be in times of the first factory or the first railroad. The pace of technological progress in an open world economy has accelerated compared to former times, resulting in a greater number of product and process innovations as well as processes related to these product and process innovations. The evolutionary nature of a dynamic, growing market economy results in the perpetual birth and death of firms and the perpetual creation and destruction of jobs -all within a single industry all at the same time.

Hence, it is difficult to identify the sources of job destruction. Apart from the theoretical possibility of technological progress destroying jobs (which will be discussed in detail later on) other explanatory possibilities are found easily. Just to give a few examples: job losses as a consequence of erroneous management decision, of omitted organisational change, of rigidities in the labour market or of imperfections in the credit market leading to a lack of investment in new machinery and products. This points to a rather complex social and economic mechanism responsible for job loss. But technological progress seems to be the most conspicuous to the public eye.

Technology plays an important role for sustainable economic growth as emphasized by the EC Commission in the White Paper (1993, p.4). Regarding the employment consequences of technological change the Commission takes an optimistic stance. According to the Commission on average technological change will create more jobs than it will destroy. Even though process innovation in manufacturing and work organisation is said to destroy jobs, through the creation of new needs and products more new jobs will be provided.

Although this point of view is supported by some economists (e.g. Katsoulacos, 1986) it lies in contrast with the results and opinions of many others. It is perceivable that process innovation may create rather than destroy more jobs. As Stoneman (1983, p. 181) puts it: „the analysis and conclusions [regarding the effects of product innovations, the authors] should not be dramatically different from the process innovation cases studied above."

One reason why product innovations may not lead to additional employment is that the creation of new needs and products might merely be substitutes for old ones. Successful innovators might increase their market share and employment at the expense of non-innovators. As A. J. Schumpeter noted at the beginning of the century, technological progress creates disequilibrium in the product and labour market. The real challenge for the political as well as the scientific community seems to lie in the question of how much disequilibrium the labour market can digest in the short-run and, more importantly, how an optimal degree of technological progress can be achieved.

The scope of the study is narrower concerning the investigation of the relationship between innovation and employment. Deeper empirical understanding seems to be a necessary precondition for a more effective policy in the face of world wide growing technological knowledge. The aim of our survey is to elabourate on the main channels through which technological change may influence employment. Although the main focus shall be on the level of firms, for theoretical reasons we will also consider the impacts on industry and economy. Due to the heterogeneity of firms, it is sometimes easier to predict the impact of technological change at the level of industry or even at the level of economy.

The results of theoretical models crucially depend on the assumptions made with regard to the behaviour of the agents (firms, administration and individuals), the nature of technological progress, the state of the economy, the time horizon considered and the institutional and legal framework. The presentation is restricted to what we consider to be the most important aspects of theoretical and empirical literature. The discussion is non-technical and intuitive. Nonetheless, the discussion will not always be straightforward since the impact of innovation and employment is a complex but fascinating area of economic research.

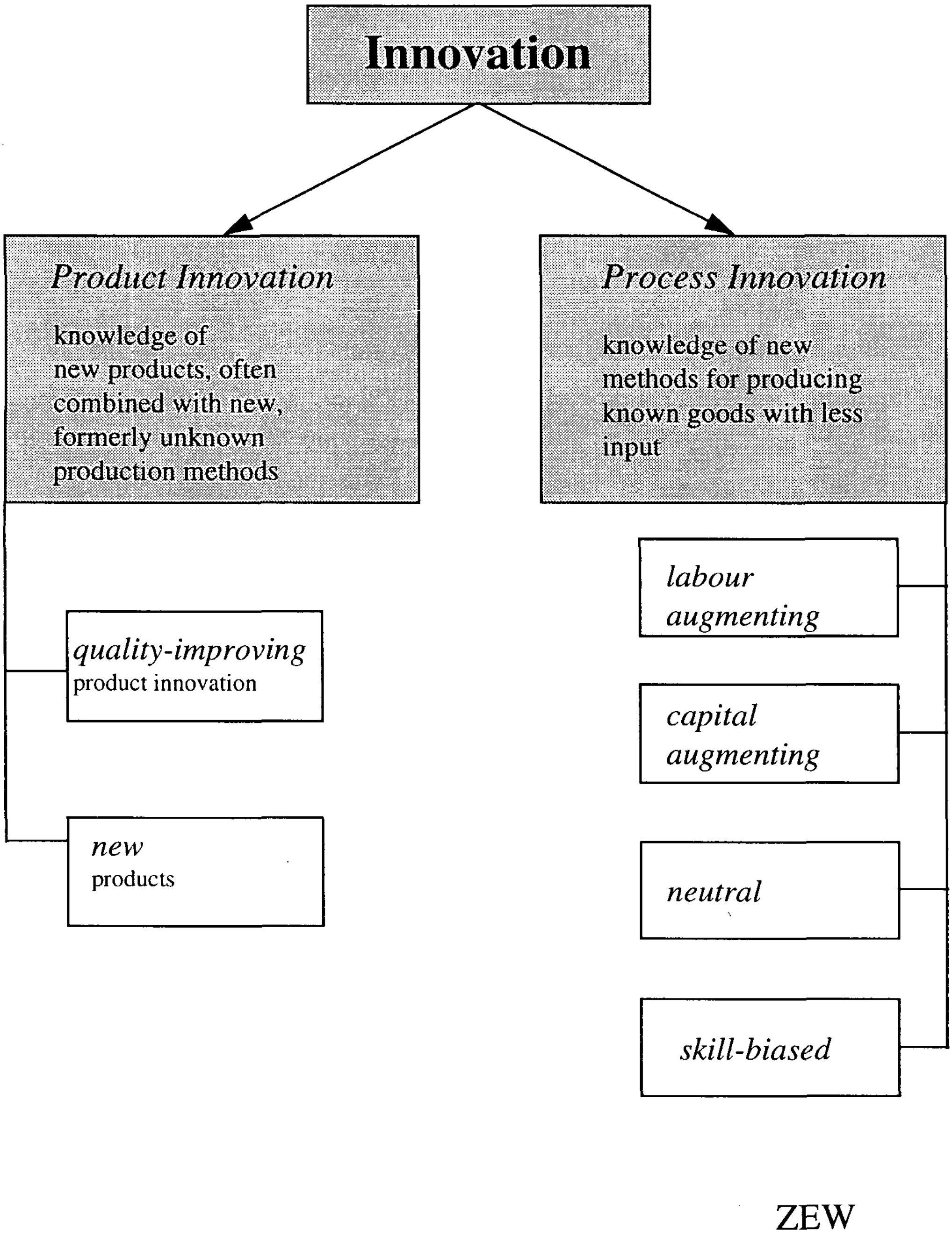
2 Survey Of Theoretical Literature On Innovation And Employment

2.1 Key Concepts And Definitions

In the theoretical part, we make use of the following definitions (Stoneman, 1983, Tirole, 1989, see Figure 1):

- *Innovation* is viewed as a change in the information set of the relationship between inputs and outputs. *Process innovations* are said to take place when a given amount of output can be produced with less input. *Product innovations* relate to possibilities found to produce new goods. From the definition it is clear that product innovations in machinery in one firm will often constitute process innovations in another firm. Innovation is different from *invention,* which is an idea or a model for a new improved product or process. In the economic sense this basic idea enters the phase of an innovation when the improved product or process is first sold in the market.
- A distinction is made between *radical* (or *major*) and *incremental* process innovation. If the cost reductions made possible by an innovation are such that the innovating firm can set a monopoly price and nevertheless take hold of the entire market share, then the innovation is called drastic. Remember that monopoly prices are above competitive level. Otherwise innovations are said to be incremental.
- Product innovations can be divided into *quality improvements* of existing goods and *new goods*. While quality improvements are often incremental in nature, new goods are more of the radical innovation type.
- Technological progress can be divided into the labour augmenting and the capital augmenting type depending on whether the amount of labour or capital can be reduced in the production of a given level of output (some writers therefore refer to it as the labour or capital *saving* type of progress). It is common to distinguish between a purely labour augmenting, a capital and a *neutral* technological change. If the reduction in one factor is greater than in the other factor, technological change is said to be biased. The most famous bias is the so-called *skill-bias* which indicates that during recent technological progress skilled labour demand has risen while unskilled labour demand has fallen.

Figure 1 The Nature of Technological Progress: Some Key Concepts



- *Employment* consists of two components: workers and hours, i.e. the number of persons working and the amount of hours these persons work. Employment relates to the active labour force engaged in production including workers as well as the self-employed.
- While the important question in this survey consists of the impact of innovation on employment, a related question deals with the consequences for labour market, especially on the subject of unemployment. If innovations destroy jobs and unemployment rises, this is called *technological unemployment.* Depending on the structure and functioning of the labour market, the employment impacts of innovation are more distinct than the concept of technological unemployment. If labour and product markets were perfect in the textbook sense, then unemployment would be of no problem at all.

When taking the economy as a whole, the pace of technological progress is dependent on market structure, human resources and functioning of the labour market. The firm's decision to innovate depends on, among other things, expected factor costs and expected market demand. If wages are expected to be relatively high in the future due to the scarcity of human capital or other reasons, the flow of R&D-resources in a market economy may be directed to capital augmenting technological progress (induced innovations, cf. von Weizsäcker, 1966). On the other hand, innovations in one industry might lead to a rise in labour demand, thus pushing up wages in innovative sectors or even in non-innovative parts of the economy (Cohen and Saint-Paul, 1994).

The repercussion effects due to the interdependence of the labour and goods market as well as the market for knowledge cannot be taken into account entirely in the present survey of theoretical literature. Capital market imperfections will not be analysed either, although they might be important for explaining omitted investment in new equipment. We will neglect what one might call the third factor of production: the behaviour of management and the organisation of business in the market economy. According to Chandler (1990), organisation mattered historically to fully capture the scale and scope opened up by the technological innovations of the second industrial revolution. The enterprises in Germany, Great Britain and the US that were the „first to make the essential, interrelated, three ponged investment in production, distribution, and management remained the leaders from the 1880s to the 1940s" (p. 91).

An important issue for Chandler when discussing the dynamics of industrial capitalism is that innovation per se had no influence on the pace of development very much in constrast to investments in new processes and products. It was this very investment (not innovation per se) that improved productivity and transformed the structure of industries. Neither repercussion effects, nor imperfect credit markets nor organisational structures will be investigated here in greater detail due to the fact that it would make our survey too complex. Because these factors are important for explaining employment in Europe during the third industrial revolution, their impact will be considered in our survey of empirical literature (see part 3).

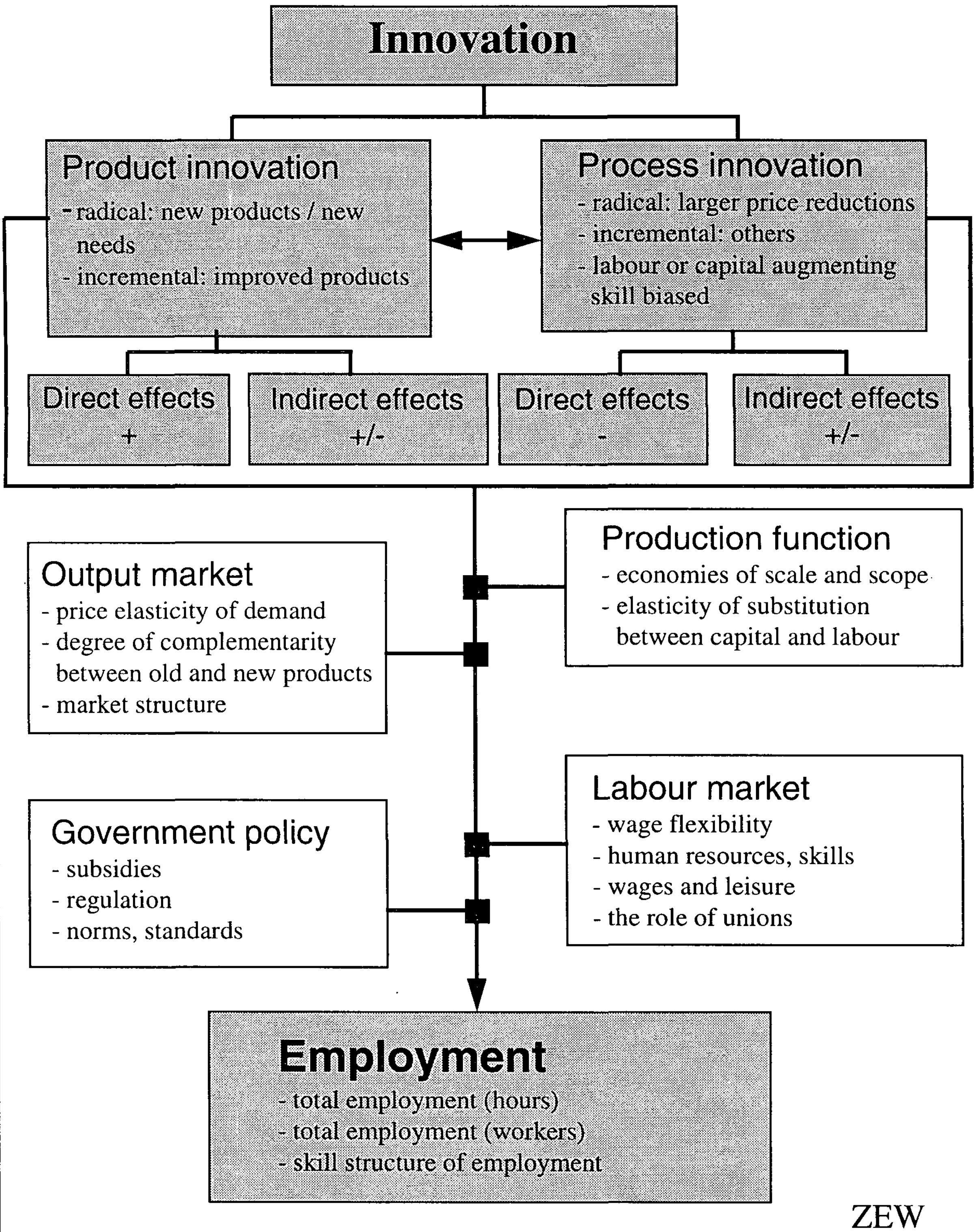
The most important economic issues responsible for the impact of innovation on employment can be summarized as follows (cf. Figure 2):

1. **The nature of current technology**. The technological elasticity of substitution measures the substitutability between two inputs, e.g. between capital and labour (the measure shows the necessary percentage change in capital, where labour is reduced by one percent while the output is kept constant). Economies of scale measure the relationship between input and output. Economies of scope measure the advantage of joint production of outputs.
2. **The nature, direction and degree of technological progress** (product vs. process innovation; radical vs. incremental technological changes; the direction of technological change called the technological bias, that is whether capital or labour is saved; the degree of technological progress: marginal improvements or technological breakthrough governing potential cost reduction). Technological progress might be induced by government regulations (e.g. policies designed to reduce air pollution).
3. **The current and expected preferences of the consumer** (the amount and dynamics of aggregate demand, that is the current and expected size of the market; the price elasticity of demand for output: this measure shows the percentage change in output, where price is reduced by one percent; the income elasticity of demand shows the percentage change in demand, where income is reduced by one percent; the degree of complementarity in the demand of new and existing products).
4. **The structure of product markets** (degree of competition, existence of entry barriers).
5. **The structure of labour markets** (flexibility of wages and the role of unions; preferences for workers of leisure and consumption).
6. **The skill structure of human resources** as well as the regional and occupational mobility of workers.

In the sequel we will discuss qualitative results derived from theoretically sophisticated models. The focus is on positive, negative or (on a priory reasons) ambiguous impacts of innovation on employment. If there is any impact the question is, whether it is big or small. The impact is examined at three levels: that of the firm, the industry or the economy. Furthermore, a distinction between short and long-run impacts will be made.

Figure 2 contains a compact sketch of the underlying economic structure and the hypothesized qualitative impact on employment. Process and product innovations can have a positive as well as a negative impact on employment. While the direct impact of process innovation at the level of the innovating firm is negative, there is an indirect effect resulting in a higher labour demand. With respect to product innovation the direct impact is positive, while indirect impacts might be positive or negative. Thus the overall impact is ambiguous in theory and has to be quantified empirically.

Figure 2 The impact of innovation on employment



2.2 The Impact Of Process Innovation

- Due to the productivity effect, process innovations have a negative direct impact on employment. In the case of (in-) elastic demand the indirect positive employment effect will (not) outweigh the direct negative one and employment will rise (fall). If demand is elastic, the impact will be higher in the case of radical as opposed to incremental innovation.
- Capital augmenting progress will lead to a reduction in employment where better labour can be substituted for capital in production.
- Provided that innovations have positive employment effects, these effects will be more pronounced in higher scale economies.
- The higher the degree of competition, the more likely technological progress will have a positive employment impact and the stronger the overall impact will be.
- The attitude of unions toward innovation depend on the bargaining structure. If they are organised at enterprise level, they will be less interested in fighting against innovations than unions which are organised at industry level. Moreover, the unions' attitudes toward technological progress are more likely to be negative in markets with restricted entry than in open markets.

2.2.1 Elastic And Inelastic Demand

Most of the literature on technological change analyses process innovations. After having determined the impact on employment we shall consider the role of demand in the following simple model (see Stoneman, 1983). A firm produces a good with labour as the only input. Assume that firms behave competitively in the output and labour market and that innovation is adopted without a time lag. A process innovation is of the labour augmenting type if the same amount of output can now be produced with less labour. This is called the productivity or direct effect on employment. Of course, this effect is negative when the output remains the same.

The issue as to whether firms in this situation increase or reduce jobs depends on how demand may fluctuate. Competitive behaviour implies that marginal costs (at constant wages), just like prices. If consumers react sensitively to price reductions, then demand for labour may rise due to increasing demand for goods despite of the fact that less labour is necessary for producing the same amount of output (compensation or indirect effect). The indirect effect will be larger (smaller) than the direct effect if demand is elastic (inelastic), that is if a one percent reduction in prices enhances consumers' demand by more (less) than one percent. Obviously, if demand is elastic, the rise will be higher in the case of a radical as compared to an incremental innovation. Consumers' demand reaction due to price changes will sustain its importance in much more sophisticated models.

2.2.2 Labour And Capital As Substitutes Or Complements

In the following it is assumed that firms use the two inputs labour and capital. Obviously, the impact of technological progress will depend on the technological relationship between the two inputs. A means of measuring this relationship is the elasticity of substitution between labour and capital. If this measure is zero, then the two inputs are perfect complements. This means that they cannot be substituted for producing a certain amount of output. Given the other extreme that capital and labour are perfect substitutes, then a firm can produce its goods with the input which is cheapest.

In the case of labour-augmenting technological progress (see Neary, 1981) labour is relatively more cost efficient than capital. Thus firms have an incentive to substitute labour for capital. The actual amount of substitution depends on elasticity of substitution (everything else being equal). The higher this amount, the bigger the positive impact on employment. If, on the other hand, technological progress is purely capital-augmenting, no direct effect on labour productivity is noticed. Firms have an incentive to substitute cost effective capital for labour. Employment decreases with further elasticity of substitution (Dobbs, Hill and Waterson, 1987, compare also Table 1 in the next subsection). Given that capital and labour are perfect complements, labour demand will tend to increase in line with capital.

In empirical research one should take into account that it is not possible to strictly distinguish between changes in the input output coefficients of labour or capital stemming from technological progress or mere substitution effects (Weizsäcker, 1966). Firms might have the possibility of choosing between labour-augmenting and capital-augmenting technological progress. The direction of research is closely linked to the labour or capital market situation (so-called induced technological progress). Tight labour markets in the development process lead to high wages, so R&D flows into labour-augmenting technological progress. Another possibility is that firms substitute capital for labour. On the other hand, if real interest rates grow (and real wages stay constant), firms might substitute labour for capital or they might invest in R&D which is steered to capital-augmenting progress.

2.2.3 Economies Of Scale And Economies Of Scope

The bigger the market or the bigger its expected growth, the better the possibilities for firms to fully exploit economies of scale and scope which result from technological innovation. If the current or expected market size is big relative to the optimal size of one firm, then economies of scale and scope inherent in technological progress can be exploited more easily as compared to when a low level of demand exists. One perceived advantage of the single European market is its sheer size, allowing for more intensive exploitation of economies of scale and scope especially in new technologies.

Change in output and employment due to technological progress depends on the extent of scale economies (Stoneman, 1983, Dobbs, Hill and Waterson, 1987, see also Table 1 in the next subsection). Economies of scale measure the change of output when all inputs are increased commensurately. With decreasing economies of scale, marginal production costs rise with output, whilst with increasing economies of scale marginal costs fall. In the competitive case economies of scale determine the optimal firm size. In general, the higher the degree of scale economies, the larger the firms. With constant returns to scale the optimal size is indeterminate, with increasing returns the competitive case breaks down.

