Does innovation stimulate employment? A firm-level analysis using comparable micro data on four European countries*

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November 2004

Abstract

This paper studies the impact of process and product innovations introduced by firms on their employment growth. A model which relates employment growth to process innovations and to the growth of sales due to innovative and unchanged products is derived and estimated with comparable firm-level data from France, Germany, Spain and the UK. Results for manufacturing show that, although process innovation tends to displace employment, compensation effects are prevalent, and product innovation is associated with employment growth. In the service sector there is less evidence of displacement effects from process innovation, and though less important than in manufacturing, growth in sales of new products accounts for a non-negligible proportion of employment growth in services. Overall the results are similar across countries, with some interesting exceptions.

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*This paper is part of European research project "Innovation and Employment in European Firms: Microeconometric Evidence." The authors thank the respective statistical offices for access to the data. Alberto Lopez and Angeles Mora have provided efficient research assistance. This research has benefitted from comments and suggestions by Laura Abramovsky, Rachel Griffith, Bronwyn Hall, Elena Huergo, Elizabeth Kremp, Norbert Janz, Pierre Mohnen, Tobias Schmidt and Helen Simpson. Any errors remain those of the authors.

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1.Introduction.

Innovation is widely considered to be a primary source of economic growth, and policies to stimulate firm-level innovation are high on the agenda in most countries. But what are the employment consequences of innovation? Low levels of employment growth are currently a key concern in many European countries, yet the links between innovation and employment remain unclear. This paper uses comparable data across four European countries to investigate empirically the firm-level employment effects of innovation. Although within-firm evidence cannot take account of important general equilibrium effects, notably firm entry and exit, it is nevertheless an essential ingredient for the effective design of innovation policy.

This paper makes three main contributions to the literature on innovation and employment. First it uses a unique comparable firm-level dataset across four large European countries: France, Germany, Spain and the UK. Firms in these contries operate in very different economic and institutional environments, which might be expected to result in interesting cross-country differences in the relationship between innovation and employment. Secondly the structure of the data allows us to apply a simple theoretical model of innovation and employment that disentangles the different effects at work. In particular we observe the mix of each firm's output growth between existing and newly introduced products. Finally, we present evidence from roughly 19,000 firms, of which more than 6,000 are in the service sector. Almost all previous studies of innovation and employment have focused exclusively on manufacturing, yet much of the employment creation in these four economies in recent years has been within the service sector

The data used in this paper comes from the Third Community Innovation Survey (CIS3). These data are available for a number of European Union countries in a similar format. Basic CIS3 variables (set out in the core questionnaire) include, for each firm in the sample, employment and sales in the years 1998 and 2000, and information about whether the firm has introduced process and product innovations during the period. Particularly useful for our purposes, the data includes the share of sales in 2000 stemming from new or significantly improved products introduced since 1998.[1] In addition, the Survey gathers information

[1] Definitions are unified according to the Oslo Manual (see OCDE and Eurostat, 1997).

on the R&D and innovation investments of firms and their financing, firms' sources of information and innovation aims, and cooperation and patenting activities.

The paper uses data on four European countries: France, Germany, Spain and the UK. The micro-data have been accessed at the national level under strict rules to preserve confidentiality, but the model and its implementation have been discussed and coordinated among the researchers from the four countries. The results of such cross-country work are stimulating: consistent regularities appear across the countries, while the employed framework highlights interesting cross-country variation.

The rest of this paper is organised as follows. Section 2 discusses the potential firm-level employment effects of innovation and relates our contribution to the literature. Section 3 develops the model and discusses what effects can be identified using the data. Section 4 briefly comments on the data and the evidence provided by simple descriptive statistics on employment and innovation outcomes in the four countries. Section 5 presents the main econometric estimates and checks their robustness. Section 6 comments on the results and presents a decomposition of employment growth in the four countries, and Section 7 concludes. A Data Appendix contains details on the sample and variables employed.

2. Employment effects of innovation at the firm level

In this section we summarise the ways in which innovation might be expected to affect employment at the firm level, and how this relates to aggregate employment changes. We then briefly survey previous findings on the firm-level relationship between innovation and employment.

2.1 Process and product innovations.—

The potential firm-level employment effects of innovation are summarised in Table 1.[2] It is convenient to distinguish between the effects of process innovations, which are directed at improving the production process and hence have a direct impact on factor productivity and unit costs, and the effects of product innovations, which are mainly undertaken to reinforce

[2] In this section we draw on theoretical discussions in several papers, including Nickell and Kong (1989), Van Reenen (1997) and Garcia, Jaumandreu and Rodriguez (2002); see also the survey by Chennells and Van Reenen (2002).

demand for the firm's products. In practice, of course, the distinction between the two types of innovation is not so clear, since process innovations often accompany product innovations and vice versa. As indicated in Table 1, both types of innovation can be interpreted as the (partly random) result of the firm's investment in R&D and other innovative activities.[3]

Pure process innovations are likely to reduce the quantities of (most) factors required to obtain a unit of output, including the required labour input. Thus process innovations tend to displace labour for a given output, although the size of this displacement effect will depend on whether the process improvement is labour or capital augmenting. The effects of a single identifiable process innovation will be additional to those of any unobservable or incremental improvements in efficiency that reduce input requirements over time.[4]

Any increase in productivity resulting from a process innovation implies a reduction in unit costs. Depending on the competitive conditions facing the firm, this is likely to result in a lower price, which will stimulate demand, and hence produced output and employment, according to the value of the elasticity of demand. The size of the compensation effect is likely to depend on the behaviour of the agents inside the firm and the nature of market competition. For example, unions may attempt to transform any gains from innovation into higher wages, while managers may seek to use market power to increase profits.[5] Both behaviours can dampen or override the compensation effect.

Product innovations may also have productivity effects, even if they are not associated with simultaneous process innovations. The new or improved product may imply a change in production methods and input mix, which could either reduce or increase labour requirements. The extent and direction of the effect must be determined empirically. However, the most important effects of product innovations are likely to be positive compensation effects resulting from increases in demand. The importance of any increases in demand resulting from product innovation will depend on the state of competition and the delay with which

[3]For a recent analysis of the simultaneous investment decisions and innovation results obtained by firms, using the same kind of firm-level data, see Griffith, Huergo, Mairesse and Peters (2004).

[4]Estimates of prroduction functions frequently account for ongoing improvements in productivity using time trends or time dummies, when estimating in levels, or constants when the estimating in first differences. Indicators of specific innovative investments or outcomes typically leave a large amount of unexplained additional productivity growth. See Huergo and Jaumandreu (2004) for an illustration of this point with detailed panel data.

[5]See Nickell (1999) for a discussion.

rivals react to the introduction of new products. In addition, sales of new or improved products may cannibalise some proportion of the firm's existing sales, reducing the positive compensation effect of product innovation.

[Something about product and process innovation in services?]

2.2 Innovation and employment at the aggregate level.—

The focus of this paper is the firm-level relationship between innovation and employment in a sample of firms. A key question is thus how the employment effects of innovation that we observe at the firm level relate to aggregate changes in employment. There are two main reasons why the aggregate effect of innovation on employment cannot be directly inferred by multiplying the average firm-level effect by the number of firms. First, the firm-level compensation effects that we observe do not distinguish between a pure market expansion component and a business-stealing component.[6] If innovation by firms results in business-stealing rather than market expansion then the aggregate effect of innovation on employment will be smaller (either less positive or more negative) than the firm-level effect. We should note, however, that to the extent that we observe firms' competitors within the sample then average firm-level employment growth already includes some of the effects of business-stealing.