If technological progress takes place, if a firm has high scale elasticities and provided the elasticity of output demand is high, then labour demand will increase. Cost reductions due to innovations will lead the firm to a stronger output than in a situation of low economies of scale. Thus in the case of elastic demand, the impact of process innovations on employment will be higher when there are higher economies of scale (see Dobbs, Hill and Waterson, 1987, who show this impact in the case of capital augmenting progress; the argument is valid for neutral or labour augmenting progress as well).

Economies of scope (cost advantages resulting from joint production) in the process of technological change have been widely ignored up to now in theoretical analyses. According to Kalmbach's (1992) informal analysis, technological progress may induce synergetic effects in joint production. The number of applications of a specific technology (e.g. application of industrial robots) and its areas of application may rise. Therefore, indirect employment effects of specific process innovations might occur in different fields of application. These indirect impacts positively depend on the amount of economies of scope.

2.2.4 Output Market Structure

The impact of process innovations on employment depends on the market structure. In the case of elastic demand (see subsection 1.3.1) theory predicts a positive impact for a competitive as well as a monopolistic firm. In both cases, the productivity effects are compensated by increases in demand (see Katsoulacos, 1986). However, in the competitive case employment changes will be higher than in the monopolistic cases. Due to monopolistic market power, cost reductions are not fully transmitted to price reductions, therefore the change in demand is less. Technological change in a monopolistic market is more likely to decrease the sector's labour demand. The importance of the price elasticity of demand lies in its relation to market structures. Closed markets (for example regional markets) tend to be of low elasticity and of monopolism, while an open market is more likely to be of high price elasticity and, by definition, of high competitiveness. Cost reductions in the latter case are more easily transmitted to price reductions and through the increase in output lead to higher labour demand. On the other hand, monopolists might reinvest the gains in new technology, thereby having expansionary impacts on employment.

Dobbs, Hill and Waterson (1987) enlarge this analysis which also takes into account oligopolistic market structures. They concentrate on capital augmenting technological progress, because „such innovations are far more likely to be biased against employment creation" (p. 552). The intuitive reason lying behind this argument is that it may be more cost effective to invest in the factor having improved technically, that is capital, and, consequently, to reduce the other input: labour. The main results are valid true in a qualitative sense for the case of neutral or labour augmenting progresses.

In table 1 we present a comparison of employment effects in the case of both competitive and oligopolistic markets. The role of demand, substitutability of labour and capital as well as economies of scale are highlighted. In addition, the authors compare short-run and long-run impacts of introductions of new techniques. The qualitative impact of innovation on employment is comparable as far as the role of demand and the elasticity of substitution between capital and labour are concerned. These results have already been discussed above.

Table 1 Qualitative impact of capital augmenting progress on labour demand

		Competition		Oligopoly	
		no entry (short-run)	free entry (long-run)	no entry (short-run)	free entry (long-run)
elastic demand		+	+	+	+
inelastic demand		-	-	-	-
substitutability between	low	+	+	+	- / +
capital and labour	high	-	-	-	-
economies of scale with	inelastic demand	-	-	- / +	- / +
	elastic demand	+	+	- / +	- / +

Source: Dobbs, Hill and Waterson (1987)

The main difference between competitive and oligopolistic markets is most remarkable when considering variations in scale economies. In this case, oligopolistic behaviour is less predictable, and its impact on employment depends on the structural parameters of the models. In oligopolies the impact again depends on the price elasticity of demand, but the overall impact of innovation with differing scale economics is not clear-cut. Little research has been done for the case of increasing returns to scale. Dobbs, Hill and Waterson (1987) suggest (without formal analysis) that in a world with only a few firms with increasing returns to scale and elastic demand at industry level, capital augmenting technological progress will lead to a large proportionate increase in the demand for labour. Dobbs, Hill and Waterson (1987) pay further attention to the time path of the introduction of capital augmenting technological progress. In the short-run, the number of firms is fixed whereas in the long-run entry is free. Given free entry and exit, new firms may enter the market or incumbents may leave the market after the introduction of some innovation. In the competitive case, if there are constant returns to scale, the short-run and long-run impact of technological progress will be the same.

In the case of decreasing returns to scale, the change in competitive firms' labour demand (measured as a percentage to the actual level of labour demand) will be stronger in the short-run than in the long-run (see Table 2). The reason is that firms will react as fast as possible in order to reach new optimal firm size. An oligopolistic industry is most likely to react (this depending on the demand structure in a rather complex manner) the other way round: the long-run reaction is stronger than the short-run reaction (when there are diseconomies of scale). Intuitively, this results from a lower degree of competition in an oligopoly with a fixed number of firms. Provided entry is allowed in the long-run, oligopolistic behaviour becomes competitive. Nevertheless, the market results are different. It is most likely that under oligopolistic competition labour demand will increase to a lower degree than if it had been under perfect competition and it will also more often decrease.

Table 2 A comparison of short and long-run impacts of innovation

Competition	Oligopoly
short-run > long-run	long-run > short-run

Source: Dobbs, Hill and Waterson (1987).

2.2.5 Wages And Work Hours

Up to now, the reaction of wages has been neglected. Firms' labour demand depends on real wages which might change as a consequence of technological progress. This issue is taken up in part by Sinclair (1981) and Ott and Wied-Nebbeling (1992), who show that the employment consequences depend on the assumed reaction of real wages. There are theoretical and empirical reasons explaining the fact that wages are not flexible downwards. It may result from union behaviour (see the next subsection) or for efficiency wages reasons. Sinclair compares fixed real wages with fixed money wages. The conditions for an increase in labour demand are as follows (see Table 3).

Given fixed real wages, employment will always rise, unless technological change is purely labour-augmenting. In this case the employment consequences depend on the relative magnitudes of the elasticity of substitution and the firms' profit share. If the firms' profit share is lower than the elasticity of substitution, then it is profitable to substitute labour for capital, and labour demand is more likely to increase. Given fixed nominal wages, the impact on employment depends furthermore on the price elasticity of demand. In this case only a high price elasticity of demand leads to an increase in labour demand. Technological progress leads to a price reduction, while this in turn means that real wages rise and labour demand is reduced. This reduction can only be compensated by higher demand. Rising real wages can furthermore be a consequence of higher labour demand in the process of technological change (Cohen and Saint-Paul, 1994).

Table 3 Positive employment impacts with fixed real and fixed money wage rate

	labour augmenting progr.	capital augmenting progr.	neutral progress
real wage rate fixed	elasticity of substitution > profit share	always +	always +
money wage rate fixed	elasticity of substitution > profit share and high price elasticity of demand	price elasticity of demand > elasticity of substitution	high price elasticity of demand

Source: Sinclair (1981)

Sinclair (1981) introduces hours of work in order to further investigate labour demand and unemployment due to technological progress. The author assumes that a rise in the real wage rate leads the workers to a reduction in their desired amount of work hours. In the case of fixed real wages hours of work remain the same. Thus, unemployment rises as employment will be reduced due to innovation. If nominal wages are fixed, real wages will rise due to a decrease in prices. Workers reduce their hours of work. Hence, the decrease in employment is not as large as before. However, the result depends on the questionable assumption whether hours do fall with real wages.

2.2.6 Sector Specific vs. Industry Wide Innovations And Demand Complementarities

In a world with different sectors or goods the impact of innovation on employment will depend on the structure of demand and on whether innovation is sector specific or industry wide, respectively. As the following simple reasoning shows, let an industry wide technological change lead to a same amount cost and hence price reduction in all sectors. If demand for the different products rises so as to keep the shares identical, then total labour demand will be unaffected by technological progress (Katsoulacos, 1986). For the result to hold, total income in the economy has to stay constant.

The more complementary various products are in the view of the consumer the more likely the impact of sector-specific innovation on overall employment will be positive, (see Cohen and Saint-Paul, 1994). Since demand for the innovating firm rises due to reduced prices, the overall employment impact will depend on the demand for other goods. If it rises, that is if goods are complements, then demand of the non-innovating firms will rise as well.

2.2.7 Unions And Bargaining

Bargaining Structure

Strongly unionized labour markets are sometimes blamed for Europe's delay of innovativeness compared with the US or Japan. Unions try to hinder new technologies with a negative impact on employment. This in turns reduces firms' incentive to invest in R&D. However, since there are many reasonable circumstances leading to a rise in employment and/or wages due to technological progress, unions' overall attitudes to technological progress are not as clear cut as this argument suggests. Rational unions will anticipate firms' investment reactions and take into account the indirect effect on employment stemming from too little investment in R&D in the future (Ramser,1992). The organisation of unions is important because due to technological progress some sectors or firms lose, while at the same time others gain. In this context it is not surprising that empirical studies show positive, zero or negative impacts of union power on productivity and employment (see e.g. Pencavel, 1991 and Ulph and Ulph, 1994).

Given that firms and unions bargain, then the type of bargaining, the relative power of unions and the objectives of unions will all have an influence on the impact of innovations on employment (Grout, 1984 and esp. Pencavel, 1991). There are several interesting results in the literature. Ulph and Ulph (1988) find that the greater the productivity in the firm that already is the least productive, the larger the employment reduction will be, meaning that unions lose in the process of technological change. In other words, if productivity is already high, the increase in demand following the cost/price reduction due to technological progress will tend be relatively small. The indirect effect of a rise in labour demand due to an expansion in output is more than offset by the direct effect of labour saving technological progress. If in addition unions can bargain over the time of introduction of new technology in the situation described above, strong unions will prevent the new technology in every industry. If unions are weak, firms will immediately adopt the process innovation. Therefore, unions might have some incentives to block innovation. However, the results depend on the structure of bargaining, on the structure of the market and on how much weight unions put on employment and wages.

The Degree of Competition

Ulph and Ulph (1994) argue that in a tournament model (where only the first firm whose R&D effort is successful can reap the full profit of R&D) the possible enhancement of market shares as a result of effective R&D expenditures can lead to cases where a strong union will even help the firm to innovate first (that is to win the patent race or the tournament). The labour markets of the two firms are interrelated through oligopolistic output markets, with unions operating on a firm level. When unions and firms bargain over wages and when firms put bargaining before employment (this is called the „right-to-manage" model) then „the more unions care on employment, the less effect they have on the outcomes of the innovation process" (p. 208). The firm will never win a tournament which it would have lost as in the case of a perfect competitive labour market. When bargaining is put before wages and employment (efficient bargaining), a strong union might even help the firm to win the tournament. Therefore the firm might be better off with a strong rather than a weak union. The reason is that unions take into account the enhancement of profits due to the higher market share if their firm wins the tournament.

Enterprise versus Industry Wide Union

Dowrick and Spencer (1994) have investigated the difference between an industry wide union and an enterprise related union regarding labour saving progress. Their argument is that the structure of unions and the relative weight unions place on wages and employment is of more concern than mere union strength. Furthermore, the effects of unions depend on industry structure. Table 4 is a slightly modified version of table 1 in Dowrick and Spencer (1994, p. 319) and shows a detailed set of results. It is not surprising that employment will decrease as a consequence of labour saving technological progress if wages are determined exogenously and labour demand does not react to change in wages. The effect on unions depends on their preferences. If employment is important for them, they will lose, if wages are important they might win. A rise in wages cannot be assured in technological progress. Therefore in the table the entry is „?yes", that is a yes with a question mark.

Table 4 Will unions gain from labour-saving innovation?

	Exogenous Wages	Single Union with Bargaining	Multiple Unions with Bargaining
Union preferences			
Weighted to wages	no effect	? yes	? yes
Rent maximization	no effect	? yes	? yes
Weighted to jobs	no effect	? no	? no - less likely
Labour demand			
Elastic	yes	yes	...
Inelastic	no	?no	...
Union organisation			
Enterprise	more likely	...	...
Industry	less likely	...	...
Craft	less likely	...	...
Industry structure			
Monopolistic	less likely	...	...
Competitive	more likely	...	...

Source: Dowrick and Spencer (1994)
?no or ?yes means that the conditions are necessary but not sufficient.

Unions will gain from innovation the higher the elasticity of the firms or the higher the industry labour demand. A single innovative firm might expand its market share at the cost of non-innovative firms, and as a result labour demand will rise. In this case enterprise unions will gain from innovation. If other unions in the same industry also bargain over wages, the gains will be lower (this is the case of multiple unions in Table 4). Other firms can react by cost reduction through lower wage bargains, thereby reducing the competitive advantage of the innovative firm. Industry labour demand is more inelastic, because the gains of one firm can be the losses of the others. Therefore, an industry union will maintain a rather negative attitude towards labour saving innovation.

The last important determinant of unions' attitudes towards innovation discussed here is the market structure in the output market. In a competitive market with many firms labour demand is more elastic than in a monopolistic industry with one or just a few firms. Therefore opposition to innovation is most likely to occur where industry- or craft-based unions operate within a monopolistic industry, while it is less likely to occur where enterprise unions operate within more competitive industrial structures.

2.3 The Impact Of Product Innovation

- By their very definition successful product innovations have direct positive employment impacts. Indirect negative impacts result from substitution effects for already existing goods, e.g. in the case of quality-improved products.
- The net employment impact is more likely to be positive if not only new products but also new needs (complementary needs) are created.
- In multiproduct firms the positive impact might be smaller in the presence of considerable economies of scope.
- Process innovation can be a precondition for creating markets for new products.

2.3.1 Overall Demand And The Preference For Leisure

The successful introduction of new products creates employment opportunities. The question is whether new products serve as substitutes for existing ones or whether they lead to an enhancement of economy-wide demand. If new products simply act as substitutes for existing ones, there will be positive employment effects only, provided product quality is higher than before and product quality is labour intensive (Katsoulacos, 1986). However, the impact might as well be negative as when new products are to be produced with a better and cheaper technique.

If new products simply act as substitutes for existing ones, saturation effects might even lead to economic stagnation if overall demand is not commensurate to income. „If there were only the same unchanged products available, people would tend to reduce their purchases more and more as they gradually reach satiation" (Frey, 1969, p. 29). If this is true, the creation of new needs might be a condition for continuing economic growth and employment. Whether new needs enhance overall demand depends on people's preferences with respect to leisure and these new needs (Katsoulacos, 1986, 1991). To produce the new products people have to work more or more people have to work. So the (empirical) question which has been stated by Stoneman (1986) is whether people want to give up leisure for the satisfaction of additional needs.

2.3.2 Complementarities In Demand

The relative magnitudes of direct positive and indirect negative or positive effects determine the net employment impact of new products. If new products are complements to existing ones, product innovation may create jobs in the innovating firm as well as in the firms which produce the complements (positive indirect effect). If new products are substitutes for existing ones, the indirect employment effects in other firms or industries is likely to be negative. The net employment effect therefore depends on the degree of complementarity between existing and new products. This argument rests, of course, on a partial analysis. The actual impact will depend, among others, on the reaction of the labour market (see e.g. Cohen and Saint-Paul, 1994). An increase in demand in the innovative firms will increase their labour demand with the likely consequence of rising wages. This rise in labour cost will weaken positive employment effects.

The impact of product innovation on employment has not received the same attention as the impact of process innovation in theoretical literature. Among the more important questions which have not been addressed up to now, the role of economies of scope should be mentioned. The incentives to engage in product-related R&D will depend on the group of products already produced by the firm. If cost advantages due to joint production are important, then the employment impact especially in big and diversified firms might not be as large as in small ones.

The demand for new products depends, inter alia, on their price and hence on their production costs. High production costs can prevent the creation of new markets. In this sense process innovation can be seen as a precondition for the creation of new markets.

2.4 Skills And New Technology

- Technological progress may be biased against low-skilled labour. Given a complementarity between new technology and skilled labour, the demand for skilled labour can rise, while the demand for unskilled labour might fall.
- In a free market economy qualification and training may be too low if returns of general training cannot fully be internalized by firms. This can be an economy wide obstacle to innovation.

Already 30 years ago Solow (1964) argued that owing to technological progress much of the rising unemployment in the western industrialized world was caused by a relative in opportunities for the unskilled group of workers. This important issue has gained a lot of attention since, though mainly in empirical work (discussed in Chapter 3). A formal model is to the best of our knowledge not available in the literature. However, the impact of innovation on skilled and unskilled labour can be analysed in the framework presented in chapter 1.3. The impact will depend on the degree of substitution between skilled and unskilled workers, on the degree of substitution between the two types of labour and capital, and on the type of technological progress.

The most important result of empirical work (for details see Chapter 3) is that the firms' demand for unskilled labour has declined in industrialized countries as a consequence of technological progress, while the demand for skilled labour has risen. In this context Leoni (1992) suggests that technological change may have a different impact on male and female employment. If technological change is skill-biased, a continuous adjustment in training is necessary, which will not be so easy for married women with children.

Modern economists are concerned with the related question as to whether „society invests the correct amount of resources in the accumulation of skills" (Acemoglu (1994)). He analyses an economy where process-innovations can only be implemented at firm level when workers have the right set of skills. When there is underinvestment in human capital, investment in new technologies in turn will be too low. If there is an insufficient number of skilled workers, innovation will not be profitable at firm level. Alternatively, the higher the expected future skill level, the more firms will invest in the adoption of new technology.
The results of Acemoglu (1994) depend on three assumptions:

- there is a basic complementarity between new technology and skill level of workforce
- training creates general, not firm-specific skills which are transferable from one firm to another
- there are labour market imperfections stemming from e.g. union behaviour

Acemoglu (1994) shows, that the firms' investment in the skills of their workforce could be too low, the investment in new technologies becoming too small in relation to the socially efficient amount as a consequence. One underlying reason is the positive externality resulting from the firms' investment in general human capital. The firms' investment in human capital is too low, because the returns of this investment can flow to other firms who themselves did not invest in training. Alternatively, the more firms innovate, the more workers and firms are prepared to invest in skill improvement (this is called a *thick market effect* by Acemoglu, 1994, p. 4). The complementarity between human skills and innovation and the externalities resulting from skill improvement will cause an underinvestment in human capital, which in turn will hinder innovation. In this model, innovation and employment will rise with the benefits of new technology and they will decline with training and installation cost, the amount of positive externalities as well as the interest rate (see Table 5).

Table 5 Positive and negative factors influencing process innovation and employment

Factor	Impact
Training costs of workers (general skills)	-
Costs of technology installation	-
Benefits from new technology	+
Discount rate, interest rate	-

Source: Acemoglu (1994).

2.5 Diffusion and Employment

- During the diffusion phase employment may fall or rise, even if, in the long-run, the employment level is not affected. In the case of information imperfections employment falls, in the case of complementarities in demand employment rises.
- If the country under consideration is the technological leader and the other countries do not adopt, then a fast diffusion of technology does not necessarily point toward higher employment. The impact on employment crucially depends on price elasticity of demand.
- The early introduction of successful innovation can lead to a long lasting technological leadership and a high positive employment impact, this being further reinforced if learning is of importance.

2.5.1 Uneven Technological Progress and Imperfect Competition

Employment consequences of new techniques depend on the speed of diffusion. The speed of diffusion is determined by adjustment costs and other market imperfections like information deficits in the firm. Theoretical analysis has shown that innovation in one firm or in the whole industry may affect labour demand with no respect to adjustment costs and other market imperfections. In the following, attention is paid to some results concerning the diffusion pattern. We shall take a look at imperfect information about new production processes and uneven technological change, whereby process innovations are introduced in one sector first and then in the other with a time lag.

Imperfect Information and Technological Leadership

If all firms do not adopt a new technique simultaneously, a reduction in employment in transition to the new long-run equilibrium may be the consequence (Katsoulacos, 1991). Some reduction may occur even if overall employment rises in the long-run. In the model of Katsoulacos (1991) technological leaders introduce a new technique. Since the information of new technological possibilities spreads only gradually in the economy, imitation takes time so imitators follow with a time lag. In the transition period, that is before all firms have adopted the new technique, employment might decrease. The reason is that at the beginning of diffusion the demand shifts towards the firm(s) with the superior technique and lower prices. As the technological leader produces less intensive labour in this model, overall employment will be lower shortly after the introduction of the new technique, although the technological leader has higher employment. The realisation of technological progress might have similar short-run impacts on employment (see Katsoulacos, 1986). If firms have to invest in machine construction, they require additional workers in the construction phase. This increase in the amount of labour for producing new capital good represents higher costs and hence firms may reduce their capacity in actual production, which leads to a fall in employment in the transition period.

According to Stoneman (1987), the interaction of the direct negative and indirect positive effects in the diffusion phase determines the path of employment, a path which need not be as clear cut as indicated above. If the new technology diffuses over time, the net employment impact in every time interval observed will depend on the relative magnitudes of the negative direct and positive indirect impact. The expansion effect presents higher industrial output from the firms adopting new technology as they profit from a decrease in production costs and hence prices. As a consquence, their labour demand will increase. On the other hand, output and employment of non-adopting firms fall as diffusion proceeds. Since the two impacts are contrary in sign in general, the employment path cannot be predicted. There may be more employment in some periods and less in others, even if the overall impact is positive.

Uneven Technological Progress

Cohen and Saint-Paul (1994) consider a two-sector economy (manufacturing and services) where technological progress occurs in the manufacturing sector first. The only production factor is labour. The reallocation of workers between the two sectors is costly, e.g. due to training costs. Manufacturing and service goods are assumed to be complements, that is if the demand for manufacturing goods rises, the demand for services rises, too. Technological progress in manufacturing lowers output prices thereby reducing labour demand in this sector. Due to the demand complementarity, demand for service goods will rise and so will the demand for labour. Overall employment may increase even when technological progress widens the productivity differential between the two sectors. However, if there is a huge rise in productivity in the innovating firm, the manufacturing sector will eventually fire more workers than the service sector will hire. This is, of course, more likely to happen if the two goods produced are not perfect complements. Final demand in the service sector will not be sufficient to raise overall employment. As a result, unemployment may develop.

2.5.2 Diffusion And Competitiveness

Diffusion in an Open Economy

If innovation occurs in a foreign country where lower costs are generated, foreign firms may raise their production. Domestic firms may suffer from reductions in output and employment (Stoneman and Diederen, 1994). The loss of competitiveness will be enhanced if innovative success overseas induces further technological progress. The advantage of foreign technological leadership could be sustained forever. Therefore, a rapid introduction of new technology might be necessary to keep employment constant at home. Stoneman and Diederen (1994) argue that this will not be the best solution with respect to employment, when the country under consideration is the technological leader and other countries do not adopt. Technological progress at home together with non-adoption in other countries means higher output at home but not necessarily increased domestic employment. Only if output increases sufficiently to offset the reduced labour input per unit of output, will employment increase.

If we look at product innovation where new goods may be sold at a lower price than old ones, a non-innovating firm will experience continual decline in output and employment. Hence, with product innovation one can realise faster employment and output gains by faster adoption of technology. Innovation at home implies higher output and employment at home. The impact on output and employment is greater the more old and new products differ in prices and the greater the reaction of product demand will be due to a decrease in prices. The arguments mentioned suggest the targeting of policy towards high demand elastic sectors.

Optimal Diffusion Path

Stoneman and Diederen (1994) argue that a high rate of diffusion can lead to adopting a technology before it has become profitable. This will not improve competitiveness. Adopting a less developed or higher priced technology today prevents the adoption of a more developed or cheaper technology in the future. Current competitiveness is being bought at the expense of future competitiveness. Sub-optimal diffusion paths result, among other reasons, from market failure due to imperfect information or market structure. If by a lack of information expectations with respect to the technological improvements or price reductions are too pessimistic, then adoption will take place too early. To reduce the uncertainty about future technological improvement the government could create information by imposing technological standards on the market. In general, new technologies appear in many variations that are often not compatible. During the time before an industry standard is established, potential adopters face the risk of opting for the wrong standard, which could have a slow-down effect on diffusion. The market structure of innovation using industry affects the incentives to adopt a new technology, too. A great number of supplying industries give more incentive to innovate as firms try to increase their market share. Monopoly power could reduce innovation activity.

2.6 Human Capital, R&D and Growth

The novel idea of the 'new growth theory' is the endogenisation of technological change. Technological progress does not appear like manna from heaven but is the result of goal-oriented investment in research and development as well as in human capital (see e.g. Barro,1991, Grossman and Helpman, 1991, Lucas, 1988, Mankiw, Romer and Weil, 1992, Romer, 1994). The frameworks explaining the high and monotonous increase of countries' labour productivity in the last years are the result of high levels of human capital investment and R&D-expenditures. Growth of knowledge is a crucial source of growth whereas human capital investment is the most important input for augmenting technological knowledge and for precipitating adoption of new technologies. Due to the nonrivalling character of knowledge the optimal growth path of an economy may not be reached in a market economy. Positive externalities induce underinvestment in research because present researchers and their employers are not fully rewarded for their findings (that is, the results are not fully applicable). Other firms may have the chance to use research outcomes free of charge, which is socially optimal but detrimental to R&D in a private economy.

New growth theory indicates that international diffusion of knowledge and international trade of new processes may lead to further investment in human capital and R&D and hence to augmented growth. This accelerating effect in open economies results from greater competitiveness, so that single countries try to avoid duplications of existing technological innovations. Since only full employment equilibriums are investigated the new growth theory has no direct implications for employment policies. But it has direct implications for policies designed to improve growth and income through a proper investment in R&D and human capital, which means a proper reduction of consumption today for enhanced consumption possibilities in the future.

3 Survey Of Empirical Literature

3.1 Introduction

In empirical research three main approaches can be distinguished according to the level of aggregation: micro-studies, industrial studies and macro-studies. Micro-studies focus on the process of technological change at the level of the individual firm, especially on direct labour displacement and employment generation effects. They potentially provide an overestimation of positive employment impacts as well as an underestimation of negative employment impacts of innovations, because indirect effects between different firms are not accounted for. The employment decrease in one firm may be compensated by an employment increase in other firms and vice versa. This problem is taken up in industry or sectoral studies, where indirect effects are integrated.

Changes in employment due to the introduction of new technologies can have less dramatic results at sectoral level than at firm level (see Brainard and Fullgrabe, 1986, and the discussion in chapter 2). Whereas firm and sector studies capture the employment consequences of technological progress, macro-studies try to quantify the aggregate net employment and qualification effects by taking into account inter-firm and intersectoral relationships.

Empirical investigations concerning the impact of innovation on employment have to deal with a number of problems. Some of the more serious problems will be discussed here.

1. The first is a problem of **identification**. The level of employment is determined by many economic factors, one of which is technological progress. In order to isolate the specific contribution of innovation to changes in employment the researcher has to be aware of other possible influential factors. As far as labour demand is concerned, industry structure, wages, investment and expected output are among the prominent ones. On the labour supply side preferences for leisure, institutional restrictions w.r.t working time and household composition matter.
2. Another more technological issue is a potential **selectivity problem** in the dataset in the hands of researchers. Innovative firms are often those having an unobserved comparative advantage in implementing new technologies. If the firms' success and employment growth

is driven by these unobserved components, the innovation per se might not be the decisive cause of changing employment.

3. Displacement effects and compensation effects often do **not coincide in time and space**. As a rule, the displacement effect can be measured and attributed to more easily than the compensation effects (Franz, 1994). Therefore, it might be difficult to estimate the overall net impact at the time an innovation is introduced, when the lagging compensation effects are still unknown.

From a scientific point of view there is **more than one solution** to these problems and researchers often choose different ways and solution methods. In addition data sets also differ greatly so empirical results from different studies and countries are not easily comparable. Furthermore, empirical analysis has to solve the **problems of measurement** of employment and innovations, which are discribed in the next section. There is not always a direct relationship between the theory discussed in Chapter 2 and the empirical work discribed in chapter 3.3. Thus not all economically relevant concepts and variables are taken up in the empirical work surveyed here. This makes it difficult sometimes to interpret empirical results in terms of theoretical concepts.

The summary of the literature will be selective referring mostly to studies at firm level. To the best of our knowledge such studies have been undertaken in Austria, Germany, Italy, the Netherlands and the United Kingdom. The gaps concerning the number of countries involved will be filled in by using the Community Innovation Surveys data set later onwards. This topic has been extensively studied in the US, too. In their report Cyert and Mowery (1988) conclude that rapid generation and adoption of new technologies has expanded US employment and wages, so US society has overall broadly profited from technological change.

Industry and macro studies are given rather brief attention here. The focus will be on outcomes -not on statistical procedures. Information concerning the samples and statistical methods used in the studies is summarized in the appendix. A number of recent empirical studies deal with the determinants and incentives of firm-based innovations (see e.g. Evangelista, 1994, Evangelista, Archibugi and Simonetti, 1993, König et al., 1993). They are not discussed any further, for their subject is not directly linked with employment effects.

3.2 Measuring Innovation And Employment

Innovation indicators typically involve either some measure of an input into the innovative process or a proxy for innovative output (see Table 6). The different indicators have specific merits and disadvantages. Input measures suffer from indicating only budgeted resources allocated towards innovative activities rather than the actual amount of successful innovations. And the reliability of output measures is questionable if they solely refer to inventions (patents) irrespective of economic success.

Most studies rely on self-reported statements on process- or product innovations (as is the case in the Community Innovation Survey). However, there is by far no consensus as to what is considered a product innovation and what is considered a process innovation (cf. Evangelista, Archibugi, and Simonetti, 1994). Using the Italian CIS DATA it is possible to compare the share of product and process innovations based on different definitions. The authors find that according to the person who is responsible for the classification, i.e. managers, experts the majority of innovations can be classified as either relating to products or to processes.

Table 6 Different indicators of innovation

Innovation Input Indicators	R&D personnel (scientists, engineers, technicians) R&D expenditures (total, per employee) innovation expenditures
Throughput Indicators	patents applied for and granted number of patents
Output Innovation Indicators	revenues by selling patents, licenses and know how innovation counts share of turnover attributable to innovations self-reported statements on product and process innovations

A universally accepted measure of innovations is hardly available. For empirical work, it is necessary to have the most suitable definition for the objective of the study. As far as employment is concerned it is useful to rely on indicators that emphasize economic success because they also incorporate the demand situation, which is an important factor to the firms' employment decisions. Employment consists of the number of employees and the number of hours they work. Due to data restrictions some studies use the number of employees neglecting the hours worked. If the labour-saving potential is implemented through a reduction of hours worked instead of a reduction in the number of employees, the extent to which the introduction of new technologies induces a decline in employment can be underestimated. Some researchers use expected employment (e.g. König, Buscher and Licht, 1995) instead of actual employment, since innovative behaviour is directed to the future.

3.3 The Impact Of Innovation On Employment At Firm Level

3.3.1 Product Innovations: Empirical Results

Product innovations enhance the demand for labour at firm level. Competition and especially growing demand are factors stimulating innovation and employment. The positive employment impact of product innovation declines over time.

König, Buscher and Licht (1994) find a positive impact of product innovation on employment plans due to an increase of final demand in Germany in 1993. They used data obtained from the Mannheim Innovation Panel (MIP) and the Mannheim Enterprise Panel (MUP), where a broad range of topics related to the entire innovation process within the firms interviewed is included. Reported demand expectations are the most important factors for future employment plans as has been confirmed in earlier work for German firms in the period from 1981 to 1984 (Zimmermann, 1987).

Pohlmeier and Entorf (1990), using a cross section of firms in 1984 and estimating a simultaneous model of innovation, export and employment, also find a positive impact of product innovation on employment. They furthermore notice that firms' returns to innovations are higher in the domestic market than in foreign markets. Innovations as well as employment depend on the business cycle. In the years 1993 and 1981 when Germany experienced a deep recession product innovations seemed to have stabilized employment at firm level. The only study finding negative employment effects in Germany (between 1981 and 1984) is that of Zimmermann (1987), who uses self-reported innovation plans as well as realised product innovations. Leo and Steiner (1994) find a positive impact for Austrian industrial firms in the period of 1990 - 1992.

The employment impact of product innovations seems to vary over time. There is empirical evidence that employment is not affected immediately after implementation but rises soon afterwards and declines later (for a theoretical analysis see Chapter 2). Leo and Steiner (1994) find a positive impact of product innovations. In particular, they find that successful product innovations stemming from the last five years before the survey have had a huge positive impact on employment.

A similar result is obtained by Van Reenen (1993), who uses yearly information on past product innovations. His study is based on a dataset of UK firms as well as on firm and industry counts of innovations for the period of 1976-1983. New technologies generally exert a large positive effect on employment at firm level, which is greatest in the current year of introduction and gradually declines over the next years as other firms imitate and catch up with the innovating firm. Innovation raises company employment by 9-12% in the short-run, and up to 40% in the long-run. Four years into introduction the author measures negative employment impacts.

Firms whose R&D activities are directed to the field of information technology have on average a significantly higher rate of employment growth (see Brower, Kleinknecht and Reijnen 1993). Using a survey of Dutch manufacturing firms which covers the period of 1983-1988, the authors also find that the share of product-related R&D in total R&D has a positive effect on employment growth, whereas the growth of R&D intensity of firms (R&D men years as a percentage of total employment) has a significantly negative effect on employment.

3.3.2 Process Innovations: Empirical Results

The impact of process innovations on employment is far more ambiguous than the impact of product innovations. Process innovations seem to have no measurable impact on employment at firm level. Nevertheless, they are partially responsible for the decline of employment in the whole manufacturing industries in the last two decades.

The relationship between process innovations and employment at firm level is less straightforward than in the case of product innovation. The already mentioned studies by König, Buscher and Licht (1994), Leo and Steiner (1994) and Entorf and Pohlmeier (1990) find no negative impact of process innovation on employment. This result is not astonishing, if one keeps in mind the ambiguous predictions from the theoretical models in Chapter 1. On the other hand, one can observe a decline in employment especially in manufacturing (see the section Industry and Macro Studies later on), that means at the level of industries. So process innovations will have a positive or no impact on innovation in innovative firms, employment might decrease at the level of an industry. This result will depend crucially on the development of demand.

The employment in German manufacturing industries is investigated by Zimmermann (1991). Zimmermann's empirical findings, indicate clearly that a lack of demand must be the dominant factor in employment decisions. The second most important factor is technological advance, while labour costs place third. All three decision factors - demand situation, level of labour costs and labour-saving technological advance - have a significantly negative effect on employment. These findings are confirmed in a subsequent study (Ross and Zimmermann, 1993) where the influence of demand on employment is estimated to be about twice as large as that of technological progress. Moreover, large firms are more likely to discharge workers than small firms, which points to the role of economies of scope. Similar results were reported for Germany nearly ten years later when the economy was in a deep recession again (König, Buscher and Licht, 1994).

Höflich-Häberlein and Häbler (1989) explore the diffusion and application of information and communication technologies as well as their impact on the German service sector. A general displacement effect due to process innovations is not found. The extent to which the innovation is labour-saving depends on the number of installations, the kind of application, and the organisational structure of the firms. A labour-saving effect can be found especially in the fields of data processing and correspondence (secretariat, bookkeeping), for new information and communications technologies have enormous productivity effects in these fields. The role of organisational change due to process innovations is confirmed by Campbell (1993), who uses a dataset based on a sample of UK companies in 1991. He finds that the average job losses per establishment affected by organisational change are far more important than the average job losses per establishment affected by technological change.

3.3.3 The Role Of Unions

Unions exert a positive influence on the level of employment in firms with product innovations. In non-innovative firms their impact is negative.

The economic literature on unions usually deals with the impact of unionism on employment and wages (see e.g. Alogoskoufis and Manning, 1990, Blanchflower et al., 1994, Kraft, 1989, Machin and Wadhwani, 1991). The empirical results are rather ambiguous and depend, inter alia, on the time horizon chosen as well as on whether strategic behaviour of unions and firms is taken into account. According to Pencavel (1991), there is some evidence that unions take into account potentially negative consequences on employment, putting more weight on employment than on wages.

Table 7 Average employment change in the UK

Union density / Innovation	Innovators	Non-Innovators
High-Density (>85%)	-2.75	-3.71
Low-Density (<85%)	-3.69	-2.17

Source: Van Reenen (1993); average employment for the whole sample: -2.5.

In the above-mentioned study Van Reenen (1993) investigates the interaction of union density, employment change and innovation in the UK. In the whole sample high union density firms experience an above average decrease in employment. The pattern is completely different when the sample is divided into innovating and non-innovating firms. Job is greater among innovative firms with weak unions than in innovative firms with strong unions. In the subsample of non-innovative firms job is greater among firms with strong unions than among firms with weak unions (see Table 7). These results can surely not be generalized, since the institutions and the procedures of bargaining differ between European countries. To the best of our knowledge, Van Reenen (1993) is the only study of union impact on innovation and employment.

3.3.4 Obsolescence of Skills and Skill-bias Hypothesis

Recent technological progress is responsible for a remarkable change of the occupational profile at the level of the firm. Labour demand for high-skilled workers has risen, while the demand for low-skilled workers has d.

New technologies often change a firm´s skill requirements and the occupational distribution of jobs. A number of studies support the view of skill-enhancing and skill-biased technological progress (cf. Allen, 1992, Bartel and Lichtenberg, 1987, FritzRoy and Funke, 1992, Kugler, Müller and Sheldon, 1989, Leo and Steiner, 1994, Machin, 1994, Machin, Ryan and van Reenen, 1996, Mincer, 1991). Especially if technological progress is embodied in new machines and equipment a complementarity between physical capital and skilled labour emerges.

According to Leo and Steiner (1994), the skill-bias pattern of innovations holds true for the different units within the firms (production, office and administration) and across the sectors as well as the varying sizes of enterpresises. In Austrian industrial establishments they find substantial additional demand for technicians, skilled workers, researchers and high level experts due to the introduction of innovations, whereas demand s for semi-skilled workers with on-the-job training, for supporting workers and for typists. Kugler, Müller and Sheldon (1989) find that from 1970 to 1984 technological change in German manufacturing industries has enhanced the share of white-collar employees relative to blue-collar workers. Equipment and white-collar labour seem to be complements, whereas equipment and blue-collar labour appear to be substitutes. This result has been confirmed for Switzerland between 1955 - 1988 (Kugler and Spycher, 1992).

At the beginning of the eighties the growing diffusion of microelectronics and computer technologies raised fears of negative consequences for employment. According to Ewers, Becker and Fritsch (1989), the diffusion of computer technologies has not exerted a generally negative effect on the level of employment, but a tremendous impact on the structure of labour demand similar to that observed earlier (for Germany) has occured. The demand for unskilled workers has decreased significantly, while the demand for highly-skilled workers has increased. The result is confirmed by Machin (1994) for UK manufacturing industries between 1979 and 1990. He uses different technology indicators including one for the introduction of computers. He finds evidence supporting a move to non-manual highly skilled employment especially in R&D intensive industries and in establishments which introduced computers between 1984 and 1990. The amount of change in skill structure in Sweden and Denmark attributable to technological progress is larger than that of the US or the UK (Machin, Ryan and van Reenen, 1996). According to the authors, the skill structure and labour market institutions are linked. In the US and the UK, the role of unions and collecting wage bargaining has d, influencing skill structure in the process.

Table 8 Average employment growth rates in occupational groups

Country	Time Period	Total	Pro/tec	Adm	Cler	Sales	Servic	Agric	Prod
Austria	1984-1991	1.0	2.7	3.5	1.4	1.3	1.5	- 2.6	0.5
Belgium	1985-1990	0.7	4.2	0.6	1.2	0.2	0.7	0.4	-0.3
Denmark	1984-1991	0.9	2.3	4.0	0.9	1.4	-0.6	- 1.6	0.3
Spain	1983-1992	1.3	5.7	4.1	3.7	2.5	1.9	- 5.5	1.4
Finland	1983-1992	-0.7	2.2	0.9	-0.8	2.7	-2.7	- 3.8	-3.1
Germany	1984-1991	1.6	3.4	-0.6	3.2	1.4	1.0	- 4.2	0.5
Greece	1983-1991	0.3	3.4	-0.4	3.5	2.9	1.6	- 3.3	-0.2
Ireland	1983-1991	0.01	0.7	2.3	-0.3	1.1	3.0	- 2.5	-0.5
Netherlands	1983-1991	3.4	5.1	8.5	2.9	3.5	4.2	1.3	1.8
Norway	1983-1992	0.3	2.9	2.2	-0.4	1.3	0.4	- 3.2	-1.4
Portugal *	1983-1992	0.5	7.6	31.0	2.1	-2.1	3.9	-10.3	-0.3
Sweden	1983-1992	0.07	2.3	.	3.3	1.8	-3.9	- 5.5	-1.1

Source: Yearbook of Labour Statistics (1993)

Average growth rates calculated from the absolute figures on the distribution of the employed by occupation according to the International Standard Classification of Occupations (ISCO-1968), for detailed information see Appendix. * In some cases the change in growth rates is partially caused by changes in official statistics. This is especially true for Portugal in the administrative occupational group, as from 1992 onwards the armed forces are included. If 1992 is excluded, the average growth rate of the second occupational group is only 10% as compared to 31%. Data for Luxembourg and the United Kingdom were not available.

Pro/tec: Professional, technological and related workers; Adm: Administrative and managerial workers; Cler: Clerical and related workers; Sales: Sales workers; Servic: Services workers; Agric: Agricultural, animal husbandry, fishermen and hunters, forestry workers; Prod: Production and related workers, transport equipment operators and labourers.