Secondly, and related, we do not observe entering or exiting firms in our sample of continuing firms. Firm entry, which may be the result of innovation, is an important source of employment growth, while exit may be induced by successful innovation and business-stealing by rival firms.

Despite these limitations, the analysis of the effects of innovation on employment at the firm level can provide important information on the micro-mechanisms that underly aggregate employment growth. For example, the firm-level relationship between innovation and employment will determine the extent to which different agents within the firm resist or encourage innovation, and may influence the way product and labour market regulations and other aspects of firms' environments affect their incentives to innovate.

[6] See, however, the use of rival's data in Garcia, Jaumandreu and Rodriguez (2002) to separate these effects.

2.3 Previous literature on innovation and employment.—

A number of previous papers have provided evidence on the relationship between innovation and employment at the firm level. The survey by Chennels and Van Reenen (2002), although focused on a related but different question, provides a useful overview.[7] Existing papers differ widely in terms of both methodology and data employed. Given the relationships summarised in the previous discussion, it is not surprising to find a broad range of modelling strategies, ranging from the assessment of correlations or estimation of reduced forms to more structural models. At the same time, different data provide various measures of innovation, both output oriented, such as innovation counts, and input oriented, such as R&D intensity. Finally, papers differ widely in the extent to which they address issues of heterogeneity and endogeneity.

On the whole, product innovation emerges as clearly associated with employment growth (see, for example, Entorf and Pohlmeier, 1991; König, Licht and Buscher, 1995; Van Reenen, 1997; Greenan and Guellec, 2000; Smolny, 1998 and 2002; Garcia, Jaumandreu and Rodriguez, 2002; Peters, 2004). R&D is often found to be positively associated with employment growth (see, for example, Blechinger, Kleinknecht, Licht and Pfeiffer, 1998, and Regev, 1998), although not always (see Brouwer, Kleinknecht and Reijnen, 1993, and Klette and Forre, 1998). Process innovations and the introduction of new technologies show effects which range from negative to positive according to the specification (see, for example, Ross and Zimmerman, 1993, for a negative process innovation effect; Doms, Dunne and Roberts, 1995 or Blanchflower and Burguess, 1999 for positive technology impacts, and the various effects obtained for process innovations from the many of the above papers).

The focus of our paper is the development of a simple theoretical framework applicable to the cross country comparable data at hand. In particular, our data allow us to observe firms' sales of new or improved products as well as sales of unchanged products. The theory suggest various restrictions which we impose in order to estimate some structural effects using appropriate econometric techniques. Overall our findings support the robustness of the product innovation effect on employment and throw some light on the reasons why the estimated effects of other technological measures vary across studies.

[7] The survey is focused on the impact of technological change on the skill and pay structure of labour. This is an important related literature of which an early example is Berman, Bound and Griliches (1994).

3. Theoretical framework and estimation strategy.

3.1 A simple multi-product production function.—

A firm can produce two types of products: old or only marginally modified products ("old products") and new or significantly improved products ("new products"). Outputs of old and new products at time t are denoted Y_{1t} and Y_{2t} respectively. We observe firms at two points in time, and the beginning and end of the period. At the beginning of the period all products are old products by definition, so Y_{21} is always equal to zero. If the firm does not introduce any new products during the period then Y_{22} is also equal to zero. We assume that each type of product is produced with an identical separable production technology, with constant returns to scale in capital, labour and intermediate inputs. Each production technology has an associated efficiency parameter that can change over time. New products can be produced with higher or lower efficiency than old products, and the firm can influence the efficiency of production of either product through investments in process innovation. The production technology for product i at time t can be written as follows

$$Y_{it} = \theta_{it} F(K_{it}, L_{it}, M_{it}) \qquad i = 1, 2; t = 1, 2$$

where θ represents efficiency and K, L and M stand for capital, labour and materials. The firm's cost function at time t can then be written

$$C(w_{1t}, w_{2t}, Y_{1t}, Y_{2t}, \theta_{1t}, \theta_{2t}) = c(w_{1t})\frac{Y_{1t}}{\theta_{1t}} + c(w_{2t})\frac{Y_{2t}}{\theta_{2t}} + F$$

where $c(w)$ is marginal cost (a function of input prices w) and F stands for some arbitrary fixed costs. According to Shephard's Lemma, we have

$$L_{it} = c_L(w_{it})\frac{Y_{it}}{\theta_{it}}$$

where $c_L(w_{it})$ represents the derivative of marginal cost with respect to the wage.

The growth of employment over the period can be decomposed into the growth of employment due to production of the old product, and the growth of employment due to production of the new product (note that $L_{21} = 0$ by definition).

$$\frac{\Delta L}{L} = \frac{L_{12} - L_{11}}{L_{11}} + \frac{L_{22}}{L_{11}}$$

We assume that the derivative of marginal cost with respect to the wage does not change over the period, so that $c_L(w_{11}) = c_L(w_{12}) = c_L(w_1)$. This will be the case, for example, if the cost function is homogenous of degree one and relative prices are constant over the period. We can then write an approximate employment growth decomposition as follows

$$\frac{\Delta L}{L} \simeq -\left(\frac{\theta_{12}-\theta_{11}}{\theta_{11}}\right)+\left(\frac{Y_{12}-Y_{11}}{Y_{11}}\right)+\frac{c_L(w_2)}{c_L(w_1)}\frac{\theta_{11}}{\theta_{22}}\frac{Y_{22}}{Y_{11}} \tag{1}$$

where we use a linear approximation to obtain the two first terms.

This expression says that employment growth is the result of the change in efficiency in the production process for the old products, the rate of change of the production for these products, and the expansion in production attributable to the new products. The increase in efficiency of the old production process ($\frac{\theta_{12}-\theta_{11}}{\theta_{11}}$) is expected to be larger for firms which introduce process innovations relating to the old process, although the efficiency of all firms may grow over time. If we assume that the derivative of marginal cost with respect to the wage is equal for old and new products (i.e. $c_L(w_1) = c_L(w_2)$),[8] the effect of product innovation on employment growth depends on the difference in efficiency between the production processes for the old and the new products (the ratio $\frac{\theta_{11}}{\theta_{22}}$). If new products are produced more efficiently that old products then this ratio is less than unity and employment does not grow one-for-one with the growth in output accounted for by new products.[9]

Equation (1) suggests the following population relationship

$$l = \alpha + y_1 + \beta y_2 + u \tag{2}$$

where l stands for employment growth over the period, variables y_1 and y_2 stand for the rates of output growth $\frac{Y_{12}-Y_{11}}{Y_{11}}$ and $\frac{Y_{22}}{Y_{11}}$ respectively (output growth accounted for by the old and new products), and u for a random disturbance which is expected to have zero mean conditional in a suitable set of instruments, i.e. $E(u|z) = 0$. The parameter α represents (minus) the average efficiency growth in production of the old product, while β captures the relative efficiency of the production of old and new products.

In principle we could extend equation (2) to allow process innovation to affect changes in the efficiency of production of old and new products as follows

$$l = (\alpha_0 + \alpha_1 d_1) + y_1 + (\beta_0 + \beta_1 d_2) y_2 + u \tag{3}$$

[8] Again this will be the case, for example, if the cost function is homogenous of degree one and relative prices are the same for the two products.

[9] If the derivative of marginal cost with respect to the wage is higher for new products (i.e. $c_L(w_1) < c_L(w_2)$), then the estimated ratio will be biased upwards, in other words the efficiency increase associated with new products will be underestimated.

where d_1 and d_2 are dummy variables equal to one if over the period the firm introduced any process innovations relating to the production of old or new products respectively. In practice we do not know whether the process innovations of firms that introduce new products relate to their old or their new products, but we can experiment with various alternatives, for example we can assume that all such process innovations relate to old products, or all to new products.

We should comment briefly on the significance and limitations of equation (2), as well as the likely properties of u. On the one hand, equation (2) can identify two important effects. Firstly, under the assumption that the growth of sales due to the introduction of new products is observed, equation (2) clearly identifies the gross effect of product innovation on employment. Secondly, observation of the introduction of process improvements in the production of the old products brings the opportunity of identifying the productivity or "displacement" effect of process innovation.[10] On the other hand, variable y_1 embodies three different effects which - at least for the same firm - cannot be separated without additional (demand) data: the "autonomous" increase in firm demand for the old products (attributable to cyclical or industry effects, say); the demand effect induced by the price variation following a process innovation, wherein lies the main process innovation "compensation" effect; and the demand "substitution effect" resulting from the introduction of new products. As these components cannot be disentangled, total variation y_1 will be in practice simply substracted from l imposing the unitary coefficient.

To compare (2) or (3) with other specifications, notice that it can be transformed into the productivity growth equation (for simplicity assuming that all process innovations refer to the production of old products, i.e. $d_2 = 0$)

$$y_1 + y_2 - l = -\alpha_0 - \alpha_1 d + (1 - \beta) y_2 - u$$

by simply rearranging terms. This transformation shows that growth in output per worker will depend positively on process innovation and that the expected sign for product innovation depends on the value of the relative efficiency of the old and new processes. If β is equal to one, efficiency is the same across production processes and new products do not

[10] See below, however, the problem which appears when the data refer to sales which are not properly deflated.

affect output per worker. If β is less than one, new products are produced more efficiently, and thus output growth due to new products increases output per worker.

Finally, the need for a suitable set of instruments results from the possibility that the key variables d and y_2 may be correlated with the error term u, although this is not necessarily the case. Notice that equations (2) and (3) involves rates of growth of the variables. We must clearly allow for the possibility that the error term contains unobserved shocks correlated with the introduction of process or product innovations (for example investments, bursts in capacity utilization, labour and organizational problems). However, we a-priori exclude the presence of long run determinants of productivity growth differences in the error term, which would imply rather unlikely long run differences in the rates of growth among firms according to certain characteristics (and for which we are unlikely to find good instruments in our data). On the other hand, to judge the likelihood of endogeneity problems in variables d and y_2 we must bear in mind that a positive correlation of the introduction of innovations with unobserved favourable productivity shocks would induce a downward bias both in α_1 and β[11], in other words we will estimate displacement effects of process innovation and the introduction of new products that are too large.

3.2 Estimation strategy..—

To estimate equation (2), however, we must substitute nominal sales, which are the magnitudes that we observe, for real production. The problem that prices are unobserved is common in productivity analysis, but it is particularly relevant in this case since we are attempting to separately identify the productivity effects of old and new products, which may be sold at different prices. Let g_1 be the nominal rate of growth of sales due to the old products ($\frac{P_{12}Y_{12}-P_{11}Y_{11}}{P_{11}Y_{11}}$). If π_1 is the rate of increase in the prices of these products over the period ($\frac{P_{12}-P_{11}}{P_{11}}$), we can write the approximate relation $g_1 = y_1 + \pi_1$. Let g_2 be the nominal growth in sales that is due to new products ($\frac{P_{22}Y_{22}}{P_{11}Y_{11}}$), and define π_2 as the proportional difference of the prices of new products with respect to the prices of the old products ($\frac{P_{22}-P_{11}}{P_{11}}$), so that we have $g_2 = y_2(1 + \pi_2) = y_2 + \pi_2 y_2$. We assume that π_2 is

[11] To see this notice that a favourable unobserved productivity shock is a negative realization of u in the "productivity" equation, where u enters with minus sign. This would be trasmitted to d and y_2 through their dependence of productivity and, hence, their "reduced" forms would contain a positive shock, negatively correlated with the realization of u in equation (2).

mean-independent of y_2 with a mean of zero, i.e. $E(\pi_2|y_2) = 0$.[12] Then $E(\pi_2 y_2) = 0$ and $\pi_2 y_2$ is uncorrelated with y_2 (although $\pi_2 y_2$ is likely to be correlated with π_2). Substituting g_1 and g_2 for y_1 and y_2 respectively, and reordering the expression, we obtain

$$l - g_1 = \alpha + \beta g_2 + v \tag{4}$$

where the new unobserved disturbance is now $v = -\pi_1 - \beta\pi_2 y_2 + u$. In case of a non-zero mean of π_1 the model will include $-E(\pi_1)$ in the intercept and $-(\pi_1 - E(\pi_1))$ in the disturbance. The equivalent estimated version of equation (3), assuming again that all process innovations relate to old products, would be

$$l - g_1 = \alpha_0 + \alpha_1 d + \beta g_2 + v \tag{5}$$

To estimate the parameters of (4) or (5) consistently, we have to take into account three main problems. First, g_2 is an endogenous variable, in the sense that it is correlated with the composite error term. The problem originates in our inability to measure the ratio y_2 directly (a variant of the classical errors in variables problem), and we can try to solve it by instrumenting g_2 with variables correlated with the real ratio and uncorrelated with the price differences. We discuss potential instruments below.

Secondly, the composite error term includes π_1, the change in the prices of the old products, as long as we cannot control for them. This induces an identification problem. Any increase in proportional efficiency decreases marginal cost by the same proportion. If, for example, firms are pricing by setting some unspecified markup on marginal cost, then price variations are likely to be roughly proportional (with the opposite sign) to the increases in efficiency. In addition, firms endowed with some market power might pass on this cost decrease by different amounts. Suppose that price variations follow marginal cost variations c according to $\pi_1 = \pi_0 + \gamma c$, where γ is the pass on parameter. Marginal cost changes depend on innovation efficiency gains, ceteris paribus, according to $c = \alpha_1 d$. Hence $\pi_1 = \pi_0 + \gamma\alpha_1 d$, and in equation (4) we will only be able to estimate an effect $(1 - \gamma)\alpha_1$. That is, we only identify an effect of productivity changes on employment net of the possible compensating price movements.

[12] New product sales will depend, among other things, negatively on the new product price according to the price elasticity of demand for the new product, and positively on the price of the old product (if they are substitutes) according to the cross elasticity of demand. Equilibrium price level relationships are likely to vary widely across firms even for similar y_2 values.

In our econometric estimates we use a system of price indices $\widetilde{\pi}_1$computed at a detailed industry disaggregation (for manufacturing) as a proxy for π_1. Thus we use $l-(g_1-\widetilde{\pi}_1)$ as dependent variable, which will leave in the error the term $-(\pi_1-\widetilde{\pi}_1)$. With this arrangement, we are likely to identify the average real productivity effect, but a problem of identification will remain to the extent that firms deviate from average price behaviour. That is, if individual differences in price behaviour $(\pi_1-\widetilde{\pi}_1)$ are, as is likely, related to individual efficiency growth differences, with price variation only partially controlled for, then the identification problem is only partially addressed.

Finally, we must take into account the possible endogeneity of d and g_2 for employment growth as discussed above. The instruments for the errors in variable problem embodied in g_2 may also address this problem, but we do not assume that this is the case. Instead we test for the endogeneity of d given the available instruments.

4. Innovation and employment across four countries

In this section we present descriptive statistics and discuss the results of initial exploration of the data. Table 2 presents descriptive statistics for manufacturing from the four countries. For each variable the sample in each country is split into three sub-samples according to whether the firm reports that it has not introduced any innovations, has introduced only process innovations, or has introduced product innovations. For ease of presentation we do not distinguish firms that have introduced both product and process innovations from those that only introduce product innovations. The data cannot distinguish if the two types of innovations introduced by one firm are related and to what extent. The table shows that innovators represent between about 40% (UK) and 60% (Germany) of firms in the samples. Innovators that only introduce process innovations generally constitute up to one in four of all innovators.