Computer-based technologies tend to require higher levels of cognitive skills and lower levels of manufactural skills (see Brainard and Fullgrabe, 1986, for a survey of OECD countries). Between 1970 and 1980 there has been a relative increase in the proportion of white-collar workers to blue-collar workers. Furthermore, professional, technological and higher management occupations grew more rapidly than other white-collar occupations. This trend continued between 1983 and 1992 for most European countries (see Table 8).

Human capital theory suggests that the higher their human capital the more easily individuals adapt to changing environmental circumstances (see especially Schultz, 1989). The life cycle approach of human capital theory indicates that older workers have fewer incentives to adjust to the requirements of new technologies by engaging in further training, as the expected pay-off period of training investments s with increasing age. „Investments in human capital diminish over time because (a) benefits as the payoff period (remaining work life) shortens; and (b) the opportunity costs of time, which is an input in the learning process, are likely to rise over the working life" (Mincer, 1989). Warnken and Ronning (1989) report that personnel policies in innovative industries are not directed against older workers, although the share of younger workers aged 20-25 in innovation intensive industries is above average.

3.3.5 Technology And Wages

Wages of employees with comparable skills and qualification experienced in the usage of new technologies are above average. Process innovations have a greater impact on wages than product innovations.

In the face of technological progress the wage structure may change. The impact depends on whether the introduction of new technologies is substitutional or complementary with respect to different qualification or age groups. Krueger (1993) finds that in the US the mere usage of a computer at work raises wages up to 10-15% for otherwise identical qualification levels of the employees. In France the wage differential amounts to only 50% of the US-differential, see Entorf and Kramartz (1994). Furthermore, in France the differential increases with experience in using new techniques and is significantly lower for workers with high human capital.

Brouwer and Kleinknecht (1994) use a more general innovation concept to investigate the income effects of new technologies. On the basis of Dutch firm level data they find that process-related R&D expenditures exert a positive effect which is three times as high as product-related R&D expenditures. Process innovations require an important investment in human knowledge by the firm, which will pay above average wages to prevent this human capital from leaking out.

4 Long-run Employment And Productivity Changes In Manufacturing - Cross-Country Comparisons

Technological change exerts a considerable impact on redistribution of jobs among regions, sectors, industries and occupations. Technological progress has contributed to a shift in employment towards service and more R&D intensive sectors.

4.1 Introduction

In the last two decades the key sectors for employment growth have been technologically sophisticated industries and services (OECD Jobs Study, 1994). The manufacturing share of employment has declined in many industrialized countries, whereas the share of the service sector has risen. This can be attributed to finance, insurance, real estate and business services as well as to technology-oriented industries such as computers and aerospace. These changes in employment differ between countries indicating that the impact of innovation differs between European countries as well.

According to Brainard and Fullgrabe (1986) the application of advanced technologies has lead to a displacement of workers in the manufacturing sector. Between 1981 and 1983 the net changes in manufacturing employment due to the use of microelectronics were negative for three European countries (United Kingdom, France, Germany). These losses, however, have been offset by job growth in the service sector (business, financial and communication services), so that the overall employment effect of technological change is slightly positive - but at cost of the manufacturing sector. They also point out that the extent to which the decline in employment of the manufacturing sector can be attributed to new technologies is relatively small (about 5%). The overall employment is influenced much more by factors such as low demand and international competition.

Edler et al. (1989) stress the importance of strong aggregate demand for positive employment effects of innovations for Germany as well. A high level of R&D expenditures has a large positive effect on additional employment in industries investing in R&D. Increases in the demand for labour can primarily be seen in industries which supply sophisticated products like computers and chemicals. Between 1980 and 1986 innovative sectors demonstrated a much more favourable employment growth rate than non-innovative sectors (Legler et al, 1992).

In a recent paper with French time-series-cross-section firm level data Greenan and Guellec (1995) find that over a five year period innovating firms create more jobs than other firms do. While product innovation creates more jobs at the sector level, process innovation creates more jobs at firm level. According to the authors, process innovations in France help firms at expense of other firms. So employment rise is higher in innovative firms than in the whole sector, where innovative firms are active. New products on the other hand lead to more increased employment at sectoral level than at firm level. So overall demand rises due to the introduction of new products in the sector.

To get broader insights into the empirical relationship between innovation and employment at industry level in Europe, we have employed the OECDs STAN database. We will focus on the last two decades of development of employment and labour productivity in the manufacturing sector as a whole. Due to data limitations in the OECDs STAN we omit calculation of total factor productivity and instead use labour productivity as a rough indicator of technological progress. The analysis relates to the manufacturing sector of OECD member states (West European Countries, the USA and Japan).

4.2 Growth Of Employment And Labour Productivity

In the second half of this century employment has shifted from the manufacturing sector to the service sector. In all countries, except for Japan, between 1970 and 1993 the manufacturing sectors have shrunk (cf. figure 3). The United Kingdom has faced the highest annual decrease of -2,4 percent followed by Belgium, Sweden, Spain, Norway, and France. The Japanese manufacturing sector has grown at an annual rate of 0,3 percent whereas the United States, Austria, Germany, and Italy have shown a slight decrease in employment.

At the same time all countries show positive average growth rates of labour productivity. Japan turns out to have the highest productivity growth in these two decades. It also has the highest increase in employment. Belgium and the United Kingdom, in contrast, which follow next in productivity ranking face a large decrease in employment. For the other countries figure 3 suggests that the correlation between employment growth and labour productivity growth in manufacturing is negative. But given the high level of aggregation and some measurement problems we should try not to put too much weight on this observation.

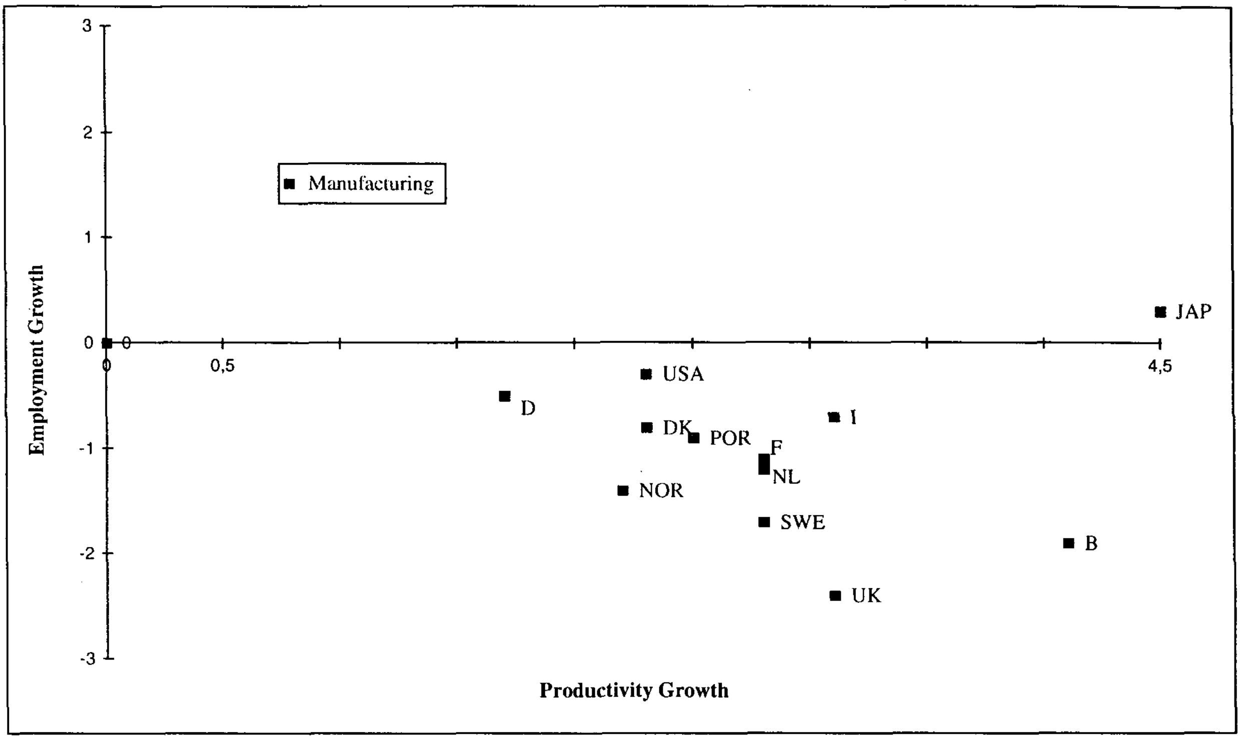
4.3 R&D-Intensity And Employment Growth

A more refined picture emerges when industries are distinguished by the average level of R&D expenditures. Industry typically spending more than 3.5% of sales for R&D activities are often called high-tech resp. medium-tech sectors; industries with lower R&D to sales ratios are labelled low-tech industry. This classification of industries is based on Grupp and Gehrke (1995). The division of ISIC sectors into high- and medium-tech and into low-tech is given in Table A3 in the appendix.

Due to data limitations in the OECD STAN database it was not possible to further distinguish between high- and medium-tech sectors in most of the countries. Therefore, both types of industries have been taken together. It should be noted that the classification of Grupp and Gehrke (1995), which is based on R&D intensities of groups of goods, remains relatively stable over time. It can thus be used to compare average growth rates for a longer period of time.

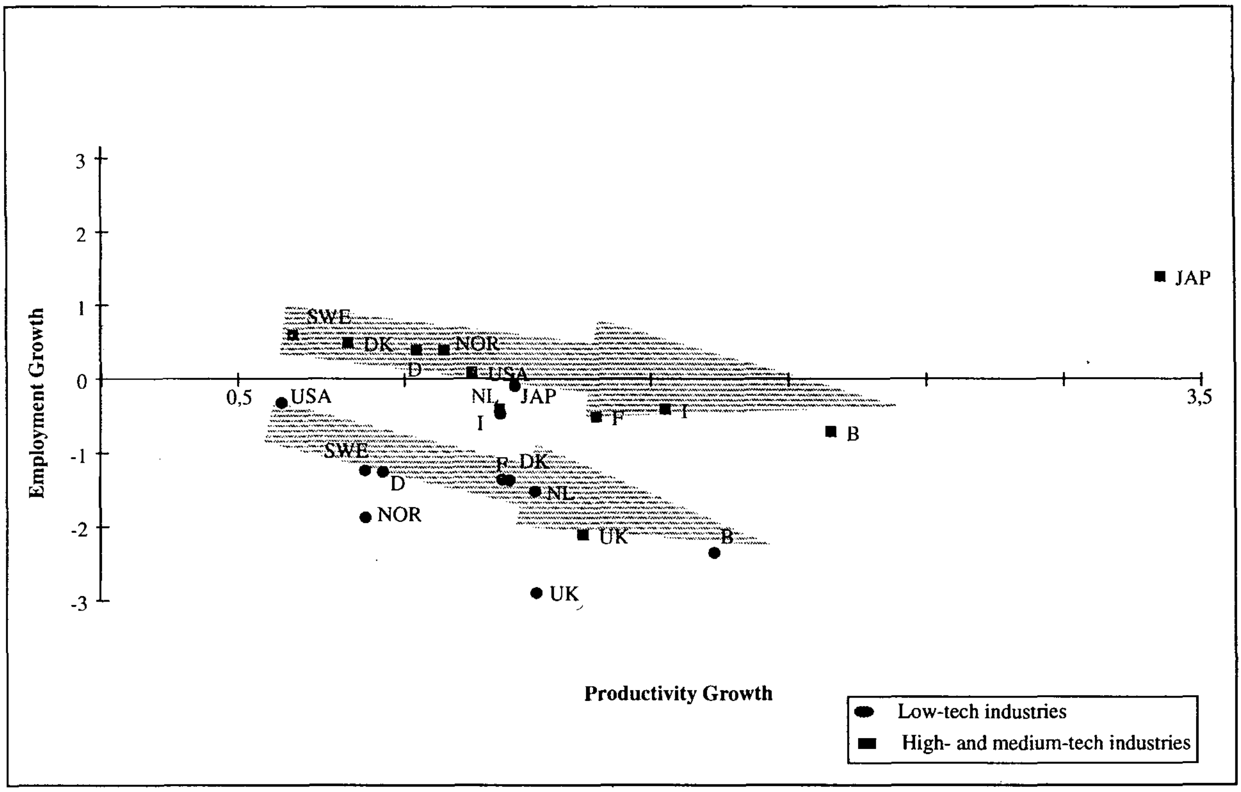
The results are shown in figure 4, which contains the long-run labour productivity and employment growth for high- and medium-tech industries and low-tech industries for several OECD countries. The long-run growth rate has been calculated for the period of 1970-1991 as opposed to 1970-1993 (Figure 3) where missing values occur for almost all countries in the more disaggregated sectors.

Figure 3: Long-run Employment and Productivity Growth in Manufacturing 1970-1993



Source: own calculations using OECD STAN database.

Figure 4: Long-run Employment and Productivity Growth in High-/Medium- and Low-Tech Industries 1970-1991



Source: own calculations using OECD STAN database.

Figure 4 clearly shows that long-run annual employment growth rates of high- and medium-tech sectors have always been above the employment growth rates of low-tech sectors. Moreover, most countries have faced a positive employment growth in high- and medium-tech branches over the last two decades. The only remarkable exception is the United Kingdom with an average decrease of 2,1 percent even in high- and medium-tech branches of industry. Since the firms' labour demands depend on the business cycle, we have computed all growth numbers for seven sub-periods, each covering a three years time intervall. As shown in the appendix, the dominance of high- and medium-tech sectors over low-tech sectors in terms of employment growth is present even for most sub-periods between 1970 and 1991 (cf. Table A4 in the Appendix).

Moreover, for high- and medium-tech sectors there is no obvious negative correlation between productivity and employment growth. On average the differences in productivity growth between high- and medium-tech sectors and low-tech sectors are far less remarkable than the differences in employment growth (cf. figure 3). In most countries for the last two decades average annual productivity growth rates for high- and medium-tech branches compared to low-tech branches have been higher. The exceptions are made up of Denmark, the Netherlands, Portugal, and Sweden where the opposite is true. Again, in most countries the short-run productivity growth rates for high- and medium-tech sectors are higher, who in general also have better employment growth rates (cf. Table A4 in the Appendix). The only time period, where low-tech sectors have had higher labour productivity growth rates was between 1977 until 1979 (cf. Table A5 in the Appendix). After that this period high- and medium-tech sectors have dominated again with respect to productivity gains.

The differences between high- and medium-tech industries on one hand and low-tech industries on the other can be explained by the different nature of innovative activities. Innovation activies in high-tech sectors are to a larger extent directed towards the generation of product innovations whereas in low-tech sectors process innovations are given more importance. Moreover, in low-tech sectors the success of enterprises is dominated by the realisation of cost advantages whereas in high- and medium-tech sectors product quality is focused upon as well. Several studies using CIS-data point to the large degree of intra-industry heterogenity with respect to R&D activities. Our study will now turn to the analysis of innovation and employment which uses this unique firm level database for Europe.

5 The Impact Of Innovation On Employment In Europe

5.1 The Community Innovation Survey 1993

In this chapter we will investigate the relationship between innovation and employment in Europe using the Community Innovation Survey (CIS). The 1993 database has been conducted in the manufacturing sectors of thirteen European Union member states. Theses states are made up of Belgium, Denmark, France, Germany, Greece, Italy, Ireland, Luxemburg, Netherland, Norway, Portugal, Spain and United Kingdom. The CIS data contains, among others, comparable European firm level information on the innovation output, introduction of new products and processes, turnover, exports, R&D and labour inputs and last but not least, on the barriers to innovation.

The data for the current analysis has been provided by EUROSTAT. Due to legal protection rights EUROSTAT does not provide the original data but a micro-aggregated database. Unfortunatly, the data from Greece, Portugal and United Kingdom are insufficient for our analysis. They simply contain too few firms to do so. For some parts of the analysis the data from Ireland, the Netherlands, Norway and Spain cannot be used either. In these countries the information on sales in 1992 and/or sales in 1990 is either not comparable in dimension or not available and therefore cannot be used. The CIS database has been described and analysed by x, y, z [GLI einfügen].

The survey of theoretical and empirical literature has shown that the impact of innovation on employment is not so easily discovered. Innovation can destroy jobs or it can create them at firm as well as at industry level. Whether overall impact is either negative or positive depends on the organisation of the labour market, on the structure of other input markets, on the degree of competition in output markets, on currently used technology, on the direction of technological process and on economic policy. Studies for different European countries up to now have used varying datasets all with their own definitions of innovation, so the results are usually not directly comparable. This is the advantage of the CIS database: We have comparable sets of information for measuring the impact of innovation on employment for every possible European country.

5.2 Labour Productivity And Innovation In Europe Reconsidered

Innovative firms have higher labour productivity than non-innovative firms in Europe

The impact of innovation on employment absolutely depends on technology. Technology determines labour productivity. The higher the labour, the more sensitive employment reacts to innovation, especially when demand remains stationary. The more the labour productivity is increased by technology the smaller the possible employment gains will turn out. In chapter 4 we considered the long-run relationship between labour productivity growth, a measure of changing technology, and employment growth. The results point toward the assumption that medium-and high-tech firm realise higher productivity and employment growth than low-tech firms do.

In this part, we shall examine the relationship between labour productivity in innovative vs. non-innovative and large vs. small and medium sized firms in eight European countries using the CIS database (cf. Table A7 in the Appendix). Average labour productivity, which is defined as sales per employee, ranges from 95,000 ECU in Spain to 142,000 ECU in Norway. This span indicates the different technologies in the European manufacturing sector. Labour productivity is high for Belgium, Luxemburg, Italy and Norway in contrast to France or Germany. One specific reason for this difference may be the higher share of working hours per employee in the former countries.

The division into innovative and non-innovative firms indicates that non-innovative firms do not have higher labour productivity. In the four countries of Italy, France, Norway and Spain average labour productivity is significantly higher in innovative than in non-innovative firms. It is not of particular necessity to differ between process and product innovators, since nearly all of the firms are both (cf. cf. Evangelista, Archibugi, and Simonetti, 1994). Furthermore, as one might expect, large firms have higher labour productivity on average than small and medium sized firms. The only exception is made for firms in Luxembourg and Denmark, which may have fallen out of line due to the number of available firms.

The difference of labour productivity between small/medium and large firms amounts to 68,750 ECU in Norway, which leads the other countries in this respect, closely followed by Italy and Belgium. The labour productivity difference is lowest in Luxemburg and Belgium , where it amounts to a mere 12,000 and 17,000 ECU, respectively. The rift in labour productivity between innovative and non-innovative firms is greatest in Spain, where it amounts to 29,000 ECU. It follows Luxemburg, Italy and France and Germany, where the rift only amounts to 5000 ECU. In Spain, innovative firms are like the firms who use modern technology. The difference between these firms in Spain or Germany is not that great. Non-innovative firms in Spain, on the other hand, lag farther behind the technology frontier; more so than in Germany, where the difference between the two types of firms is comparably low.

The impact of innovation on employment does not depend on technology alone. Other factors, like turnover and labour costs, must be taken into account. In the next part, the impact of innovation on employment in a labour demand framework will be analysed, allowing us to measure innovation impact and other factors simultaneously.

5.3 Labour Demand, Innovation And Exports

- The most important factor determining employment is turnover.
- In five European countries, innovation plays the second most important role (Germany, Denmark, Luxembourg, Belgium, Italy), in other two European countries this rank is reserved for labour costs (France, Spain).
- In the five countries, where innovation is an important employment determining factor, labour costs usually rank at place three. Innovative firms engaged in R&D realise a positive employment differential of up to 38%.
- The organisation of firms, export activities and the lack of finance or skilled labour determine employment in some countries while in others they do not. The impact on employment is usually less important quantitatively. It lacks a clear pattern between the European countries.

5.3.1 Model And Data

The firms decide about the level of employment. Labour demand depends, among other factors, on turnover, labour costs, export and innovative activities. Our framework for the empirical analysis of labour demand in Belgium, Denmark, France, Germany, Italy, Luxemburg, Norway and Spain is similar in nature to that of König, Buscher and Licht (1995). They derive the firms' labour demand function from profit maximisation (cf. also Hamermesh, 1993). We have modified the empirical approach of König, Buscher and Licht (1995) to be compatible with the CIS database. The aim of our analysis is to estimate a simple static labour demand function for each of the eight European countries.

It is postulated that labour demand is a linear function of turnover, labour costs, export activities, process and product innovations, R&D, the organisational structure of the firm and restrictions on labour and finance markets. To capture non-linearities, we include the square of turnover and furthermore use indicators of export and R&D activities. The R&D activities are classified according to whether they are directed to process or product innovation. Improving productivity (R&D related to process innovations) should have no positive impact on employment (after controlling for turnover). It is highly unlikely, on the other hand, that the development of new or improved goods should have a negative impact on employment. For exact definitions of all variables constructed from CIS cf. Table A9 in the Appendix, summary statistics are provided in Table A10.

The model is estimated for each country using ordinary least squares. The dependent variable is the natural logarithm of the firms' employment (measured in full time equivalents) in 1992. The firm size distribution varies across the industries of the European Union member states. On average, German manufacturing firms have 140 employees, while firms in Luxembourg have only 15. Firms in Norway have 32 employees, in Italy they have 45, in Spain 58, in Belgium 103, in France 79 and in Denmark 110. Turnover and squared turnover of 1992 is measured in natural logarithm as well (*sales*, *sales_sqrd*). Turnover per enterprise is highest on average in samples collected from Belgium and lowest in the ones from Luxembourg. In this log- log specification estimated coefficients of continuous variables can be interpreted as elasticities. That is, the coefficients of factors like turnover measure the percentage change of employment due to a one percent change of the explanatory variable.

The firms' innovative activities relate to the period of 1990 til 1992. An indicator variable is included for innovation activity. This variable has the value of 1, if the firm introduces any technologically changed product or process (*innovative*). In the German sample 87% of the firms are said to be innovative, in Luxembourg 30%. This indicator can become rather imprecise as a measure of innovation. Marginal as well as radical innovations are taken together. Therefore an additional indicator variable is included separating innovative firms who were engaged in R&D activity (*R&D*) in 1992 from those who were not. In Germany, 65% of the firms are engaged in R&D, in Luxembourg only 17%. To furthermore account for labour saving efforts, we explicitely consider firms who are engaged in R&D related to process innovation (*R&D_process*) and direct more than the average percentage (of all firms in the industry) of their R&D share to process innovation. In Germany 40% of all firms are in this group, in Luxembourg only 5%.

Labour costs are unfortunatly not available in the CIS dataset from EUROSTAT, although they surely are important for labour demand. To fill the gap we employ the two digit- industry level data on labour costs per employee in 1992 provided from the OECD STAN database (*lab_costs*). There, labour costs are in thousands of dollars. We converted these values of industrywide labour costs per employee into the ECU (the exchange rate amounted to 1,298$/ECU, on average in 1992, Eurostatistik, 1995). Labour costs are highest in Germany and lowest in Spain. In German manufacturing firms, average labour cost amount to 30.946 ECU, in Spain to 16.317 ECU. In Italy, labour costs are around 19.535 ECU. In Belgium and France labour costs are 12%, respectively, 10% lower than in Germany, in Norway they are as low as three percent.

Organisation and export activities matter to employment. An indicator variable is included, if firms are part of a group (*part*), and furthermore whether or not they are the mother/or sister enterprise (*part_moth*). In Denmark 66% of all firms are dependent, in Germany 30%, in Italy 18%, in Luxembourg 15%. Firms engaged in exports (*export*) face different market structures than firms only selling at home. The number of firms engaged in export varies in Europe from the lowest value of 50% in Norway and the highest value of 92% in Denmark. If the ratio of export is higher than 30% of total sales, *export_30* takes on the value of 1. Again, this indicator variable shall explicitely consider firms with high and firms with low activities abroad. The relevant markets might differ according to the firms' activities, leading to differences in firm reactions regarding labour demand.

The measurement of restrictions in the labour and capital markets is tricky from a theoretical point of view. The availability of skilled personnel and financial resources depends on, among other reasons, the prices of these factors. For instance, if firms realise a lack of skilled personnel, higher wages may raise the supply of qualified workers. In the analysis we contruct a measure for possible market restrictions relying on the firms' own point of view. In the CIS firms are asked whether such issues like the lack of skilled personnel are important barriers to innovation. The answers can take on any of the five following categories: „ insignificant", „slightly significant", „moderately significant", „very significant", and „crucial". If the firms individual answer is above the median value of all the firms answers, the indicator variable takes on the value 1 (*skill_lack, finance_lack*).

Although the information itself might be incomplete or biased, this method allows for the testing of relevancy of politically important issues of labour and capital markets in our multivariate analysis of labour demand. Between 25% (in Luxembourg) and 48% (in Norway) of the firms face restrictions in the labour market; in all countries a higher amount of firms faces restrictions in the capital market: 29% of German firms and 67% of Spanish firms do. So the framework for innovative activities which firms face in manufacturing differs between the member states.

Our simple approach to the estimation of labour demand might have some deficiencies. First it is a static framework, that is we observe labour demand at one point in time instead of observing the change in labour demand over time. Therefore, we cannot model the dynamic character of technological change and employment. A dynamic approach to labour demand and innovation is provided in chapter 6 for the Netherlands and Germany. In this chapter, the focus of interest is on a cross-country comparison of the relationship between innovation and employment with CIS cross-section data.

5.3.2 Overview Of Results

The results of the estimated employment equation and of several tests regarding the significance of the explanatory variable or groups of explanatory variable are presented in Appendix 11. The equation for each country is statistically well detemined. The adjusted coefficient of determination (adj. R^2) ranges from 0.66 in Italy to 0.88 in Norway. So the model chosen can explain between 66% and 88% of the variation in employment by the variation of the explanatory variables.

In all countries the most important factor determining employment is turnover. In five countries innovation plays the second most important role (Germany, Denmark, Luxembourg, Belgium, Italy), in two other countries it is played by labour cost (France, Spain). In the five countries, where innovation is an important factor determining employment, labour costs hover at place three. The organisation of firms, the export activities and the lack of finance or skilled labour determine employment in some countries while in others they do not. Their impact on employment is usually less important in quantitative terms and there is no such simple tangible pattern between the countries like in the case of turnover, innovation and labour cost.

5.3.3 Discussion

Turnover

In all European countries the greatest impact on employment derives from the firms' sales. In Germany, France, Luxemburg and Norway a rise in turnover leads to an increase in employment at all sale levels. This is not the case for four of the other countries. In Denmark, Belgium, Italy and Spain firms with lower turnover than 105,000, 241,000, 103,000 and 69,000 ECU reduce employment when sales grow. Firms whose turnovers are above this value will increase their employment. Since no firms in these countries have sales below these values, the firms' reactions can be seen as normal in all of the eight European countries. An increase in turnover leads to an increase in employment. In all countries, the estimates hint at declining economies of scales. The higher the output already is, the more the input factors are required to produce the next output unit. In table 9 the change in labour demand due to a one percent increase in turnover is calculated (at the means of turnover in the sample).

Table 9: Percentage change of employment due to a one percent increase in sales

country	Germany	Denmark	France	Luxemburg
employment reaction	0.77	0.65	0.68	0.72
country	Belgium	Italy	Spain	Norway
employment reaction	0.55	0.42	0.55	0.73

Calculated at the mean of sales; based on OLS estimates, see Table A11 in the Appendix

The firms' reactions to increased sales vary between 0,42 for Italy and 0,77 for Germany. The significantly smaller employment impact of increased sales in Italy compared to Germany and most of the other countries is at least in part the result of the different firm size. In Italy, there are more small and medium size firms (SMEs) in the industrial sector of the economy than in Germany or France. SMEs operate at a level at which additional output can be produced with less additional labour and/or capital.

Innovation

There are three variables measuring innovative activities of firms: *innovative* , *R&D*, *R&D_process*. They are tested together (see Table A11 in the Appendix) and have to be interpreted together. In Belgium, Italy, Denmark, Germany and Luxembourg, the joint test reveals a significant impact of innovation on employment. Innovation per se (*innovative*) has no measurable impact on employment the only exception consisting of Italian innovative firms, which have a 5.4% higher employment rate than non-innovative firms. Since the Italian firms sample has the most observations, the estimates are definitely more precise.

What really does matter for employment in Europe, however, is whether innovative firms are engaged in *R&D*. In Denmark, innovative firms engaged in R&D have 24% (-0.026 + 0.267) more employees, in Germany 23% (-0.027 + 0.253), in Belgium 38% (0.139 + 0.241), in Italy 12.4% (7% plus the 5.4%). So *innovative* seems to be too imprecise to measure employment impacts of innovations. It contains all types of innovations, some of them marginal, others of the more radical type. While some of them have a positive impact as when firms are engaged in R&D, others may have a negative impact or none at all.

Table 10: Comparison of employment differentials between innovative firms engaged in R&D and other firms

country	Germany	Denmark	France	Luxemburg
employment differential	0.23	0.24	n.s./n.a.	n.s
country	Belgium	Italy	Spain	Norway
employment differential	0.38	12.4	n.s.	n.s.

Based on OLS estimates, see Table A11 in the Appendix; n.a.: not available; n.s: not different from zero.

When R&D-effort is directed to cost saving activities (*R&D_process*) theory would suggest a decrease in employment provided that turnover stays constant. That indeed is the case in the estimates for Germany, Denmark and Belgium. In Germany for instance, employment in these firms is 7% lower relative to innovative firms engaged in R&D, 4.4% in Belgium, 1% in Denmark. In Italy and Luxembourg, however, the partial impact is not in line with theory, because the estimated coefficients are positive. In the Luxembourg sample, the estimated coefficient is 0.504, which seems to be really high in substantial terms; in the Italian sample the coefficient is 0.071. Since only 5% of the firms in Luxembourg are engaged in R&D effort directed to cost saving, the result is unique to these firms and should not be generalized. In Italy, labour costs do not play an important role for labour demand compared with Germany for instance. This is discussed in more detail in the next paragraph. The reduction of employment as a response to cost saving is not as likely in Italy as in Germany. In Italy, most of the firms are SMEs. A further reduction of labour as a result of cost saving strategies or a further substitution of labour by capital is often not possible in SMEs. In the industry a minimum number of employees is usually necessary to start business.

In Norway there is no measurable impact of innovation on employment. In France and Spain there is no measurable impact either. However, in the last two countries this might be due to the missing information of R&D in the microaggregated CIS from EUROSTAT. Nevertheless, the analysis has shown significant differences with respect to the impact of innovation on employment in Europe. By and large, innovative firms who are engaged in R&D have higher employment than the rest of the firms.

The employment differential is highest in firms who are furthermore engaged in R&D directed to new products. The employment differentials are different in the member states. They range from zero to 34%. R&D-efforts to cost saving have a negative impact on employment, at least in some member states. The indirect employment impacts in other sectors like the service sector cannot be calculated in the framework of this study. In the panel data analysis of chapter 6 this issue will be discussed in more detail.

Labour Costs

The higher the labour cost, the lower the employment. This relationship holds true in most countries, although the impact may differ. There are the two exceptions of Belgium and Norway where labour cost has no measurable impact. In Germany, France and Spain, the firms' reactions to a one percent decrease in labour cost are quantitatively comparable: employment rises by about 0.20%. In Italian firms employment rises only by about 0.04%.

Table 11: Percentage change of employment due to a one percent decrease in labour costs

country	Germany	Denmark	France	Luxemburg
employment reaction	0.18	n.a.	0.22	n.a.
country	Belgium	Italy	Spain	Norway
employment reaction	n.s.	0.04	0.18	n.s.

Based on OLS estimates, see Table A11 in the Appendix 10; n.a.: not available; n.s: not different from zero.

In the framework of the simple approach proposed in our analysis, the estimated coefficient of labour cost measures the degree of substitution between labour and capital. The lower the cost of labour in relation to capital cost, the more capital will be substituted by labour. Despite the fact that there is no information on individual firms' labour cost, it is permissible to utilize the average labour costs in the sectors instead, so the results become comparable to those of other studies who have made use of individual labour cost. König, Buscher and Licht (1995), for instance, find nearly the same coefficent in a cross-section of the Mannheim Innovation Panel dataset from 1993 having individual labour costs at hand.

The degree of substitution between capital and labour depends on technology. While it is plausible that the firms' reaction in France and Germany is similar, it does not seem to be plausible that Belgium firms are totally different. According to the estimates, substitution of capital with labour is not possible there. On the other hand, the small coefficient of Italian and Norwegian firms can be explained by the different firm size structure hinting at a different technology. In Italy and Norway the firms are much smaller on average than in Germany for instance. If firms already are small, there are limits to substitutability of labour and capital. To be successful in production, a minimum requirement of labour is often necessary. When firms are small they cannot reduce employment even further.

There is a caveat. The CIS dataset contains no information on the skill structure of labour. Labour costs per employee rise with the share of skilled workers. So, part of the measured substitution effect may be due to different skill structure. The true substitution effect is likely to be overestimated when the skill structure differs a lot in different firms. This has to be taken into account when thinking about policy implications.

Labour cost contain wage and non-wages labour costs as well. With most of the members of the European Union, government can only influence non-wage labour costs, that is, contributions to the social security system which amounts to 40% of pre-tax wages in Germany. Public policy measures directed at a decrease in non-wage labour costs will have a direct beneficial employment impact in the industry of some European member countries, but not in all. Indirect effects might appear, too. However, these can be the result of a different finance modus of the transfer payments and may therefore not be calculated in the framework of this study.

Market Restrictions

Restrictions in labour and capital markets do have some employment consequences in some European countries. There is, however, no obvious pattern in the estimates. Neither the lack of finance nor the lack of skilled personnel seems to have a systematic influence on employment in all countries. In Italy, Belgium, Luxembourg, Denmark and Germany, firms facing a lack of skilled personnel specialized on innovative success have indeed a lower employment rate than other firms. However, the impact is only statistically significant in Germany where employment is 7.4% lower. In Norway the coefficient is even positive: restricted firms employ 7% more people than firms who do not feel restricted in this sense.

The estimates of the lack of appropriate sources of finance provide no overseeable picture either. Although the coefficient of *finance_lack* is negative in Denmark, Norway, Spain and Belgium, it simply does not possess any statistical significance. In Germany the coefficient is strongly positive indicating that restricted firms have a higher employment rate than non-retricted firms. In Luxembourg and Italy the impact is also positive, although not as well determined in the statistical sense. It is possible that firms in Germany who are already bigger in terms of employment than others, feel more restricted in finance markets than other firms. If this interpretation is correct, the positive coefficient only just manages to capture highly successful German firms. A general policy implication cannot be derived from the estimates on market restrictions.

Organisation and Economic Integration

The last set of explanatory variables relates to the organisation of firms and to international trade. In most European countries firms who are part of a group of firms employ more people than single ones. On the other hand, being the mother or sister enterprise does not really change things that much. The difference varies between the member states. In Norway single firms employ 8.9% less people than firms who are part of a group, in Belgium 43.9%, in Italy 23.9%, in Denmark and Spain 11.9% and in Germany 10.5%; in France and Luxembourg the impact is simply insignificant. Conglomerates can realise economies of scope and pool their risks more effectively than single firms. The results of the labour demand estimates seem to reflect this advantage in terms of employment.

Firms engaged intensively in international trade (*export_30*) realise significantly higher employment in Belgium, Italy, Spain and Germany. The differential ranges from 29% in Belgium, 12.7% in Spain, 7.7% in Italy, to 4.1% in Germany. However, in Denmark, France, Luxemburg and Norway trade has no impact. Firms engaged strongly in trade face a different type of market abroad than at home. Therefore they react differently in the labour market. Export markets seems to be more elastic, leading to a higher labour demand. This is true with the exception of Denmark where nearly all firms (92%) are engaged in trade, 57% of them intensively.

5.4 Innovation And Growth Of Turnover

- The European manufacturing industry went through a period of low and even negativ economic growth between 1990 and 1992.
- Innovation contributes to the growth of turnover in France, Italy and Germany, even though in the short-run impacts are more modest.
- Performances of individual firms depend on macroeconomic conditions.

5.4.1 Model And Data

The last section has shown that the most important factor determining employment is turnover: the higher the turnover, the higher the rate of employment. In this section the relationship between firm turnover and innovation is investigated in greater detail. Our approach to the estimation of turnover growth is empirical in nature. The aim is to find out whether product and process innovations influence turnover and if they do to what extent. The CIS not only contains information on the turnover in 1992 (the time of the survey), but also on the turnover in 1990, two years before- at least for Denmark, France, Italy, Belgium and Luxembourg. This information allows the calculation of turnover growth rates. As can be seen in Table A10 in the Appendix, turnover rose approximately 12% in Belgium and only 3% in Italy. This reflects the industry recession in Europe, which hit some countries a little harder than others.

Unfortunately, the information on turnover in 1990 is not available for Spain, Norway and Germany. The 1993 dataset of the Mannheim Innovation Panel (MIP), which is available at the ZEW in Mannheim, contains a question on turnover growth. MIP asked firms whether, in the period of 1990-1992, their turnover had „increased very much", „increased much", „not changed", „decreased much" or „decreased very much".

In the following, it is postulated that the firms' individual turnover growth is a linear function of the European business cycle, the national business cycle, innovation and R&D and firm export activities. We included measures of the business cycle at home and in Europe, since the economic activities of sectors are strongly interrelated. If sales go down in machinery, all firms in this sector may be hit equally. Average country-wide growth of gross national product in each industry between 1990 and 1992 (*sales_mean_c*), and average Europe wide growth of gross national product in each industry (*sales_mean_c*) between 1990 and 1992 have been calculated from the OECD STAN database for each of the NACE two digit levels and have been matched with the CIS database.

Export activities matter to turnover growth. The two variables indicating exports (*export*) and exports higher than 30% of total sales (*export_30)* have already been described in the section above.. We furthermore examine the influence of product innovation on sales growth. For the exact definitions of all the variables constructed from CIS cf. Table A9, summary statistics are provided in Table A10.

The model is estimated for each country except for Germany, using ordinary least squares. The dependent variable is firm turnover growth between 1990 and 1992, which is calculated from the difference between log turnover in 1990 and 1992. Continuous explanatory variables also enter the equation in logs. In this log-log specification estimated coefficients of continuous variables can be interpreted as elasticities. That is, the coefficients of factors indicating the European business cycle measure the percentage change of employment due to a one percent change of the explanatory variable. For German data an appropriate econometric model in form of the ordered logit is employed.

The firms' innovative activities relate to the period of 1990 and 1992. Similar to the employment equation, an indicator variable is included for innovation activity. This variable has the value of 1, if the firm introduces any technologically changed product or process (*innovative*). To be more precise, in the sales growth equation we include an additional indicator variable for those innovative firms who have introduced new or significantly changed products during 1990 to 1992 (*innbas*). This shall capture the idea that there may be a difference between basis and incremental product innovations. In Germany 62% of the firms belong to this group, in Luxembourg 17%.

In chapter 4 it was shown that in the long-run high- and medium-tech sectors have grown more than low-tech sectors. To test whether this is also true for the short-run we include an indicator variable for firms operating in R&D intensive sectors (manufacture of coke, refined petroleum products and nuclear fuel, manufacture of chemicals and chemical products, manufacture of machinery and equipment, manufacture of electrical, optical and transport equipment, NACE 23, 24, 29 -35, cf. Grupp and Legler, 1995: *R&D_high*). In Germany, 52% of all firms are in this group, in Luxembourg 9%. In addition, we include a variable indicating firms who are operating in the high-tech sector and have basis innovation in their product portfolio (*R&D_high_b*). In Germany 42% of all firms are in this group, in Luxembourg 7%.

5.4.2 Overview Of Results

The results of the estimated turnover growth equation and several tests regarding the significance of explanatory variables or groups of explanatory variables are presented in Table A12 in the Appendix. The explanatory power of the turnover growth equation is low in all six countries. This result shows the relevance of individual firms heterogeneity. The joint test of significance shows that together the explanatory factors contribute to the explanation of turnover growth in Germany, France and Italy; however they do not contribute to the explanation of firms turnover growth in Denmark, Luxembourg and Belgium at all.

Innovation contributes to the growth of turnover in France, Italy and Germany, although the impacts are rather modest in quantitative terms. Nevertheless, one has to bear in mind that during the observation period the European industry went through a period of low and even negativ economic growth. Furthermore, the empirical analysis of turnover growth is restricted to only six member states due to data limitations. The impact of trade on turnover growth is rather weak. By and large, the analysis shows that firm sales depend on macroeconomic conditions.

5.4.3 Discussion

Product Innovation and R&D

In Italy turnover growth is 9% higher in innovative firms than in non-innovative firms. A positive impact of innovative activity on turnover growth is measured for most European countries (Belgium not included), although the coefficients are not significant (with the exception of Italy). The more observations in the sample, the more precise the estimates. The Italian sample of firms is by far the largest sample and therefore the estimates are the most precise. In France innovative firms realise a one percent higher growth rate; in Denmark the value consists of 1.4% and in Luxembourg 6.6%.

In Germany only basic innovations raise the probability of higher turnover growth, not all types of innovation. In other countries, there is no measurable difference between the type of product and process innovation. The difference between innovative firms with basic innovations operating in the high-tech sector and in the low-tech sector has no explanatory power concerning turnover growth. Therefore, we can conclude that in the short-run there is an impact of innovation on turnover growth, which is still rather weak. However, the differences between product and process innovation and furthermore between more incremental and more radical innovation do not seem to be of great importance in the short-run.