The sizes of the national samples differ, but all samples are broadly representative by strata. Representativeness, however, diverges somewhat across countries, and therefore direct comparisons must be interpreted carefully. For example, while the Spanish and UK samples present proportions of innovators close to the estimated population proportions (+3.5 and 2 percentage points), the German sample slightly underestimates the population proportion (-4.5 percentage points) and the French sample seem to be over-representing innovators (+12%).[13] Details on the samples and variable definitions can be found in the Data Appendix.

Employment growth of innovators is consistently higher than the employment growth of non-innovators across the four countries, with the employment growth of product innovators slightly higher than firms that only introduce process innovations. Apart from in Spain, where there is little difference in average productivity growth between innovators and non-innovators, the increase in employment of innovative firms is higher despite their larger labour productivity gains. This suggests that compensation effects resulting from the growth of output dominate displacement effects of innovation at the firm level.

The average increase in sales over the period 1998-2000 is high in all countries, reflecting both an expansionary phase of the industrial cycle and the fact that these are samples of continuing firms. Average sales growth is particularly high for Spain, even when deflated with the corresponding highest rate of price increase, but the Spanish economy was at the time experiencing high overall growth. Average industry price increases are negligible at that time in the UK and very low in Germany.

Sales growth is consistently higher for innovators than non-innovators, with no systematic difference between firms that only introduce process innovations and those that introduce product innovations. For product innovators, sales of new products are a very important component of total sales growth: sales of new or significantly improved products introduced during 1998-2000 period amount to more than one third of the old products sales at the beginning of the period for the German, Spanish and UK firms, and nearly 20% for the French firms. Sales of new products appear to partly cannibalise sales of old products, although the extent of cannibalisation varies across countries, and is markedly lower in France than in the other countries.[14] The proportion of sales of new products that are accounted for by products that are new to the market (as opposed to simply new to the firm) is almost one half for France, about one third for Germany and Spain, and only one quarter for the UK.

[13] To check the country population proportions see Abramovsky, Jaumandreu, Kremp and Peters (2004).

[14] We should note that the fact that average growth in sales of unchanged products is negative for product innovators does not necessarily imply cannibalisation of old products by new products. For example, it is possible that firms whose traditional markets are declining are more likely to introduce product innovations.

Table 3 reports the same information for firms in the Service sector.[15] The proportion of non-innovators is higher in all countries than in manufacturing, but relatively low in Germany and particularly high in the United Kingdom and Spain. The proportion of innovators that only introduce process innovations is slightly higher than in manufacturing for all the countries.

In all countries employment growth is slightly higher for innovators, and is higher for product innovators than for firms that only introduce process innovations. This suggests that demand increases associated with new products are particularly important for employment creation in service sectors.

The growth of sales during the period is very high, but notice that average price increases are now also significant for all countries.[16] As with employment growth, sales growth is higher for product innovators, but not particularly for firms that only introduce process innovations. The productivity growth of product innovators is, however, sometimes higher (France, Spain) and sometimes lower (Germany, UK) than productivity growth of non-innovators.

For product innovators, sales of new products are as large a part of total sales growth as in manufacturing, although there appears to be slightly less cannibalisation of old products by new products. As in manufacturing, the proportion of sales of new products that are accounted for by products that are new to the market (as opposed to simply new to the firm) is higher in Germany and Spain than in France and the UK.

4.1 Exploratory OLS regression results.—

Before estimating our empirical model in the next section, we briefly discuss an initial exploration of the conditional correlations observed in the data. Table 4 presents OLS regressions for the manufacturing and services samples in each country. In each case, employment growth is regressed on deflated total sales growth, dummies for "process innovation only" and product innovation, and a full set of industry dummies.

The coefficient on real sales growth is fairly stable across samples and is a long way below unity in all cases. On face value this suggests that sales growth is associated with less than

[15] See the Data Appendix for a description of the industry composition of the service sector samples.

[16] A single deflator for services is used for France and Spain. In Germany and the UK deflators are used at the 2-digit level. See the Data Appendix for more details.

one-for-one growth in employment. However, in the presence of the type of errors in variables problem discussed in the previous section this coefficient is likely to be biased downwards. The coefficient on the "process innovation only" dummy is insignificant in all cases apart from Spanish manufacturing, where it is positive. This Spanish result remains in the results that follow, and may reflect greater pass-through of cost savings in prices, or possibly the fact that process innovation is correlated with negative shocks to productivity growth. The coefficient on the product innovation dummy is positive in all cases and significant about half the time, again suggesting the possibility of important demand enlargement effects of product innovation.

Overall the results are quite uninformative about the relative roles of displacement and compensation effects in the relationship between innovation and employment growth. For this reason, in the next section we impose more structure on the data using our theoretical model and information about the mix of sales between old and new products.

5. Econometric results.

5.1 Basic specification: the effects of product innovation on employment.—

Table 5 presents the results from estimating equation (4) for firms in manufacturing. In all cases the dependent variable is employment growth minus the growth of sales due to the unchanged products. We control for changes in the prices of old products by deducting an industry price growth index from the nominal sales growth of unchanged products. The value of the constant constitutes therefore an estimate (with negative sign) of average real productivity growth (over a two year period) in production of the old products, after any compensating price effects.

Panel A presents OLS results. The estimated coefficient on sales growth due to new products is an estimate of the relative efficiency of the production process for new products compared with that for old products. The fact that the coefficient is significantly less than one for all countries suggests that new products are produced more efficiently than old products. However, as discussed above, any endogeneity due to unobserved price changes is likely to produce a downwards bias in this coefficient, overstating the efficiency increases associated with new products.

Panel B applies a two stage least squares approach, taking the *sales growth due to new* *products* variable as endogenous and using a single instrument (i.e. the equation is exactly identified). Ideally any instrument would be related to growth in new products but not to any change in the price of new products compared to old products. In order to preserve comparability across countries, our choice of instruments is restricted to variables that are present in the common questionnaire. The instrument that we use is the degree of impact of innovation on the increase in the range of goods and services produced, as reported by the firm (*Increased range*). The variable is coded as zero if innovation is not relevant for the range of goods and services produced, one if the impact of innovation on the range is low, two if it is medium and three if it is high.[17] Other related questions ask about the impact of innovation on market share or product quality, so the *improved range* variable could be interpreted as a measure of the extent to which the firm's innovation is associated with horizontal as opposed to vertical product differentiation. While innovation activity itself may not be exogenous with respect to employment growth, it seems plausible that the *effects* of innovation on the range of products produced could be. The variable is positively and significantly correlated with the endogenous variable[18], but there remain concerns about the true exogeneity of the instrument. We attempt to investigate this in the next panel by testing the validity of overidentifying restrictions in an overidentified specification.

The IV estimates of β in Panel B are as expected higher than the OLS estimates, consistent with a downwards bias due to unobserved price changes. All of the IV estimates are now extremely close to one, so there is no evidence that new products are produced with higher efficiency than old products. From the constant term, these estimates give an estimate of average productivity growth (over two years) in production of the old products between about 3.6% in France and 6.4% in Germany.

In Panel C we attempt to test the validity of the instrument using an overidentified specification. The two additional instruments that we use are the extent to which the firm uses clients as a source of information for its innovation activities, and whether the firm is continously engaged in R&D. Neither of these instruments has as much explanatory power

[17] We have experimented with a more flexible form of this variable, but this step variable appears to fit the data remarkably well, with very little evidence of any non-linear effect.

[18] In the UK the R-squared in the first stage reduced form regression is 0.28 and the coefficient on improved range is equal to 14.5 with a t-statistic of 16.0. In Germany the equilavent numbers are 0.20, 10.5 and 15.8 respectively.

in the reduced form as the *increased range* variable, but there seems no intuitive reason why they should be correlated with the relative price of new products compared to old products. In all countries the results are extremely robust to the inclusion of the new instruments (compare Panel B to Panel C) and the test of overidentifying restrictions does not reject at conventional levels.

5.2 Introducing process innovation.—

In Table 6 we extend the basic specification by allowing process innovation to affect productivity growth. Panel A considers only the process innovations of firms that do not introduce new products, since in this case we can be sure that the process innovation relates to the old product. In this context a negative coefficient on the *process innovation only* dummy represents an increase in productivity (and thus a displacement of labour) in production of the old product, after allowing for any pass through of productivity improvements in lower prices.[19] The coefficient is negative and significant for Germany and the UK. In both cases the size of the coefficient is similar to that of the constant, so process innovation is associated with about a doubling in the rate of productivity growth in production of the old product. The coefficient is negative but insignificant for France, and positive but insignificant for Spain. The Spanish result is a little surprising, and could be due to larger pass-through of any productivity improvements in prices, or alternatively to reactive process innovation in response to negative productivity growth shocks. It is not obvious, however, why either of these effects should be more important in Spain than the other countries.

In Panels B and C we introduce separately the process innovations of firms that also introduce product innovations. Since we do not know whether these process innovations refer to the production of the old or the new products we try both alternatives. In Panel B we assume that all the process innovations of product innovators refer to production of the old product, while in Panel C we assume that they all refer to production of the new product.

[19] We tested for the endogeneity of the *process innovation only* variable using the overidentifying restrictions provided by the additional instruments in Panel C of Table 5. We were never able to reject the hypothesis that the variable was exogenous, though this may be partly due to the low explanatory power of the instruments in predicting process innovation.

The coefficient on *process and product innovation* in Panel B is negative and insignificant for Germany and Spain, but positive and marginally significant for France and the UK, apparently suggesting that the process innovations of product innovators are associated with employment growth in production of the old product (or slower productivity growth) after allowing for any price pass-through. However, in both cases the coefficient on *sales growth due to new products* is reduced from about one to 0.9, suggesting lower employment growth associated with production of the new product.

An alternative hypothesis is that the process innovations of product innovators are in fact associated with production of the new product, and this is tested in Panel C, where we introduce an interaction between the *process and product innovation* dummy and *sales growth due to new products.*[20] This allows the average relative productivity in production of the old and the new products to be different for firms that also introduce process innovations. The results correspond closely with those in Panel B, with insignificant negative coefficients on the interaction for Germany and Spain, and positive and marginally significant coefficients for France and the UK, suggesting that new products are associated with smaller productivity increases (or larger productivity decreases) for firms that also introduce process innovations. One possible interpretation of this result for France and the UK is that new products that are associated with less productive production technologies tend to induce process innovations in order to reduce the cost of production.

However, given the available data we are not able to distinguish between the alternative hypotheses embodied in Panels B and C, and the truth is probably somewhere in between, with some process innovations being associated with old products and some with new products. For this reason our preferred specification is that in Panel A, where we can be sure that the process innovations of firms that do not introduce new products relate to the old product.

5.3 Robustness.—

[Control for investment over sales, and some results using country-specific data.]

[20] We also introduce as an additional instrument the interaction between the *process and product innovation* dummy and the existing *increased range* instrument.

5.4 Service sector results.—

Tables 7 and 8 present equivalent results for firms in the service sector. Several factors suggest that the results should be treated with more care than the manufacturing results. First we use only a single price deflator for all services activities in France and Spain, and the deflators used for Germany and the UK are at a higher level of aggregation than those used in the manufacturing results. Secondly the proportion of innovating firms is lower than in manufacturing, particularly in Spain and the UK. Neverthless, the results throw up some interesting differences.

Table 7 presents the results of the basic OLS and IV specifications. As with manufacturing the coefficient on *sales growth due to new products* is less than one in the OLS case, but rises to become insignificantly different from one for all countries once the variable is instrumented with the *increased range variable.* Thus we cannot reject the hypothesis that new products are produced with the same productivity as old products on average, although there is some suggestion that new products are produced with higher productivity in Germany and lower productivity in France. As with manufacturing the results are extremely robust to introducing more instruments, and the overidentifying restrictions are never rejected. Average productivity growth in production of the old product, as revealed by the constant term, is higher than in manufacturing for France, lower in Germany and Spain, and about the same in the UK.

Table 8 introduces the effects of process innovation as before. None of the coefficients on *process innovation only* is significant in Panel A, suggesting no net effect, after any price pass-through, of process innovation on the productivity of production of the old product for firms that do not introduce product innovations. The same is true for both process innovation variables in Panel B. In Panel C we assume that all the process innovations of product innovators relate to the new product. The only significant result is the negative interaction term for Spain, suggesting that new products are associated with larger productivity increases (or smaller productivity decreases) for firms that also introduce process innovations.

6. An employment growth decomposition.

Using the estimation results from our preferred specifications (Table 6 Panel A and Table 8 Panel A), we can decompose employment growth for each firm in the following way

$$l = \widehat{\alpha}_0 + \widehat{\alpha}_1 d + [1 - 1(g_2 > 0)](g_1 - \widetilde{\pi}_1) + 1(g_2 > 0)(g_1 - \widetilde{\pi}_1 + \widehat{\beta} g_2) + \widehat{u}$$

where d is dummy variable denoting the introduction of process innovation by firms that do not introduce new products. For a given firm, we can interpret these components as a *productivity trend in production of old products* ($\widehat{\alpha}_0$), a *process innovation net contribution through production of old products* ($\widehat{\alpha}_1 d$), an *output growth of old products contribution* ($(g_1 - \widetilde{\pi}_1)$, only non-zero for non product innovators), a *product innovation net contribution* ($(g_1 - \widetilde{\pi}_1 + \widehat{\beta} g_2)$, taking into account any substitution of new products for old products), and a residual effect resulting from other unobserved variables ($\widehat{u}$). An average value for this decomposition can be computed using average variable values. Table 9 reports the application of this decomposition to the whole samples of manufacturing and services firms, using the the averages from Table 2 and Table 3, and the regression results from Table 6 Panel A and Table 8 Panel A.

Before we discuss the results of the decomposition we should note its limitations. First and most importantly, as discussed in Section 2, we can only present results based on our samples of continuing firms. Since we have no information on entry and exit these results should not be seen as representative of the aggregate employment effects of innovation. Rather they are indicative of the average effects of innovation on within-firm employment growth. Secondly these results are based on an expansionary period for all four countries, and so may not be representative of average firm-level effects at other stages of the cycle.

Table 9 shows that in Manufacturing productivity trends in production of existing products, for example due to incremental technical improvements or spillovers, are an important source of reductions in employment requirements for a given level of output. The effect is smallest in France (-1.9% over two years) and largest in Germany (-7.5% over two years). However, growth in output of existing products over this expansionary period more than compensates the productivity effect in all countries except Germany.

Process innovation accounts for only a small employment change in all countries, generally resulting in a small net displacement effect. This is partly because we are measuring process innovation effects in net terms after any price pass-through, but also because the number of firms that introduce only process innovations is small. Employment reductions resulting from process innovations may be important for individual firms, but they amount to only a small fraction of overall employment changes.