Economic Integration

European and country-specific growth of sectoral gross national products positively influence firm turnover growth, although the impact is significant for France only. If the sector where a French firm operates experiences a one percent change in growth rate in Europe, French firm turnover growth rates will vary by 0.5%, Danish firms' turnover growth rates by 1.43%. This shows the degree of integration of these countries into the European industry. The result for Germany which is positive but insignificant cannot be interpreted in this quantitative way, since the German equation has been estimated using the ordered logit model.

The impact of export on turnover growth is positive in most countries, but the quantitative amount is weak and often insignificant. In Denmark growth of turnover of firms intensively engaged in export is about 5% higher than for firms not engaged in trade, in France this figure lies in the whereabouts of 1%, in Belgium of 6%. In Germany the impact is negative.

By and large, the analysis of turnover growth with the CIS dataset is not fully satisfying, since the explanatory power of the regression equation is lower. With the exception of the Italian sample with a high number of observations, the impact of innovation on turnover growth can only be measured with a high degree of imprecision. Firm turnover growth seems to be dependent on a large set of factors which are not included in our estimates. On the other hand, the analysis has pointed towards the relevance of economic integration and innovative activity for the explanation of turnover growth. In the very short-run and in the recession period between 1990 and 1992 firms engaged in trade and in innovative activity seem to have performed slightly better compared to competitors not as intensively engaged in trade and R&D.

6 Innovation And Employment Growth In The Netherlands And Germany

6.1 Firm level evidence for the Netherlands 1988-92

This part investigates factors which influence employment growth at the firm level. We use micro data from two national innovation surveys in the Netherlands, covering the years 1988 and 1992. The second survey was part of the *Community Innovation Survey* (CIS). While in most countries the CIS was confined to manufacturing, the two innovation surveys in the Netherlands covered *all* service industry sectors in addition. This was an innovation in itself. In general, the experience made with the survey in the service sector was quite satisfactory (for details see Brouwer & Kleinknecht 1995a). Both surveys are representative of firms with 10 or more employees in all manufacturing and services sectors of the Netherlands. The response rates were 58% in 1988 and 52% in 1992. Further details on the surveys can be found in Brouwer & Kleinknecht (1994).

We estimate a maximum likelihood sample selection model, using exogenous variables from the 1988 survey. It should be noted that, starting from a number of 1881 manufacturing firms and 1899 service firms which initially responded to the 1988 survey, over the period of 1988-92 we have comparable information on only 772 manufacturing and 836 service firms. A large part of the fall-out results from non-response in 1992, but some of the firms had to be omitted because they were no longer comparable. We omitted all firms of the 1992 survey which indicated having undergone major structural changes (e.g. a merger) during the last three years which made their employment data incomparable. Moreover, firms with extreme values in employment growth (deviating more than 2 standard deviations from the average) and firms with an exceptionally high R&D intensity (>30%, implying that R&D laboratories are excluded), were omitted as outliers. In order to deal with a possible selection bias, we estimate a probit model which, besides an intercept, includes information on whether the firm belonged to a larger organizational unit, on the size of the firm and the sector dummies as exogenous variables.

6.1.1 Hypotheses and variables

For an explanation of employment growth, we use qualitative and quantitative variables. A key variable is R&D intensity. The latter consists of R&D man years as a percentage of a firm's total labour force. It should be noted that the manner in which R&D was asked for leads us to measure a lot of small-scale and informal R&D which is not catched adequately in standard R&D surveys (Kleinknecht & Reijnen 1991). In our surveys, we asked firms to distinguish which part of their R&D was dedicated to new products (or services) and which part was related to new processes. About 67% of all R&D falls into the product and services category, 28% is related to processes and 5% cannot be classified, probably because the two aspects are too intertwined (Brouwer & Kleinknecht 1994: 38). In earlier studies, we discovered that product and service-related R&D had a positive impact on employment, whereas the impact of process-related R&D was ambiguous (E. Brouwer et al. 1993, N.M. Brouwer & Kleinknecht 1994).

It should be noted that process-related R&D is not necessarily a good measure of process innovation, given that process renewal and productivity growth are often realized through the acquisition of new investment goods rather than being developed through in-house R&D. We have the impression that, in recent years, much process-related R&D in the Netherlands is dedicated to better environmental solutions in which case the primary aim is better ecological standards rather than higher factor productivity. This may be an explanation of our finding of a positive impact of process-related R&D on employment. To our surprise, positive employment effects are *not* realized via higher sales, but via *lower* rates of productivity advance (N.M. Brouwer & Kleinknecht 1994).

In order to get at least a rough outline of the impact of new investment goods, in our 1988 survey we asked whether, besides or instead of R&D activities, the acquisition of new machines or equipment for office automatization and/or for production automatization played an important role for that year. One should note that the acquisition of such equipment will in any case create employment in upstream sectors. However, among the firms which buy and use it, the employment effects may be ambiguous. On one hand, they replace labour per unit of production, on the other hand, increased cost efficiency may allow for lower prices and higher sales, partly because of an extension of markets (along the logic of Engel curves), partly via gains of market shares from competitors (i.e. Schumpeterian creative destruction).

Since the seminal work by Birch, it has often been argued that small firms may act as an engine for new employment generation. We therefore include employment as an explanatory variable. Instead of the number of workers as a continuous variable, we use employment size classes- a simple way to allow for non-linearities in the relation between firm size and employment growth. In an earlier round of estimates, we also experimented with sector dummies. It turned out that sectoral differences do not really make a difference in explaining employment growth.

One could argue that the relationship between R&D and employment may differ between manufacturing and services. For example, when estimating total innovation expenditure in 1992 for the Netherlands, we found that the share of R&D in total innovation expenditures is higher in manufacturing than in services, which points toward non-R&D activities being weighted more heavily in services innovation (Brouwer & Kleinknecht 1995b). One can therefore doubt whether R&D typifies the most suitable indicator of innovation in services. Hence, we estimate our model for manufacturing and services separately.

6.1.2 Results

A summary of our estimates can be found in Table 12. The probit part of our estimate (Table 12a) indicates that there are few systematic factors which increase the chance of a manufacturing firm disappearing from the panel. Only firms in the food and beverages industry have a systematically higher probability of falling out of the panel. Against our expectations, smaller manufacturing firms experience no greater chance of disappearing. Only smaller service firms act according to our expectations. We had also expected firms belonging to a group to have a higher probability of disappearing from the panel. This holds indeed for services, but not for manufacturing. The significant value of Rho indicates that firms with a negative employment growth have a higher probability of disappearing from the panel which sounds plausible.

Our estimate in Table 12b confirms earlier results with respect to employment effects of product-related R&D in manufacturing (Brouwer et al. 1993): firms with high product innovation intensity have a significantly higher growth of employment. In services, the level of significance is lower (significant at 90% level), which corresponds with our impression that R&D is perhaps a less effective measure of innovation in services. Process-related R&D has a positive impact on employment in manufacturing (significant at 90% level), and a highly significant one in services. It should be noted that the separation between product- and process-related R&D in services is somewhat different from manufacturing, since the 'product' of a service firm often constitutes a process.

It is obvious that office automatization is more important to services than to manufacturing. For production automatization the opposite may hold. Interesting to note is that for office automatization in services and for production automatization in manufacturing, the positive effects on employment seem to dominate. Of course, our dummy variable only measures whether the acquisition of automatization equipment prior to 1988 was considered 'important' by the firm. Moreover, it remains open whether these employment gains are indeed due to an 'autonomous' growth of sales because of lower prices (Engel curve) or whether the employment gains are due to market shares lost by competitors (creative destruction). As a consequence, one needs to be careful when translating such findings to the macro-level.

Both in manufacturing and in services, employment growth in the group of firms with 50-199 persons does not differ from the reference group (10-49 persons), implying that firms with 10-199 employees have the same employment growth. The same holds for firms with 2.000 or more employees in manufacturing. However, the group of intermediate size (200-1.999 employees) has a lower employment growth. In other words, the smaller (<200) and the larger (2.000 employees and more) firms have a more favourable employment record than firms of intermediate size (200-1.999 workers). Within services, all the larger size classes have significantly lower rates of employment growth which allows the conclusion that smaller firms in services (up to 200 persons) contribute more to overall employment growth than medium-sized and large firms do.

Table 12: Factors which influence employment growth in manufacturing and service firms (1988-92). Summary of maximum likelihood estimates (simultaneous estimate of probit and ols parts)

a) Probit estimate for firms which disappear from the panel

	Manufacturing		Services	
	coeff.	t-value	coeff.	t-value
intercept	-0,17	-3,11	-0,22	-2,80
firm size (employees)	-0,001	-0,003	-0,23	-3,29
firms belonging to a group	-0,03	-0,63	-0,20	-2,99
sector dummies (manufacturing):				
- food & beverages	-0,27	-3,08	-	-
- textiles, clothing, shoes and leather goods	-0,05	-0,50	-	-
- wood, furniture, paper, printing	0,007	0,09	-	-
- chemicals, petroleum refineries, fibres, plastics & rubber	-0,06	-0,68	-	-
- construction materials, glass, earthenware	0,08	0,73	-	-
- basic metals, metal goods	-0,03	-0,33	-	-
- machinery, electrotechnical & electronics industry, transportation equipment, instruments, etc.	reference group		·	-
sector dummies (services):				
- public utility enterprises	-	-	-0,10	-0,45
- construction, installation	-	-	0,43	3,82
- wholesale and intermediate trade	-	-	0,23	2,14
- retail trade, hotels, restaurants, repair shops	-	-	0,09	0,84
- transport, communication	-	-	0,21	2,02
- banks, insurances, brokers, rental & leasing companies, holdings	-	-	0,09	0,93
- non-commercial services	-	-	reference group	

b) Factors which account for employment growth

	Manufacturing		Services	
	coeff.	t-value	coeff.	t-value
intercept	-0,06	-6,38	-0,02	-0,53
product-R&D intensity	0,18	2,75	0,32	1,71
process-R&D intensity	0,41	1,74	1,16	2,39
important investment in office automatization	0,007	1,28	0,02	2,12
important investment in production automatization	0,01	2,39	0,02	1,37
dummies for firm size classes (reference group: less than 50 employees):				
- 50-199 employees	-0,005	-0,79	-0,01	-1,40
- 200-499 employees	-0,03	-4,02	-0,04	-2,34
- 500-1.999 employees	-0,04	-3,47	-0,10	-5,47
- 2.000 or more employees	0,01	0,31	-0,18	-3,57
sigma	0,09	22,75	0,13	3,14
Rho	0,78	18,46	0,24	62,55

6.2 Firm level evidence for Germany 1992-1994

Product innovations are frequently seen as prerequisites for creating new jobs and preserving old ones, whereas process innovations are usually ascribed an adverse effect on employment levels. Based on the literature review in chapter 2 and 3 of this paper this thesis often guidelines public debate on innovation. As also clearly shown in this report, economic theory does not allow this conclusion: the influence of innovations upon employment levels depends on a complex interweaving of direct and indirect effects, on the structure and demand/supply conditions exhibited by goods and labour markets, and of course, on the characteristics of the innovations themselves. Nor does empirical economic research have any simple answers to offer in relation to the consequences on employment of innovation activity: the answers will depend inter alia on the level of analysis, the time period concerned and last but not least on the methodology selected and the extent of the effects covered.

In view of the complex causal interrelationships involved, it would appear appropriate to address another problem with the data from the German Innovation Panel. Almost all studies on a corporate level conclude that employment trends are dominated by sales trends. The analysis below will accordingly focus on this interrelationship. As a new element, we examine whether this interrelationship differs by the types of innovation. We ask whether product innovators differ from non-innovating companies and companies that only performed process innovation. Moreover, we investigate whether the newness of the innovation concerned is a factor in this context. In view of the ongoing debate on the future of Germany's industrial base, we also examine whether product innovators exhibit a different reaction to a change in labour costs in terms of employment than non-innovating companies and companies only implementing process innovations do.

A recession will produce short-term, severe fluctuations in employment levels and sales. Workforces cannot be adjusted accordingly. This is why we use the growth in employment from 1992 to 1994 instead of yearly growth rates. We examine the demand for labour separately in the west and east of Germany. The explanatory variables used are development in real labour costs (separately for product innovators and non-innovators (including pure process innovators)) and real sales growth.

The development in sales is broken down into the changes attributable to new or significantly improved products, to improved products, and to unchanged or insignificantly modified products. The item new or significantly improved products capture either products new to the firm or products which have been significantly improved in recent years. So, this type of output refers to innovation which is usually not performed on a continuous basis but only at some points in time. This covers market innovation as well as diffusion activities. The item improved products refers to ongoing, marginal improvements typically made in the time interval between major innovative steps.

Since it is a three-year period under review when examining sales with new or significantly improved products, with twenty-four months between the years under comparison, the majority of the new or significantly improved products involved will be different ones. Sales of new or improved products during the years 1992 - 1994 are compared with sales of new or significantly improved products in the years 1990 - 1992. Sales trends with unchanged or insignificantly modified products are represented using two indices: one for product innovators and one for non-innovators. The sales indices are deflated with sector-specific producer prices.

When new products represent market innovations, a company is at least temporarily in a (quasi-) monopolistic position, and can earn monopoly profits not available to non-innovators. This enables product innovators to pay higher wages (including auxilliary staff costs). At the same time, manufacturing of new products requires more highly qualified employees, who will usually be more expensive. So, although the absolute level of labour costs is not incorporated in the employment equation, in principle, monopoly profits could enable a company to react less markedly in the short term to changes in labour costs.

In addition, size classes (number of employees) are taken into account: this reflects the fact that changes in labour costs and sales alone are not sufficient to explain trends in employment levels. In West Germany, employment levels in large companies fell more sharply than in small firms, even if they did not differ in their sales and labour cost trends as postulated in the multivariate analysis (see Table 13a and 13b). In companies employing more than 500 people, total employment dropped by almost six percent between 1992 and 1994 (i.e. by three percent per annum on average), and by three percent in companies employing 50 - 500 people. Companies with fewer than 50 employees exhibit no decline in payroll. This trend is partially attributable to the traditionally greater influence exerted by the trade unions in large companies, which tends to militate against continuous changes in payroll sizing. In a crisis, large companies find it easier to push through rationalization and reorganization programmes.

Table A13: Changes in employment level, sales growth and labour costs - OLS regression results

Dependent variable: growth in employment 1992 - 1994	West Germany	East Germany
Number of observations	443	220
Corrected coefficient of determination $(\overline{R}^2)$	0.3908	0.4758
Growth in sales due to		
new or significantly improved products	0.3636* (0.0493)	0.3017* (0.0421)
improved products	0.4191* (0.0453)	0.3507* (0.0538)
unchanged or marginally changed products of innovators	0.4334* (0.0442)	0.2515* (0.0466)
unchanged or marginally changed products of other companies	0.4012* (0.0446)	0.2577* (0.0375)
real increase in labour costs	-0.2232* (0.0268)	-0.2094* (0.0422)
Size classes (number of employees)		
5 to under 50	0.0075 (0.0128)	0.0358 (0.0285)
50 to under 250	-0.0211* (0.0120)	-0.0996* (0.0277)
250 to under 500	-0.0246 (0.0182)	-0.2569* (0.0596)
500 or more	-0.0566* (0.0138)	-0.2711* (0.0521)

Source: ZEW (1996): Mannheim Innovation Panel

Notes: Standard error in brackets,
* significant to 95% level

Table 13b: The influence of sales growth and increases in labour costs on employment between 1992 and 1994

		Change in employment (full-time equivalents) West Germany	East Germany
		in %	
A 1-percent increase ...		leads to a change in the number of employed by ... percent	
in sales due to ...	new or significantly improved products	0.36	0.31
	improved products	0.42	0.35
	unchanged or marginally changed products (of product innovators)	0.43	0.25
	unchanged or marginally changed products (of non-innovators and pure process innovators)	0.40	0.26
of real labour costs		-0.22	-0.21
A company's inclusion in the ...		leads to a change in the number of employed by ... percent[1]	
size class	5 to under 50	0.01	0.04
	50 to under 250	-0.02	-0.10
	250 to under 500	-0.02	-0.26
	500 or more	-0.06	-0.27

Source: ZEW (1996): Mannheim Innovation Panel

[1] In the 2-year-period 1992 - 1994, i.e. per annum half on average

The elasticity of labour costs is minus 22 percent both with product innovators and other companies as well. This means that an increase of 1 percent in real labour costs results in payroll downsizing of 0.22 per cent. The employment equation utilized is not an employment-related question in the sense that the intended reactions of the companies surveyed are requested; on the contrary, the equation retrospectively analyses what actually happened. This is why the labour supply is also a factor in labour cost elasticity. The dramatic fall in employment levels, not primarily attributable to changes in labour costs, may have released sufficient highly qualified human resources (or caused them to see their jobs as threatened) to suppress conceivable differences in the labour cost responsiveness of product innovators and non-innovators or pure process innovators.

The sales elasticities do not differ significantly: 1 percent growth in sales results in 0.4 percent more employment on average. This figure seems low at first glance, but accords with the results of numerous other studies. Sales growth of 2.5 to 3 percent is required to keep employment levels stable. It can also be hypothesized that companies refrained from complete payroll downsizing during the recession, hoping for a future recovery in sales. Without a substantial upturn in demand, intra-company underutilization will continue to be reduced.[1] The sales elasticities of product innovators fall with the product's age, i.e. the new or significantly improved products of the years 1992 - 1994 require less labour for their manufacture than the new or significantly improved products of the years 1990 - 1992 do. This is the case with improved products, too. This indicates that when improving their products companies endeavour to reduce the workload involved, as well. The sales elasticity of non-innovators and pure process innovators is even lower than the sales elasticity due to new or improved products of product innovators. It may be that intra-company underutilization is higher with non-innovators than with product innovators. Lack of capital prevents some non-innovators from introducing (rationalization or) process innovations, so that these companies downsize their payrolls primarily by means of natural fluctuation. A relatively small sales elasticity of pure process innovators is not surprising, since process innovations increase the capital-labour ratio.

The last section established that employment is essentially determined by changes in sales. Product innovations should involve growth in sales, provided they are not simply replacing old products. In actual fact, product innovators are expecting significantly better increases in sales than non-innovators and pure process innovators in both the west and the east of Germany for the period of 1995 to 1997 (see Table 14). However, when sectoral factors and company sizes are explicitly taken into account, product innovators expect better employment levels only in the west of Germany.

1 There are several studies in the literature which reveal similar low sales elasticities in the troughs of the business cycle or during a recession. When the person-hours actually worked are taken into account, these elasticities are higher (cf., for example, König and Pohlmeier (1988)).

Table 14: Sales and employment expectations in the manufacturing sector 1995-1997

Change	Manufacturing sector					
			of which			
	all companies		Non-innovators and pure process innovators		Product innovators	
	Sales	Employees	Sales	Employees	Sales	Employees
	in %					
West Germany						
substantial increase	7	1	3	0	12	1
slight increase	44	26	33	21	60	35
no change	31	49	40	54	19	41
slight decrease	13	19	16	19	9	20
substantial decrease	5	5	8	6	0	3
East Germany						
substantial increase	11	3	10	5	13	0
slight increase	59	32	53	35	67	33
no change	22	48	27	46	15	49
slight decrease	6	12	8	9	3	14
substantial decrease	2	5	2	5	2	4

Source: ZEW (1996): Mannheim Innovation Panel; figures weighted with the number of employees

The larger a company, the better its sales expectations, and the worse its employment expectations, in both the west and the east of Germany. In the country's western Laender, pessimistic sales and employment expectations are particularly prevalent in the textile and clothing industries and among the automotive industry's suppliers, followed by the food industry and the rock, stone and related mineral products sector. In the east of Germany, the textile and clothing industries likewise report the most pessimistic prognoses, followed by the food industry. This again points towards a more intense pressure on employment in large firms.

The results of this section can be briefly summarized: Product innovating companies seem to have better prospects of developing in sales than non-innovating companies. But, depending on the character of innovation, the degree to which sales are transform to employment differs within the group of product innovating companies. Mostly remarkable, large steps in product innovation go hand in hand with process improvement, so that product innovation is accompanied by an improvement in the efficiency of production process. An increase in demand for a new product leads to less employment growth than the same sales growth with old or only marginally improved products.

7 Summary and Conclusions

The Commission aims at creating 15 millions new jobs in Europe by the end of the century. This is necessary to reduce the number of unemployed in Europe which is, for instance, very much higher compared to the USA. The US-unemployment-rate was 5.6% on average in 1995 with a declining tendency since then; in Europe the unemployment rate was 10.8% on average with a rising tendency. The unemployment rates in the European Union states are, of course, diverse. They reach from 22.2% in Spain to 4% in Luxembourg. To fight unemployment it is therefore necessary either to create jobs in countries or regions where unemployment is high or to contribute to worker mobility.