In contrast, product innovations play an important role in stimulating employment growth. The decomposition shows that the effect of new products sales, even net of the substitution for old product sales, is sizeable in all countries. It implies an average firm-level employment increase over the period ranging from 3.9% in the UK to 8.0% in Germany.

Overall, the importance of innovation in stimulating firm-level employment growth becomes clear when the different sources of employment change are compared. In Germany, where the combined effect of growth in existing output and trend productivity increases in production of existing products is slightly negative, product innovation is responsible for more than the whole average employment increase during the period. Even in Spain and the UK, where increases in sales of existing products are responsible for a large proportion of net employment creation, product innovation was on average more important than the net effect of growth in sales of existing products.

The results for service sector firms are somewhat different. Total within-firm employment growth is almost double that in manufacturing during the period, and more than double in the UK. On average, product innovation accounts for a smaller, but still non-negligible, proportion of total employment growth than in manufacturing. In Spain and the UK the main source of employment growth is growth in production of old products, with a small counterbalancing effect of trend productivity increases only in the UK. In France the contribution of product innovation is roughly the same as the net contribution of growth in sales of existing products. Total employment growth is lower in Germany, and growth in production of new products accounts for a larger share of employment growth than in the other countries.

7. Conclusions.

Using a simple model of employment and innovation applied to a unique source of comparable data across four European countries, these results are illuminating about the role of innovation in stimulating employment growth at the firm level. The results also provide a rare insight into the relationship between innovation and employment in service sectors.

In manufacturing, although process innovation tends to displace employment, compensation effects are prevalent, and product innovation is associated with employment growth. In the service sector there is less evidence of displacement effects from process innovation, and though less important than in manufacturing, growth in sales of new products accounts for a non-negligible proportion of employment growth in services.

Overall the results are similar across countries, although some interesting differences emerge which might merit further investigation. For example, there appears to be no net displacement effect of process innovation in Spanish manufacturing, possibly due to greater pass-through of productivity improvements in lower prices. Also, product innovation appears to play a larger role in employment growth in Germany than in the other countries, and possibly a smaller role in the UK, while higher levels of employment growth in Spain are largely explained by faster growth in output of existing products.

The implications of our results for aggregate employment growth are limited, mainly because we do not observe entering or exiting firms. Despite these limitations, the analysis of the effects of innovation on within-firm employment growth can provide important information on the micro-mechanisms that underly aggregate employment growth. The firm-level relationship between innovation and employment will determine the extent to which different agents within the firm resist or encourage innovation, and may influence the way product and labour market regulations and other aspects of firms' environments affect their incentives to innovate. For example, our evidence suggests that workers have little to fear from product innovation, although we have not been able to address the possibility that new technologies and products are more complementary to skilled than unskilled workers.

Data Appendix

The CIS3 survey was conducted in Germany by the Centre for European Economic research (ZEW). It is based on a stratified random sample of the total firm population with at least 5 employees (applying disproportional drawing probabilities by size class, sector and region), and the participation in the survey is voluntary. The survey collected data on 4611 firms, 1922 of which are in manufacturing (NACE 15-37), 2433 in services (NACE 50-90),and the rest in mining and quarrying (NACE 10-14), electricity, gas and water supply (NACE 40-41) and construction (NACE 45). To compare the results, we only include firms with 10 or more employees. Furthermore, we restrict the service sector to the following service sectors: wholesale (NACE 51), transport/storage (NACE 60-63), post and telecommunication (NACE 64), financial intermediation (NACE 65-67), computers and related activities (NACE 72), research & development (NACE 73) and technical services (NACE 74.2+74.3). From the manufacturing (services) sample we further exclude 100 (92) firms established during 1998-2000 or affected strongly by mergers, sales or closure, and we drop 297 (189) firms with incomplete data for all relevant variables. We also drop a total of 6 (16) outliers (employment or sales growth turns out to be higher than 300\%). This leaves us with the basic number of 1319 (849) firms.

The CIS3 survey was conducted in Spain by the Instituto Nacional de Estadística (INE) under the name "Encuesta sobre Innovación Tecnológica en las Empresas 2000" (see INE (2002)). The survey collected data on 11,778 firms, 6094 of which are in Manufacturing (NACE 15-37), 4778 in Services (NACE from 50 to 95), and the rest in Mining and quarrying (NACE 10-14), Electricity, gas and water supply (NACE 40-41) and Building (NACE 45). The population target was firms with 10 or more employees. From the Manufacturing (Services) sample we do not include in the exercise 637 (636) firms established during the period or affected by mergers or scissions, and we drop 855 (753) firms for which we cannot compute employment or turnover growth because of partially incomplete data. We also drop a total of 54 (107) firms for which employment or sales growth turns out to be higher than 300%. This leaves us with the basic number of 4,548 (3,282) firms.

The CIS3 survey was conducted in the UK by the Department for Trade and Industry. The survey collected data on 8172 firms, 3440 of which are in Manufacturing (NACE 15-

37), 3605 in Services (NACE from 50 to 74), and the rest in Mining and quarrying (NACE 10-14), Electricity, gas and water supply (NACE 40-41) and Building (NACE 45). From the Manufacturing (Services) sample we do not include in the exercise 548 (720) firms established during the period or affected by mergers or scissions, and we drop 339 (496) firms for which we cannot compute employment or turnover growth because of partially incomplete data. We also drop a total of 41 (63) firms for which employment or sales growth turns out to be higher than 300%. This leaves us with the basic number of 2493 (2325) firms.

Variable Definitions

Employment growth: Rate of change of the firm's employment for the whole period.

Expected employment growth: Rate of change in employment implied for expected employment by 2002.

Increased market share: Dummy variable which takes the value 0 if the firm reports that an effect of innovation has been irrelevant for market share, 1 of it has had a low impact, 2 if it has had a medium impact, and 3 if it has had a high impact.

Increased range: Dummy variable which takes the value 0 if the firm reports that an effect of innovation has been irrelevant for the range of goods and services, 1 of it has had a low impact, 2 if it has had a medium impact, and 3 if it has had a high impact.

Industry dummies: System of eleven dummies grouping industries in the following way

NACE	Industry name
34-35	Vehicles
23-24	Chemicals
29	Machinery
30-33	Electrical
15-16	Food
17-19	Textile
20-22	Wood
25	Plastic rubber
26	Non-metallic

27-28	Basic metal
36-37	NEC

Sectors Vehicles to Electrical correspond to the High and Medium-high technology intensive sectors of the OECD, sectors Food to Basic metal to the Medium-high and Low.

Innovation effort: Ratio of total innovation expenditure to current turnover.

Improved quality: Dummy variable which takes the value 0 if the firm reports that an effect of innovation has been irrelevant for the quality of goods and services, 1 of it has had a low impact, 2 if it has had a medium impact, and 3 if it has had a high impact.

Investment growth: Rate of change in the firm investment for the whole period (computed as $2(x_t - x_{t-1})/(x_t + x_{t-1})$ to avoid the effect of zeroes for non-investment in the base year).

Market novelties share: Fraction of the turnover due to new or significantly improved products introduced during the period corresponding to new products for the enterprise market.

Marketing expenditures: Fraction of innovative expenditures accounted for by the expenditures on market introduction of the new products.

Prices growth: Spain: computed from 88 industry series for Manufacturing, coming from the "Indices de precios industriales," elaborated by the INE, and from the services component of the Consumer Price Index; UK: computed at the 4-digit level for manufacturing using ONS output deflators, and at the 1.5 digit level for services using OECD output deflators; Germany:

Process and product innovation: Dummy which takes the value 1 if the firm reports having introduced new or significantly improved products and production processes during the period.

Process innovation: Dummy which takes the value 1 if the firm reports having introduced new or significantly improved production processes during the period.