It is obvious that the Commission as well as the governments of the member states influence labour and products markets to a large extent. The share of GNP which is controlled by government consists of approximately 48% in Europe. Therefore governments are also partially responsible for employment. Furthermore, most governments in Europe are responsible for schooling and training and for major interventions in technological development and research which is not restricted to universities. How can the government and the Commission fulfill their role in creating the best possible employment situation? Do traditional policies have to be changed? Is it necessary to think about new priorities and how can labour market policies best be integrated in research and development programms? The answers must be found for national policies of 15 member states as well as for the Commission itself.

This study concentrates on the economic impact of innovation on employment. It presents an overview over how economists perceive the relationship between technological change and employment and the empirical discoveries made. In a second step, the impact of innovation on employment is examined for eight member states building on a unique dataset: the Community Innovation Survey. The CIS has been given in order to provide the Commission with a strong analytic tool for improving policy measures. The CIS dataset was conducted in 1993. It has been provided for the current study by EUROSTAT. Moreover, to obtain some insights into the dynamics of innovation and employment we use panel data on innovation from the Netherlands and Germany to address certain aspects which is not possible using CIS-data because CIS only offers data for one year.

In the meanwhile, the European Union has reached a number of 15, the east enlargement being on the political agenda. Critics are right in pointing to the fact that the analysis of 1993 data is only of historical value. The crucial question, however, is whether there are regularities in the complex economic system which are valid today. It is the task of empirical economics to find such regularities. So, while it is definitely true that some parameters of the economic system have changed since 1993, the same cannot be said for the structure of economies, the complex system of thousands and millions of relationships, formal and informal rules and patterns governing individual, firm and government, not in three or even five years. Insofar, community innovation survey data helps to uncover such regularities connected to innovation processes at firm level. One the other hand, innovation surveys like the CIS do not tend to cover the service sector, which has been the most dynamic sector of all economies in the last decade.

The study furthermore concentrates on short-run direct impacts of innovation on employment at microlevel. Long-run impacts and indirect impacts at micro- or macrolevel, often coming with a time lag, cannot be investigated. In this sense, the study should not be viewed as the final result of a research program, but as a starting point. The role of fiscal and monetary policies, which are responsible for macroeconomic development, stability and therefore for employment, is not addressed. Likewise the effect of regulation on innovation is not covered by our approach but is surely of crucial importance for stimulating growth in Europe's economies. Macroeconomic framework conditions and regulation are important for the labour market, at least since they play a major role for firm investment decision and exchange rates.

Innovation, be it improved processes, products or totally new products, is one important key to more employment in the short and long-run. The second key is an improved competition in the product and labour market. A third key, which will not be discussed in the following, is an enhancement of macroeconomic demand through government without changing technology and goods. In fact, the first strategy, if successful, is obviously of a similar type to strategy three. It results in the creation of new markets and a rise in technological productivity.

From a practical point of view, the two strategies are interrelated and cannot be assessed separately. From a policy point of view, it is important to know whether the two strategies help each other in raising employment, whether they are neutral or even detrimental in nature; all depending on the action undertaken, technology and economic behaviour. Furthermore, in an open economy, innovation from abroad may pose a difficult question, if trade leads to substitution of superior foreign goods or processes. This question, however, is not addressed in the current analysis.

The promotion of innovation by the Commission or the member states may result in a higher competition between firms in some product markets, since new or improved products may be superior compared to old ones. If the degree of substitution is high, it is likely that net employment gain at the firm or the industry level will be made from innovation. Firms producing old products or using poor technology will disappear from the market. New firms with new products or improved technology will take their place. It is important to recognize that product innovations do not ensure more employment as the Commissions Green Paper on Innovation suggests. Whether there is a net gain in employment depends on the nature of the new products and overall demand. If new products are complementary to old ones, the net impact is likely to be positive. In addition, if new products generate new income, this new income will induce positive demand effects at economy-wide level and will therefore increase employment in turn.

A similar argument holds for process innovation. If firms improve their productivity, they are able to produce the same amount of goods with at least one input factor less. Firms can reduce output prices, they sell more of their products which in turn has a positive effect on labour demand. Moreover, lower prices will enable down-stream firms to lower costs, inducing an additional positive employment effect. If lower production costs induce a higher output level of the innovative company, up-stream suppliers will increase their business which in turn enhances employment. Whether there is a net gain in employment depends on the rise in demand and the reaction of competitors. In any case, firms who are not able to follow technological progress will disappear from the market which also will affect up- and downstream firms.

Therefore, product as well process innovations are crucial elements of the dynamics of market economies. Innovation continually generates, destroys and reallocates jobs. Hence, flexibility in the product, labour and capital markets is a decisive precondition for a positive impact of innovation on employment.

In Europe wages are inflexible downwards and - seen from an international perspective - wage as well as non-wage labour costs are high in most countries. The introduction of new products or the start up of new firms producing new goods is only possible for such new ventures where high labour costs can be paid. Therefore, new labour intensive methods of production, especially in personal services, demonstrate very low dynamics in many of Europe's economies. Furthermore, for the same reason labour saving process innovations are rather attractive to economize on the cost of labour. In times of labour shortage or high wages, technological change is directed at rationalization. Rationalization is inherently skill-biased. It favours high-skilled instead of low-skilled labour since more complex technologies need more higher skilled and often scientifically educated labour. In times of high unemployment, where unemployment is a problem of the lower skilled as well as young inexperienced people, it is necessary to 'redirect' technological change to more labour intensive production methods where lower labour costs seems to be an important device.

Recent studies show that shift of labour demand in favour of higher skilled works is not only caused by relative labour cost. New technologies, especially information and communication technologies, fosters this shift toward high-quality jobs in manufacturing as well as in services. Hence, educational policies will become even more important in the future. On-the-job and ongoing learning will become even more important in the light of technical change to provide an on-going update of the skills of workers. Bringing the unemployed as well as the young people back to work is of crucial importance. Flexibility in unions wage policy would be a necessary complement for an employment enhancing innovation policy strategies. Furthermore, intra- and inter-industry shifts in labour demand can be supported by a credible policy by the government to lower the non-wage cost of labour.

Furthermore, innovation policy should be directed at those new products having a high likelihood of not acting as substitutes for already produced products but satisfying new customer need. In addition, if new (intermediate) products will help to increase the efficiency of down-stream firms, the positive employment effect in the product innovation sector must be related to the process innovative sector which uses the more efficient product to improve production technology and thereby probably reduces employment. Although our estimates imply product innovation promotion to be a preferable strategy, this seems impossible to implement in practice and doubtful when seen from the general perspective of the whole economy.

Process innovations have a negative impact on employment if turnover stay constant. However, process innovations are necessary for firms to stay or become competitive. Discrimination of process innovations when compared to product innovations can, therefore, have a negative effect on the global competitiveness of Europe's enterprises. Furthermore, even in shrinking sectors, process innovation is called for to slow-down the otherwise more rapid output and employment decline.

Globalisation hits Europe's large enterprises harder than SME operating in market niches or local market. Therefore, large firms are forced to make a lot of effort in rationalization. They furthermore globalize their production activities to become even more competitive in the world market, to profit from international differences in labour costs and to realize gains from being near to the market. Process innovation, therefore, seems to be an important tool for improving Europe's advantage as the location of industrial production.

Given the large labour differences within Europe, intra-European shifts of production facilities will be persistent in the future. Although this regional reallocation of labour within Europe will hurt the employee in the country where production is moving out, this reallocation will be profitable seen from a European point of view. Additional demand created in the 'new home' country of the production facility will also help to increase aggregate demand in Europe as a whole. But again, flexibility in the labour market seems to be necessary to cope with the - temporary - problems caused by regional reallocation of production.

Therefore, increasing flexibility in the labour market is the key element for new jobs because it fosters the intra- and intersectoral shifts of employment caused by innovation as well as interregional employment shifts. More flexibility in the labour market especially in the form of lower wages for less qualified labour also seems to be a key element in the strategy of generating new lower paid jobs in services. The effect of lower wage on the net income of unqualified workers or workers with outdated skills can be reduced e.g. by a negative income tax. In any case as many regulations in the labour market are more motivated by a social policy aspect and less by the labour market considerations, it seems to be a preferable strategy to loosen the ties between labour market and social policy goals.

Flexibility in the labour market can also be enhanced by putting more weight on education and training. Reallocation process induced by innovation will increase the depreciation rate of existing skills. Reducing government subsidies for education and training in the light of the financial budget constraints will turn out to be the wrong strategy in the long-run. The government's expenditures on human capital formation, conservation and the rebuilding of human capital should be increased instead.

A third key for more employment through innovation in Europe is a reduction of the complicated net of regulations in Europe's economies, e.g. deregulation in the telecommunications or the banking sector would stimulate growth through innovation. The rapid expansion of the telecom-sector in Germany after deregulation is one example of how to achieve higher employment by removing regulative barriers in the product markets. Therefore, one central field of action for the Commission should be to foster the deregulation process in Europe's economies. Deregulation seems to be especially called for in services to induce new markets for the innovative products and services. Innovations rooted in deregulation will probably induce a generation of new products and services. These will have only a minor degree of substition and, thus, meet one of the preconditions for a labour generating direct effect by product innovation.

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9 Appendices: Tables and Statistics

Table A1: International Standard Industrial Classification Of All Economic Activities (ISIC-1968)

Major Division 1. Agriculture, Hunting, Forestry And Fishing

Agriculture and Hunting
- Agricultural and livestock production
- Agricultural services
- Hunting, trapping and game propagation

Forestry and Logging
- Forestry
- Logging

Fishing

Major Division 2. Mining And Quarrying

Coal Mining
Crude Petroleum and Natural Gas Production
Metal Ore Mining
Other Mining

Major Division 3. Manufacturing

Manufacture of Food, Beverages and Tobacco
- Food manufacturing
- Beverage industries
- Tobacco manufactures

Textile, Wearing Apparel and Leather Industries
- Manufacture of textiles
- Manufacture of wearing apparel, except footwear
- Manufacture of leather and products of leather, leather substitutes and fur, except footwear and wearing apparel
- Manufacture of footwear, except vulcanized or moulded rubber or plastic footwear

Manufacture of Wood and Wood Products, including Furniture
- Manufacture of wood and wood and cork products, except furniture
- Manufacture of furniture and fixtures, except primarily of metal

Manufacture of Paper and Paper Products, Printing and Publishing
- Manufacture of paper and paper products
- Printing, publishing and allied industries

Manufacture of Chemicals and Chemical, Petroleum, Coal, Rubber and Plastic Products
- Manufacture of industrial chemicals
- Manufacture of other chemical products
- Petroleum refineries
- Manufacture of miscellaneous products of petroleum and coal
- Manufacture of rubber products
- Manufacture of plastic products not elsewhere classified

Manufacture of non-metallic Mineral Products, except Products of Petroleum and Coal
- Manufacture of pottery, china and earthenware
- Manufacture of glass and glass products
- Manufacture of other non-metallic mineral products

Basic Metal Industries
- Iron and steel basic industries
- Non-ferrous metal basic industries

Manufacture of Fabricated Metal Products, Machinery and Equipment
- Manufacture of fabricated metal products, except machinery and equipment
- Manufacture of machinery except electrical
- Manufacture of electrical machinery apparatus, appliances and supplies
- Manufacture of transport equipment
- Manufacture of professional and scientific and measuring and controlling equipment not elsewhere classified, and of photographic and optical goods

Other Manufacturing Industries

Major Division 4. Electricity, Gas And Water
Electricity, Gas and Steam
Water Works and Supply

Major Division 5. Construction
Construction

Major Division 6. Wholesale And Retail Trade And Restaurants And Hotels
Wholesale Trade
Retail Trade
Restaurants and Hotels
- Restaurants, cafés and other eating and drinking places
- Hotels, rooming houses, camps and other lodging places

Major Division 7. Transport, Storage And Communication
Transport and Storage
- Land transport
- Water transport
- Air transport
- Services allied to transport

Communication

Major Division 8. Financing, Insurance, Real Estate And Business Services
Financial Institutions
Insurance
Real Estate and Business Services
- Real estate
- Business services except machinery and equipment rental and leasing
- Machinery and equipment rental and leasing

Major Division 9. Community, Social And Personal Services
Public Administration and Defence
Sanitary and Similar Services
Social and related Community Services
- Educations services
- Research and scientific institutes
- Medical, dental, other health and veterinary services
- Welfare institutions
- Business, professional and labour associations
- Other social and related community services

Recreational and Cultural Services
- Motion picture and other entertainment services

Libraries, museums, botanical and zoological gardens, and other cultural services not elsewhere classified
Amusement and recreational services not elsewhere classified
Personal and Household Services
Repair services not elsewhere classified
Laundries, laundry services, and cleaning and dyeing plants
Domestic services
Miscellaneous personal services
International and Other Extra-Territorial Bodies

Major Division 0. Activities Not Adequately Defined

Table A2: International Standard Classification Of Occupations (ISCO-1968)

Major Group 0/1 Professional, Technical And Related Workers
Physical scientists and related technicians
Architects, engineers and related technicians
Aircraft and ships' officers
Life scientists and related technicians
Medical, dental, veterinary and related workers
Statisticians, mathematicians, systems analysts and related technicians
Economists, accountants, jurists
Teachers, workers in religion
Authors, journalists and related writers
Sculptors, painters, photographers and related creative artists
Composers and performing artists
Athletes, sportsmen and related workers
Professional, technical and related workers not elsewhere classified

Major Group 2 Administrative And Managerial Workers
Legislative officials and government administrators
Managers

Major Group 3 Clerical And Related Workers
Clerical supervisors
Government executive officials
Stenographers, typists and card- and tape-punching machine operators
Bookkeepers, cashiers and related workers
Computing machine operators
Transport and communications supervisors
Transport conductors
Mail distribution clerks
Telephone and telegraph operators
Clerical related workers not elsewhere classified

Major Group 4 Sales Workers
Managers (wholesale and retail trade)
Working proprietors (wholesale and retail trade)
Sales supervisors and buyers
Technical salesman, commercial travellers and manufacturers' agents
Insurance, real estate, securities and business services salesmen and auctioneers
Salesmen, shop assistants and related workers
Sales workers not elsewhere classified

Major Group 5 Service Workers
Managers (catering and lodging services)
Working proprietors (catering and lodging services)
Housekeeping and related service supervisors
Cooks, waiters, bartenders and related workers
Maids and related housekeeping service workers not elsewhere classified
Building caretakers, tearjerkers, cleaners and related workers
Launderers, dry-cleaners and pressers

Hairdressers, barbers, beauticians and related workers
Protective service workers
Service workers not elsewhere classified

Major Group 6 Agriculture, Animal Husbandry And Forestry Workers, Fishermen And Hunters
Farm managers and supervisors
Farmers
Agriculture and animal husbandry workers
Forestry workers
Fishermen, hunters and related workers

Major Group 7/8/9 Production And Related Workers, Transport Equipment Operators And Labourers
Production supervisors and general foremen
Miners, quarrymen, well drillers and related workers
Metal processors
Wood preparation workers and paper makers
Chemical processers and related workers
Spinners, weavers, knitters, dyers and related workers
Shoemakers and leather goods makers
Cabinetmakers and related woodworkers
Stone cutters and carvers
Blacksmiths, toolmakers and machine-tool operators
Machinery fitters, machine assemblers and precision instrument makers (except electrical)
Electrical fitters and related electrical and electronics workers
Broadcasting station and sound equipment operators and cinema projectionists
Plumbers, welders, sheet metal and structural metal preparers and erectors
Jewellery and precious metal workers
Glass formers, potters and related workers
Rubber and plastics product makers
Paper and paperboard products makers
Printers and related workers; painters
Production and related workers not elsewhere classified
Bricklayers, carpenters and other construction workers
Stationary engine and related equipment operators
Material-handling and related equipment operators, dockers and freight handlers
Transport equipment operators
Labourers not elsewhere classified

Major Group X Workers Not Classifiable By Occupation
New workers seeking employment
Workers reporting occupations unidentifiable or inadequately described
Workers not reporting any occupation

Armed Forces Members Of The Armed Forces

Table A3: Classification of industries by technological standard

Group	ISIC Rev.2	Sector
High and Medium-Tech Industries	351	Industrial Chemicals
	352	Other Chemicals
	382	Non-Electrical Machinery
	383	Electrical Machinery
	384	Transport Equipment
	385	Professional Goods
	384	Transport Equipment ex 3841
Low-Tech Industries	31	Food, Beverages & Tobacco
	32	Textiles, Apparel & Leather
	33	Wood Products & Furniture
	34	Paper, Paper Products & Printing
	353	Petroleum Refineries
	354	Petroleum & Coal Products
	355	Rubber Products
	356	Plastic Products, nec
	36	Non-Metallic Mineral Products
	37	Basic Metal Industries
	381	Metal Products
	3841	Shipbuilding & Repairing

Source: Grupp and Gehrke (1995).

Table A4: Employment changes in high-, medium- and low-tech manufacturing sectors

Country		71-73	74-76	77-79	80-82	83-85	86-88	89-91	70-91[a]
AUSTRIA	HM	5,1	-0,8	1,6	0,5	-0,4	-0,8	1,9	0,9
	Low	1,1	-1,6	-0,7	-1,6	-1,8	-2,0	0,0	-1,0
BELGIUM	HM	2,4	-1,1	-1,7	-3,0	-1,0	-0,7	-0,3	-0,7
	Low	-1,1	-3,8	-4,4	-4,3	-1,9	-2,0	0,6	-2,4
DENMARK	HM	1,5	-3,0	1,9	-0,9	5,3	0,9	-1,8	0,5
	Low	-0,8	-4,0	-1,3	-2,4	2,9	-0,5	-3,0	-1,3
FRANCE	HM	3,1	0,4	-0,7	-1,6	-2,1	-2,4	0,3	-0,5
	Low	1,1	-1,4	-1,3	-2,3	-2,8	-1,6	-0,5	-1,3
GERMANY	HM	0,0	-2,0	1,2	-0,2	0,3	2,0	1,7	0,4
	Low	-1,1	-4,6	-0,1	-2,1	-1,8	-0,8	2,2	-1,2
ITALY	HM	1,3	2,9	1,3	-3,0	-3,1	0,0	-0,8	-0,4
	Low	0,4	0,8	0,9	-1,1	-3,3	0,0	-0,3	-0,5
JAPAN	HM	1,3	-2,9	-0,2	4,2	4,3	0,6	2,9	1,4
	Low	1,6	-2,1	-1,2	-0,7	0,3	-0,1	1,6	-0,1
NETHERLANDS	HM	0,1	-0,3	-0,9	-2,2	-0,2	1,4	1,5	-0,4
	Low	-2,1	-3,6	-2,5	-3,1	-1,7	1,0	0,6	-1,6
NORWAY	HM	1,3	4,0	0,8	0,4	2,1	-1,8	-3,6	0,4
	Low	-0,2	-1,0	-2,1	-2,5	-3,2	-0,9	-4,4	-1,9
PORTUGAL	HM		3,8	5,2	3,2	-4,2			1,5
	Low		1,4	2,2	0,1	-1,6			0,2
SPAIN	HM				-0,3	-3,0	3,0	2,9	0,5
	Low				-6,2	-4,6	2,0	0,3	-2,2
SWEDEN	HM	0,2	2,9	-0,5	-1,2	0,6	2,4		0,6
	Low	-1,8	-0,1	-2,9	-3,0	0,2	0,9		-1,2
UK	HM			0,8	-6,5	-2,3	-0,7	-1,7	-2,1
	Low			-0,9	-6,6	-2,7	-0,7	-2,7	-2,8
USA	HM	0,9	-1,5	5,5	-2,9	1,6	-0,6	-2,0	0,1
	Low	1,4	-1,8	2,3	-4,2	0,4	1,4	-1,4	-0,3

Source:OECD STAN Database, own calculation; geometric means in percent; larger values of high- and medium-technology sectors respectively, low-technolgy-sectors are shaded;

notes: [a] The geometric mean for Portugal is calculated for 1973-1988. Spain 79-91; Sweden 70-90; UK 76-91. HM: High and Medium-Tech Industries; Low: Low-Tech Industries (cf.Table A3)

Table A5: Labour productivity changes in high-, medium- and low-tech manufacturing sectors