Process innovation only: Dummy which takes the value 1 if the firm reports having introduced new or significantly improved production processes during the period but no new or significantly improved products.

R&D effort: Ratio of total R&D expenditure to current turnover.

Sales growth: Rate of change of the firm's turnover for the whole period.

Sales growth due to new products: Computed as the product of the fraction of turnover due to new or significantly improved products and one plus the rate of change of the firm's turnover for the whole period (notice that, calling s to the fraction, we have $\frac{S_2}{S_1+\Delta S_1+S_2}=s$ and hence $\frac{S_2}{S_1}=(1+\frac{\Delta S_1+S_2}{S_1})s$).

Sales growth due to unchanged products: Sales growth minus sales growth due to new products.

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Table 1. Employment effects of innovation

			Displacement	Compensation		
		Process innovation	Productivity effect: less labour for a given output	Price effect: cost reduction, passed on to price, expands demand	$\Longleftarrow$	Depends on firm agents' behaviour
R&D innovation expenditures	$\Longrightarrow$					$\Uparrow$
		Product innovation	Productivity differences of the new product?	Demand enlargement effect	$\Longleftarrow$	Depends on competition

Table 2. Manufacturing firms: Process and product innovation, employment and sales, 1998-2000[1,2]

	France	Germany	Spain	UK
N^o of firms	4631	1319	4548	2493
Non-innovators (%)	47.7	41.5	55.4	60.5
Process only (%)	7.1	10.2	12.2	11.0
Product innovators[3] (%)	45.2	48.4	32.4	28.5
[Of which product & process innovators]	[*24.3*]	[*27.4*]	[*20.0*]	[*14.2*]
Employment growth (%)				
All firms	*8.3*	*5.9*	*14.2*	*6.7*
Non-innovators	7.0	2.4	12.6	5.6
Process only	7.5	6.0	16.2	8.0
Product innovators[3]	9.8	8.9	16.2	8.5
Sales growth (%)				
All firms	*13.0*	*15.2*	*23.2*	*12.3*
Non-innovators	11.0	10.8	21.7	10.8
Process only	13.4	21.7	23.6	16.3
Product innovators[3]	15.0	17.5	25.7	13.9
Unchanged products	*−2.3*	*−17.0*	*−13.7*	*−21.5*
New products	*17.3*	*34.5*	*39.4*	*35.4*
[Of which new to the market]	[*8.2*]	[*13.1*]	[*13.8*]	[*9.1*]
Productivity growth (%)				
All firms	*4.7*	*9.3*	*9.0*	*5.6*
Non-innovators	4.0	8.4	9.1	5.2
Process only	5.9	15.7	7.4	8.3
Product innovators[3]	7.5	8.7	9.5	5.4
Prices growth[4] (%)				
Non-innovators	2.5	1.1	4.0	0.1
Process only	3.1	2.4	4.2	−0.2
Product innovators[3]	2.4	1.3	3.7	−0.4

[1]Rates of growth for the whole period 1998-2000.

[2]Population are firms with 10 or more employees. Entrant firms and firms affected by mergers and scissions not considered.

[3]Product innovators only + process and product innovators.

[4]Prices computed for a set of industries and assigned to firms according to their activity.

Table 3. Services firms: Process and product innovation, employment and sales, 1998-2000[1,2]

	France	Germany	Spain	UK
N^o of firms	1653	849	1839	1794
Non-innovators (%)	60.2	51.4	69.1	73.2
Process only (%)	8.5	9.3	9.4	7.0
Product innovators[3] (%)	31.3	39.3	21.5	19.8
[Of which product & process innovators]	[*17.2*]	[*21.7*]	[*11.9*]	[*8.1*]
Employment growth (%)				
All firms	*15.5*	*10.2*	*25.9*	*16.1*
Non-innovators	14.2	5.9	24.8	13.8
Process only	9.9	6.1	24.5	18.6
Product innovators[3]	19.4	16.9	30.1	23.7
Sales growth (%)				
All firms	*18.4*	*18.5*	*32.3*	*22.7*
Non-innovators	16.3	14.4	30.9	21.2
Process only	16.1	11.2	30.9	24.1
Product innovators[3]	23.1	25.6	37.8	28.2
Unchanged products	*−3.2*	*−15.9*	*−8.9*	*−14.1*
New products	*26.3*	*41.5*	*46.7*	*42.2*
[Of which, new to the market]	[*9.8*]	[*16.4*]	[*19.2*]	[*11.1*]
Productivity growth (%)				
All firms	*2.9*	*8.3*	*6.4*	*6.7*
Non-innovators	2.1	8.5	6.1	7.4
Process only	6.2	5.1	6.4	5.5
Product innovators[3]	3.7	8.7	7.7	4.5
Prices growth[4] (%)				
Non-innovators	1.8	5.0	7.3	2.3
Process only	1.8	4.7	7.3	1.0
Product innovators[3]	1.8	3.0	7.3	3.0

[1]Rates of growth for the whole period 1998-2000.

[2]Population are firms with 10 or more employees. Entrant firms and firms affected by mergers and scissions not considered.

[3]Product innovators only + process and product innovators.

[4]Prices computed for a set of industries and assigned to firms according to their activity.

Table 4. Manufacturing and Service sector firms
Exploratory OLS regressions: employment growth on (real) sales growth and innovation dummies[1]

Dependent variable: l

Regression (Sector)	A (Manufacturing)				B (Services)			
	France	Germany	Spain	UK	France	Germany	Spain	UK
Explanatory variables								
Constant	2.52	-2.22	6.59	0.25	5.15	-0.36	8.44	6.10
	(0.53)	(0.64)	(0.59)	(0.64)	(2.23)	(1.29)	(1.67)	(1.31)
Real sales growth: $(g - \widetilde{\pi}_1)$	0.43	0.43	0.35	0.48	0.45	0.49	0.48	0.46
	(0.02)	(0.04)	(0.02)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)
Process innovation only	-0.54	-0.49	2.98	-0.45	-3.78	-0.12	0.57	3.68
	(1.17)	(1.20)	(1.25)	(1.57)	(2.73)	(1.97)	(2.60)	(3.29)
Product innovation	1.11	3.99	2.0	2.14	3.30	3.94	2.82	5.57
	(0.72)	(1.21)	(0.88)	(1.31)	(2.74)	(1.85)	(2.31)	(2.05)
N^o of firms	4631	1319	4548	2493	1653	849	1839	1794
Standard error	21.64	19.31	26.10	24.38	39.33	23.50	36.09	30.13

[1]Coefficients and standard errors robust to heteroskedasticity. All regressions include industry dummies.

Table 5. Manufacturing firms
The effects of product innovation on employment[1]

Dependent variable: $l - (g_1 - \widetilde{\pi}_1)$

Regression (Method)	A (OLS)				B (IV[2])				C (IV[3])			
	France	GER	Spain	UK	France	GER	Spain	UK	France	GER	Spain	UK
Explanatory variables												
Constant	-1.87	-5.59	-3.58	-3.28	-3.60	-6.40	-5.88	-5.22	-3.51	-6.16	-5.83	-5.20
	(0.57)	(1.57)	(0.67)	(0.81)	(0.58)	(1.58)	(0.84)	(0.85)	(0.74)	(1.56)	(0.83)	(0.85)
Sales growth due to	0.77	0.88	0.86	0.80	0.98	1.00	1.02	0.99	0.97	0.97	1.02	0.99
new products	(0.05)	(0.06)	(0.03)	(0.06)	(0.06)	(0.07)	(0.04)	(0.05)	(0.06)	(0.06)	(0.04)	(0.05)
N^o of firms	4631	1319	4548	2493	4631	1319	4548	2493	4631	1319	4548	2493
Standard error	28.02	27.25	35.97	30.44	28.21	27.34	36.28	30.84	28.19	27.23	36.27	30.83
Test of overident. restrictions	–	–	–	–	–	–	–	–	1.77	3.20	0.45	1.72
(degrees of freedom)									(2)	(2)	(2)	(2)

[1]Coefficients and standard errors robust to heteroskedasticity. All regressions include industry dummies.