Country		71-73	74-76	77-79	80-82	83-85	86-88	89-91	70-91[a]
BELGIUM	HM	9,5	4,9	6,9	6,7	5,9	1,7	2,1	5,3
	Low	6,0	4,1	5,1	4,9	3,9	5,9	1,2	4,4
DENMARK	HM	4,9	7,1	-1,2	4,6	-0,7	-2,3	0,2	1,8
	Low	5,6	4,3	3,8	1,9	2,3	-0,3	3,0	2,9
FRANCE	HM	4,3	4,1	4,4	2,3	2,8	5,3	1,4	3,6
	Low	5,0	2,9	3,4	1,7	1,3	2,5	2,4	2,8
GERMANY	HM	4,9	3,7	2,2	-0,3	3,9	-0,5	2,4	2,3
	Low	3,5	4,3	2,7	-1,6	3,2	1,1	2,1	2,1
ITALY	HM	2,4	-1,8	3,2	5,9	9,5	5,6	2,4	4,1
	Low	4,2	1,3	1,3	1,1	4,5	4,1	2,2	2,8
JAPAN	HM	9,2	9,4	8,4	5,8	6,8	6,4	7,9	7,7
	Low	6,7	0,3	5,4	2,4	2,3	2,0	2,4	3,0
NETHERLAND	HM	5,1	1,4	3,6	3,4	4,4	-1,1	1,2	2,9
	Low	5,5	4,5	3,8	0,3	4,1	2,1	2,1	3,1
NORWAY	HM	5,9	1,2	-1,1	2,8	4,4	0,1	4,4	2,5
	Low	4,4	1,1	1,3	0,2	4,7	0,2	2,4	1,9
PORTUGAL	HM				0,5	0,5			
	Low				1,2	1,8			
SWEDEN	HM	4,2	0,9	-1,4	1,9	5,3	-0,4		1,4
	Low	3,5	0,6	2,9	1,5	4,1	1,5		1,9
UK	HM			-0,1	3,4	7,8	4,4	2,9	3,5
	Low			1,8	2,5	5,9	4,5	2,2	3,2
USA	HM	6,8	0,2	-0,7	0,6	4,5	6,3	1,7	2,7
	Low	3,1	0,2	1,1	0,8	2,6	1,9	0,5	1,4

Source: OECD STAN Database, own calculation; geometric means in percent; larger value of HM and Low in absolute terms is shaded;

notes: [a] The geometric mean for Portugal is calculated for 1979-1985. Sweden 70-90; UK 76-91.
HM: High and Medium-Tech Industries; Low: Low-Tech Industries (cf. Table A3)

Table A6: Summary of studies, databases and econometric methods

Authors / country	Database and sample	Empirical tools
Allen (1992) US	Data obtained from the Current Population Survey 1979 and 1989, Innovation indicators published by the National Science Foundation	Descriptive statistics and Ordinary Least Squares (OLS) regressions for wage functions
Blechinger and Pfeiffer (1996), Germany	Mannheimer Innovation Panel (1995)	Descriptive statistics and regression analysis of translog production function.
Brainard and Fullgrabe (1986) OECD countries	Summary of results of recent studies (OECD, various authors) Data obtained from Yearbook of Labour Statistics	Descriptive statistics
Brouwer, Kleinknecht and Reijnen (1993) Netherlands	Postal survey of 859 Dutch manufacturing firms with 10 and more employees in 1983 and 1988	Two-stage estimation Probit Model to control for selectivity bias (firm does not close down) OLS Model for determinants of growth rate of employment
Campbell (1993) United Kingdom	Survey of face to face interviews with a representative sample of 1.951 regional company establishments in 1991	Descriptive Statistics
Edler et al. (1989) Germany	Data obtained from various official sources and institutes as well as firm-based interviews.	Macroeconomic econometric model, sectoral disaggregated econometric model, input-output analysis
Entorf and Pohlmeier (1990) Germany	2.276 West German firms collected by the IFO Institute Munich in 1984, data on the export share of sales, average labour costs per employee and the share of the three largest firms in total sales of the sector at the two-digit level obtained from the German Statistical Yearbook and the German Monopolcommission	Estimation of a reduced form three-equation Probit Model in the reduced form Estimation of Generalized Least Squares)GLS)-Models for product and process innovation in the structural form
Ewers, Becker and Fritsch (1989) Germany	Postal survey of 3.300 industrial firms with 10 and more employees and 274 case studies	Descriptive statistics
FritzRoy and Funke (1992) Germany	Data on 32 German manufacturing industries obtained from various issues published by the Central Statistical Office and the German Institute for Economic Research for the period of 1978-1990	General Methods of Moments (GMM) estimates of differing elasticities of substitution on the basis of a two-level CES production function.
Greenan and Quellec (1985); France	Paneldata from the French annual business survey (1984-1991)	Descriptive statistic and regression analysis
Höflich-Häberlein and Häbler (1989) Germany	Comtec-Survey (yearly interview of 4.500 firms of the private service sector and the processing industries), 38 case studies / 238 users and 74 non-users	Descriptive statistics
König, Buscher and Licht (1995) Germany	Data about 3.000 industrial firms obtained from the Mannheim Innovation Panel (MIP) and the Mannheim Enterprise Panel (MUP)	Standard OLS and Probit estimations of factor demand functions including the price of capital
Krueger (1993) US	Data obtained from the Current Population Survey 1984 and 1989 as well as High School Survey	Descriptive statistics / various OLS estimations of wage functions for effect of computer use on pay

Kugler and Spycher (1992) Switzerland	Aggregate data obtained from different official sources	Econometric estimation of theoretically derived factor shares (non-linear, three-stage OLS) on the basis of a translog price function
Kugler, Müller and Sheldon (1989) Germany	Seven main groups (SYPRO) of the goods producing sector: Energy and water supply, mining, raw material and production goods, investment goods, consumption goods, food processing and luxury food industry and building trade obtained from the Statistisches Bundesamt for 1960-1981	Model of theoretically derived factor demand equations on the basis of a translog price function
Leo and Steiner (1994) Austria	Data of 400 firms obtained from the Austrian Institute of Economic Research (WIFO) Technology and Innovation Survey, Investment Survey and Business Survey for the period 1990-1992	OLS and multinomial logit models for changes in employment also accounting for lagged effects of innovations
Machin, Ryan, and van Reenen (1996), US, UK, Denmark, Sweden	OECD-STAN Database (1973-1989)	Shift/share analysis and restricted variable translog cost function
Van Reenen (1993) UK	Dataset covering 154 firms, various innovation indicators obtained from Datastream and various official sources	Econometric analyses of labour demand functions
Ronning and Warnken (1989) Germany	Data obtained from the IFO Institute in Munich	Descriptive statistics Cohort analysis for different age groups of employees
Ross and Zimmermann (1993) Germany	Data of 5.011 German manufacturing firms obtained from the IFO Institute in Munich 1980	Binary Probit Model / Categorical Indicator Model for planned stock of labour (constancy versus decline)
Zimmermann (1991) Germany	3.374 firms in 16 German industries obtained business survey provided by the IFO Institute in Munich	Probit-Model for the planned change of the labour stock
Zimmermann (1987) Germany	IFO-Konjunkturtest (1981-1984)	Descriptive statistics Binary Probit Model with planned employment change as an endogenous variable

Table A7: Labour productivity in manufacturing in eight European countries

average labour productivity in thousands ECU (t-statistic in brackets)					
type of firm	innovative activity		employment level:		all
	yes	no	<250	>=250	
Belgium	137.70 *(1.66)*	132.38	130.99 *(3.59***)*	171.76	135.60
Denmark	107.72 *(0.16)*	111.21	108.65 *(1.37)*	116.09	109.27
France	110.02 (1.05)	87.90	93.24 (12.46***)	133.66	96.72
Germany	101.43 (1.05)	96.73	98.01 (7.22***)	115.16	99.99
Italy	142.70 *(13.43***)*	120.64	126.10 *(11.28***)*	167.01	128.14
Luxemburg	161.01 *(0.67)*	131.89	139.07 *(0.32)*	151.32	140.15
Norway	149.77 *(3.91***)*	133.76	135.32 *(3.94***)*	204.07	142.29
Spain	113.88 *(8.01***)*	84.56	93.25 *(5.72***)*	127.59	95.25

Source: CIS, own calculations; the sales number for firms in the Netherlands and in Ireland turned out to be ambiguous, therefore these countries are not contained in the table; labour productivity is defined as the ratio of total sales (in thousands ECU) and employment in the manufacturing sector; average labour productivity is calculated only for firms with 20 and more employees and or firms whose calculated value lay between 5 thousands and 1 million ECU to correct for implausible low or high values; average labour productivity is calculated using the CIS weights; the t-values in brackets in column two and three provide a test against the null hypothesis, that innovative and non-innovative and small and large firms have the same average labour productivity in manufacturing; the test statistic has been calculated without the CIS weights; significant differences at the 1%, 5% and 10% level are indicated by stars *, ** and ***.

Table A8: Definition of the variables used in the sales growth and employment equation

Abbreviations	Definition of variables	sales growth between 1990 and 1992 *(sales growth)*	employment *(labour)*
labour:	number of employees in 1992 (natural logarithm)		*
sales growth:	turnover growth between 1990 and 1992 (in thousands ECU)	*	
sales:	turnover in 1992 (in thousands ECU, natural logarithm)		*
sales_sqrd:	square of turnover in 1992 (in thousands ECU, natural logarithm)		*
sales_mean_c:	average growth rate of gross-national-product in each sector in each country	*	
sales_mean_e:	average growth rate of gross-national-product in each sector in whole Europe	*	
innovative:	1: the enterprise has developed or introduced product or process innovations between 1990-1992, 0: else	*	*
innbas:	1: the enterprise has introduced new or significantly changed products between 1990-1992, 0: else	*	
R&D:	1: innovative enterprises, which additionally are engaged in R&D in 1992, 0: else		*
R&D_process:	1: high share of R&D directed to process innovation (above average in sample), 0: else		*
R&D_high:	1: the innovative enterprise operates in the high tech sector, 0: else	*	
R&D_high_b:	1: the innovative enterprise with radical product innovations operates in the high tech sector, 0: else	*	
lab_costs:	labour costs per employee in 1992 (in thousands ECU, natural logarithm)		*
skill_lack:	1: the lack of skilled personnel is an important barrier to innovative success (above the median of all firms in the sample), 0: else		
finance_lack:	1: the lack of appropriate sources of finance is an important barrier to to innovative success (above the median of all firms in the sample), 0: else		
part:	1: the enterprise is part of a group, 0: else		*
part_moth:	1: the enterprise is the head of a group of enterprises, 0: else		*
export:	1: the enterprise is exporter in 1992: 0: else	*	*
export_30:	1: the enterprise is exporter with an export share higher than 30% of turnover in 1992, 0: else	*	*
ε, η:	normally distributed error term, i.i.d.	*	*

Source: E.C. Harmonised Innovation Surveys 1992/93 - Final Questionaire -.

Table A9: Descriptive statistics of variables used in the employment equation

Variable (observations)	Belgium (557)	Denmark (528)	France (3,600)	Germany (1,807)	Italy (16,374)	Luxemburg (241)	Norway (743)	Spain (1,998)
labour	4.64 (103.54)	4.0 (109.95)	4.37 (79.04)	4.94 (139.77)	3.81 (45.15)	2.67 (14.44)	3.48 (32.46)	4.06 (57.97)
sales	9.31 (11.05mio)	9.20 (9.9mio)	8.82 (6.77mio)	9.27 (10.6mio)	8.38 (3.75mio)	6.98 (1.07mio)	8.14 (3.43mio)	8.384 (4.36mio)
sales_sqrd	90.48	86.49	80.24	90.47	72.15	52.73	69.29	72.13
innovative	0.67	0.62	0.44	0.87	0.45	0.30	0.42	0.44
R&D	0.54	0.48	---[a]	0.65	0.26	0.17	0.28	0.27
R&D_process	0.38	0.34	---[a]	0.40	0.20	0.05	0.19	---[a]
lab_costs	10.22 (27,446)	---[a]	10.24 (28,001)	10.34 (30,946)	9.88 (19,535)	---[a]	10.31 (30,031)	9.70 (16,317)
skill_lack	0.36	0.38	---[a]	0.28	0.30	0.25	0.48	0.43
finance_lack	0.45	0.46	---[a]	0.29	0.60	0.33	0.42	0.67
part	0.54	0.66	0.39	0.30	0.18	0.15	0.45	0.22
part_moth	0.13	0.13	---[a]	0.08	0.04	0.01	0.10	---[a]
export	0.86	0.92	0.73	0.73	0.64	0.57	0.50	0.55
export_30	0.57	0.57	0.19	0.29	0.25	0.26	0.24	0.15

Source: Community Innovation Survey 1993, micro-aggregated data; definition of variables are given in table A8;the original numbers of employment, sales and labour-costs are given in round brackets;
notes: [a] information not available.

Table A10: Descriptive statistics for the variables used in the sales growth equation

Variable (observations)	Belgium (549)	Denmark (532)	France (2,998)	Germany[b] (1,641)	Italy (15,614)	Luxemburg (179)
sales growth	0.12	0.08	0.03	3.37	0.03	0.05
sales_mean_c	-0.0072	0.0014	-0.0472	-0.0083	-0.0057	---[d]
sales_mean_e	0.0037	-0.0118	-0.0110	-0.0278	-0.0058	-0.0382
innovative	0.64	0.60	0.49	0.80	0.44	0.25
innbas	0.53	0.52	----[c]	0.62	0.27	0.17
R&D_high	0.24	0.29	0.25	0.52	0.17	0.09
R&D_high_b	0.20	0.26	---[c]	0.42	0.13	0.07
export	0.86	0.92	0.73	0.72	0.64	0.57
export_30	0.56	0.57	0.21	0.29	0.25	0.26

Source: Community Innovation Survey 1993, mean value of micro-aggregated data; definition of variables are given in Table A8;

notes: [a] in Norway and Spain information on turnover for 1990 is missing; an analysis of sales growth therfore is not possible;
[b] in Germany sales growth during 1990-1992 is indicated in 5 categories: 1: high decrease, 2: decrease, 3: no change 4: increase, 5: high increase
[c] in France all innovators are basis innovators
[d] information is not available

Table A11a: Ordinary least squares estimates of labour demand in European countries in 1992

Variable	Germany		Denmark		France		Norway		Spain	
	coefficient	std-error	coefficient	std-error	coefficient	std-error	coefficient	std-error	coefficient	std-error
sales	0.420#	0.050	-0.665#	0.124	0.032	0.044	0.385#	0.075	-0.569#	0.071
sales_sqrd	0.019#	0.003	0.0714#	0.007	0.037#	0.002	0.022#	0.004	0.067#	0.004
innovative	-0.027	0.053	-0.026	0.076	0.008	0.017	0.076	0.057	-0.002	0.031
R&D	0.253#	0.046	0.267#	0.095	---[a]	---[a]	-0.033	0.080	-0.026	0.036
R&D_process	-0.070*	0.039	-0.010	0.076	---[a]	---[a]	0.090	0.075	---[a]	---[a]
lab_costs	-0.183#	0.067	---[a]	---[a]	-0.222#	0.024	-0.187	0.137	-0.180#	0.035
skill_lack	-0.074+	0.033	-0.011	0.053	---[a]	---[a]	0.070*	0.041	---[a]	---[a]
finance_lack	0.210#	0.034	-0.038	0.052	---[a]	---[a]	-0.028	0.040	-0.019	0.024
part	0.105#	0.040	0.119+	0.056	0.030	0.021	0.089*	0.047	0.119#	0.031
part_moth	-0.041	0.062	0.120	0.076	---[a]	---[a]	0.082	0.065	---[a]	---[a]
export	-0.036	0.041	-0.005	0.095	-0.026	0.019	0.077	0.048	0.061+	0.027
export_30	0.077+	0.037	0.060	0.055	0.020	0.021	-0.074	0.053	0.066+	0.034
constant	1.057+	0.730	4.43#	0.575	3.406#	0.318	0.636	1.450	5.712#	0.449
χ^2 -test: sales	3406.95#		607.00#		6836.57#		1476.05#		1954.76#	
χ^2 -test: dependent firm	3.40+		4.42+		---[b]		3.65+		---[b]	
χ^2 -test: exportation	2.17		0.63		1.15		1.55		6.88#	
χ^2 -test: innovation	11.75#		6.59#		---[b]		1.92		---[b]	
adj. R^2	0.88		0.77		0.87		0.88		0.76	
observations	1,821		528		3,600		743		1,998	

Source: Community Innovation Survey 1993; dependent variable is the natural logarithm of employment in 1992;
notes: [a] information is not available;
[b] in France all innovators are said to have basis innovations; χ^2 -test is equal to the t-test in the equation;
#, +, *: significant at the 1%, 5%, 10% level.

Table A11b: Ordinary least squares estimates of labour demand in European countries

Variable	Luxemburg		Belgium		Italy	
	coefficient	std-error	coefficient	std-error	coefficient	std-error
sales	0.565#	0.116	-0.791#	0.116	-0.519#	0.022
sales_sqrd	0.011	0.008	0.072#	0.006	0.056#	0.001
innovative	0.003	0.117	0.139	0.104	0.054#	0.011
R&D	-0.039	0.157	0.241+	0.120	0.070#	0.020
R&D_process	0.504+	0.209	-0.044	0.093	0.071#	0.020
lab_costs	---[a]	---[a]	-0.146	0.120	-0.042#	0.009
skill_lack	-0.126	0.093	-0.016	0.069	-0.006	0.010
finance_lack	0.113	0.087	-0.029	0.067	0.011	0.009
part	0.075	0.131	0.439#	0.083	0.239#	0.013
part_moth	0.244	0.442	0.062	0.101	-0.008	0.024
export	0.081	0.096	0.107	0.104	-0.006	0.010
export_30	-0.157	0.112	0.186+	0.079	0.083#	0.010
constant	-1.888#	0.413	6.353#	1.299	4.389#	0.121
χ^2 -test: sales	408.03#		404.69#		8481.91#	
χ^2 -test: dependent firm	0.33		16.61#		179.17#	
χ^2 -test: exportation	1.06		4.68#		32.31#	
χ^2 -test: innovation	2.12*		6.18#		86.37#	
observations	241		557		16,374	
adj. R^2	0.8720		0.7924		0.6632	

Source: Community Innovation Survey 1993; dependend variable is the natural logarithm of employment in 1992;

notes: [a] information is not available;
#, +, *: significant at the 1%, 5%, 10% level.

Table A12: Ordinary least squares estimates of sales growth between 1990 and 1992 in European countries

Variable	Germany[b]		Denmark		France		Luxemburg		Belgium		Italy	
	coefficient	std-error	coefficient	std-error	coefficient	std-error	coefficient	std-error	coefficient	std-error	coefficient	std-error
sales_mean_c	1.1	0.9	0.3	0.3	0.3#	0.1	---[a]	---	0.5	0.5	-14.1	9.1
sales_mean_e	0.9	1	1.3+	0.5	0.5#	0.1	-0.2	0.7	0.4	0.6	14.6	9.2
innovative	-0.190	0.187	0.014	0.119	0.010	0.015	0.066	0.160	-0.020	0.111	0.089#	0.013
innbas	0.543#	0.189	0.048	0.123	---[c]	---[c]	0.033	0.183	-0.013	0.111	-0.001	0.016
R&D_high	-0.065	0.214	0.152	0.194	0.007	0.018	-0.212	0.270	-0.038	0.178	-0.045*	0.024
R&D_high_b	-0.139	0.245	-0.063	0.203	---[c]	---[c]	0.113	0.316	0.144	0.193	0.015	0.028
export	0.058	0.113	0.130	0.100	0.006	0.015	-0.000	0.081	0.061	0.091	-0.000	0.010
export_30	-0.456#	0.108	-0.078	0.056	0.005	0.016	-0.049	0.096	-0.002	0.066	-0.010	0.011
constant	---[d]	---[d]	-0.041	0.091	0.044#	0.013	0.045	0.054	0.070	0.077	0.007	0.007
χ^2-test: exportation	18.73#		1.40		0.15		0.15		0.26		0.58	
χ^2-test: innovation	16.89#		1.21		---[c]		0.34		0.49		21.89#	
F resp. χ^2-test	45.08 #		1.67		4.87#		0.22		0.48		13.78#	
observations	1.641		532		2.998		179		549		15.614	

Source: Community Innovation Survey 1993; dependend variable is turnover growth between 1990 and 1992; since information on turnover in 1990 is not available, there are no estimates for Norway and Spain;

notes: [a] information is not available;

[b] in Germany turnover growth between 1990 and 1992 is indicated by 5 categories: 1: high decrease, 2: decrease, 3: no change , 4: increase, 5: high increase; as an adaquate econometric method for the analysis of this qualitative information the ordered logit model model is employed for the German data;

[c] in France all innovators said to have basis innovations;

[d] bound 1 : -1.6; bound 2 : -0.95; bound 3 : -0.42; bound 4 : 1.1;

#, +, *: significant at the 1%, 5%, 10% level.