[2]Unique instrument used is Increased range.

[3]Instruments used are Increased range, Clients as a source of information, and Continuous R&D engagement.

Table 6. Manufacturing firms
The effects of innovation on employment: adding process innovation[1]

Dependent variable: $l - (g_1 - \widetilde{\pi}_1)$

Regression (Method)	A (IV[2])				B (IV[2])				C (IV[3])			
	France	GER	Spain	UK	France	GER	Spain	UK	France	GER	Spain	UK
Explanatory variables												
Constant	-3.52	-6.08	-6.11	-4.69	-3.51	-5.95	-6.14	-4.73	-3.50	-6.06	-6.12	-4.62
	(0.78)	(1.61)	(0.9)	(0.88)	(0.78)	(1.60)	(0.91)	(0.88)	(0.78)	(1.60)	(0.90)	(0.88)
Process innovation only	-1.31	-6.19	2.46	-3.85	-1.26	-6.20	2.47	-3.84	-1.32	-6.18	2.47	-3.88
	(1.57)	(2.92)	(1.78)	(1.87)	(1.56)	(2.92)	(1.79)	(1.87)	(1.57)	(2.92)	(1.78)	(1.87)
Process and product innov.					2.59	-1.98	-1.49	5.51				
					(1.43)	(2.80)	(2.64)	(2.55)				
Sales growth d.t. new products	0.98	1.01	1.02	0.98	0.90	1.04	1.05	0.90	0.90	1.03	1.03	0.89
	(0.06)	(0.07)	(0.04)	(0.05)	(0.09)	(0.07)	(0.07)	(0.07)	(0.09)	(0.08)	(0.06)	(0.07)
Sales growth d.t. new products * process innovation									0.14	-0.04	-0.02	0.16
									(0.08)	(0.07)	(0.06)	(0.08)
N^o of firms	4631	1319	4548	2493	4631	1319	4548	2493	4631	1319	4548	2493
Standard error	28.21	27.31	36.25	30.74	28.07	27.46	36.35	30.40	28.20	27.27	36.26	30.47

[1]Coefficients and standard errors robust to heteroskedasticity. All regressions include industry dummies.

[2]Unique instrument used is Increased range.

[3]Instruments are Increased range and Increased range interacted with Process innovation.

Table 7. Service sector firms
The effects of product innovation on employment[1]

Dependent variable: $l - (g_1 - \widetilde{\pi}_1)$

Regression (Method)	A (OLS)				B (IV[2])				C (IV[3])			
	France	GER	Spain	UK	France	GER	Spain	UK	France	GER	Spain	UK
Explanatory variables												
Constant	-2.13	-2.09	-3.04	-3.53	-5.32	-3.42	-4.06	-5.12	-5.08	-3.55	-3.95	-5.05
	(1.95)	(2.60)	(2.01)	(1.48)	(2.42)	(2.72)	(2.21)	(1.53)	(2.36)	(2.71)	(2.20)	(1.53)
Sales growth due to new products	0.85	0.75	0.92	0.89	1.15	0.93	0.99	1.04	1.13	0.94	0.98	1.03
	(0.07)	(0.06)	(0.05)	(0.06)	(0.13)	(0.08)	(0.08)	(0.06)	(0.13)	(0.08)	(0.08)	(0.06)
N^o of firms	1653	849	1839	1794	1653	849	1839	1794	1653	849	1839	1794
Standard error	44.59	33.42	43.32	37.94	45.09	33.68	43.37	38.01	45.02	33.80	43.36	37.99
Test of overident. restrictions	–	–	–	–	–	–	–	–	0.41	1.09	0.35	3.55
(degrees of freedom)									(2)	(2)	(2)	(2)

[1]Coefficients and standard errors robust to heteroskedasticity. All regressions include industry dummies.

[2]Unique instrument used is Increased range.

[3]Instruments used are Increased range, Clients as a source of information, and Continuous R&D engagement.

Table 8. Service sector firms
The effects of innovation on employment: adding process innovation[1]

Dependent variable: $l - (g_1 - \widetilde{\pi}_1)$

Regression (Method)	A (IV[2])				B (IV[2])				C (IV[3])			
	France	GER	Spain	UK	France	GER	Spain	UK	France	GER	Spain	UK
Explanatory variables												
Constant	-5.25	-3.51	-4.04	-5.51	-4.96	-3.60	-3.82	-5.45	-5.24	-3.46	-4.07	-5.61
	(2.48)	(2.78)	(2.25)	(1.61)	(2.44)	(2.77)	(2.20)	(1.62)	(2.48)	(2.80)	(2.24)	(1.62)
Process innovation only	-1.45	1.54	-0.38	3.21	-1.63	1.56	-0.46	3.10	-1.45	1.46	-0.32	3.25
	(3.47)	(3.07)	(3.37)	(3.54)	(3.47)	(3.06)	(3.36)	(3.53)	(3.47)	(3.07)	(3.37)	(3.53)
Process and product innov.					-3.81	1.80	-6.52	-6.26				
					(5.55)	(4.26)	(6.72)	(4.96)				
Sales growth d.t. new products	1.16	0.92	0.99	1.05	1.23	0.90	1.07	1.10	1.18	0.86	1.13	1.10
	(0.13)	(0.08)	(0.08)	(0.06)	(0.18)	(0.11)	(0.14)	(0.09)	(0.17)	(0.11)	(0.12)	(0.10)
Sales growth d.t. new products * process innovation									-0.04	0.09	-0.23	-0.10
									(0.20)	(0.10)	(0.12)	(0.11)
N^o of firms	1653	849	1839	1794	1653	849	1839	1794	1653	849	1839	1794
Standard error	45.11	33.66	43.37	38.02	45.36	33.53	43.51	38.19	45.11	33.76	43.25	38.07

[1]Coefficients and standard errors robust to heteroskedasticity. All regressions include industry dummies.
[2]Unique instrument used is Increased range.
[3]Instruments are Increased range and Increased range interacted with Process innovation.

Table 9
The contribution of innovation to employment growth[1]
Manufacturing and Services, 1998-2000[2]

	France	Germany	Spain	U K
Manufacturing[3] (Average values)				
Employment growth	*8.3*	*5.9*	*14.2*	*6.7*
Productivity trend in production of old products[4]	-1.9	-7.5	-5.7	-5.0
Process innovation net contribution in production of old products	-0.1	-0.6	0.3	-0.4
Output growth of old products contribution	4.8	6.0	12.2	8.3
Product innovation net contribution	5.5	8.0	7.4	3.9
Services[3] (Average values)				
Employment growth	*15.5*	*10.2*	*25.9*	*16.1*
Productivity trend in production of old products[4]	-2.3	-3.0	1.0	-5.0
Process innovation net contribution in production of old products	-0.1	0.1	-0.0	0.2
Output growth of old products contribution	9.9	5.4	18.5	15.5
Product innovation net contribution	8.0	7.6	6.5	5.4

[1]Decomposition based on tables 2 and 3 and regressions 6(A) and 8 (A).
[2]Rates of growth for the whole period.
[3]The sum of decomposition values may differ slightly from employment growth because of rounding.
[4]Productivity trend is the weighted sum of industry dummy values and hence differs from the constant of the regression.