Does innovation spur employment? A firm-level analysis using Spanish CIS data*

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Preliminary and incomplete

See attached the results for Germany (Bettina Peters) and United Kingdom (Rupert Harrison)

Abstract

This paper studies the impact of process and product innovations introduced by firms on their employment. A model which relates employment growth to process innovations and to the growth of sales due to the innovative and unchanged products is devised and estimated. Results show that the net outcome of process innovation is not employment displacement and that product innovation expands employment with a gross unit elasticity with respect to innovative sales.

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1.Introduction.

This paper focuses on testing the employment effects of innovation with data from the Third Community Innovation Survey (CIS3). The test is carried out with Spanish data, but an interesting potential feature of this exercise is that these data are available for the European Union countries in a similar format. Basic CIS3 variables (set out in the core questionnaire) include for each firm in the sample, among other things, employment and sales in the years 1998 and 2000, the change in employment expected by 2002, information about whether the firm has introduced process and product innovations during the period, and the share of sales stemming from the innovative products (new or significantly improved products).

Firm-level employment effects of innovation are complex[1]. Both process and product innovation are expected to impact employment through different channels, and some impacts imply the reduction of labour for given tasks ("displacement effects") while others imply the "creation" of new labour needs ("compensation" effects). One remarkable feature of CIS data is that, according to a simple theoretical framework which only implies mild assumptions, some of these effects can in principle be neatly disentagled. We observe, as reported by firms, the implicit change in production (derived from the change in sales) which underlies the change in employment. In particular, we observe the output issued from product innovation and the evolution of the output corresponding to the unchanged products. And we have some information on the changes applied by the firm to the productive process. We show that this is enough to identify some effects of theoretical interest.

This paper uses the Spanish CIS3 data to estimate the model. Collected by the Instituto Nacional de Estadística (INE), under the name of "Encuesta sobre Innovación Tecnológica en las Empresas," the sample consists of a total of 11,778 firms, 6,094 of which are in Manufacturing and 4,778 in the Services sector.

The rest of this draft is organised as follows. Section 2 develops the model and shows

[1] See García, Jaumandreu and Rodriguez (2002) and the references therein for the microeconomic firm-level modelling of the effects of innovation.

the identifiable effects. Section 3 briefly comments on the data. Section 4 presents several estimates and checks their robustness. Section 5 concludes. A Data Appendix contains details on the sample and variables employed.

2. The model.

Firms can produce different products and, in particular, we focus on the firms' decision to begin to produce and sell new (or improved) products during the period of reference (product innovation). Let us group the unchanged products in an "old-products" aggregate output at the beginning of the period, Y_1, which changes during the period by ΔY_1, and the new products in a current aggregate output Y_2. To produce different outputs, firms must replicate (scale) the conventional inputs, but there is a knowledge capital which constitutes a non-rival input and drives the specific efficiencies for each process and its evolution over time. Let us assume that production processes show constant returns to scale in the conventional inputs, and that knowledge proportionally increases the marginal productivity of all conventional inputs of a given process. Thus we can write

$$Y_i = \theta_i F(C_i, L_i, M_i) \qquad\qquad i = 1, 2$$

where θ represents efficiency (a function of knowledge capital) and C, L and M stand for capital, labour and materials.

According to Shephard Lemma, $L_i = c_L(w)\frac{Y_i}{\theta_i}$, where $c_L(w)$ represents the derivative of marginal cost with respect to wage (a function of input prices w). Using this expression, and assuming w is unchanged, we can write employment at the beginning of the period as $L_1 = c_L\frac{Y_1}{\theta_1}$, current employment producing the old output as $L_1 = c_L\frac{Y_1+\Delta Y_1}{\theta_1+\Delta\theta_1}$, and current employment dedicated to the innovative products $L_2 = c_L\frac{Y_2}{\theta_2}$. Hence, we can write an employment growth approximate decomposition as

$$\frac{\Delta L}{L_1} = \frac{\Delta L_1 + L_2}{L_1} \simeq -\frac{\Delta\theta_1}{\theta_1} + \frac{\Delta Y_1}{Y_1} + \frac{\theta_1}{\theta_2}\frac{Y_2}{Y_1} \qquad (1)$$

where we neglect the cross product term between the two first terms.

The expression says that, with input prices unchanged, employment growth is the result of the increase in efficiency in the productive process for the old goods, the rate of change of the production for these goods, and the increase in production attributable to the innovative products. Notice that the increase in efficiency $-\frac{\Delta\theta_1}{\theta_1}$ is expected to be different for firms which introduce process innovations, although the efficiency of all firms is expected to grow over time, and that the effect of product innovation depends on the effciency difference between processes (ratio $\frac{\theta_1}{\theta_2}$).

Equation (1) suggests the population relationship

$$l = \alpha_0 + \alpha_1 + y_1 + \beta y_2 + u \tag{2}$$

where l stands for employment growth, α_0 for (minus) average efficiency growth for non-process innovators, α_1 for average additional efficiency growth for process innovators, y_1 and y_2 for the output rates of growth $\frac{\Delta Y_1}{Y_1}$ and $\frac{Y_2}{Y_1}$ respectively (output growth due to the old and new products), and u for a disturbance with zero mean conditional in the included variables and effects.

To estimate equation (2), however, we must substitute nominal sales, the magnitudes that we observe, for real production. Let g_1 be the nominal rate of growth of sales due to the old products. Calling $\pi_1$the variation of prices p_1 for these products, we can write the approximate relation $g_1 = y_1 + \pi_1$. And let g_2 be the ratio of innovative sales to unchanged products sales. Calling π_2 the proportional difference of the prices of new products p_2 with respect to the old prices p_1, $\frac{p_2 - p_1}{p_1}$, we also have $g_2 = y_2 + \pi_2 y_2$. Notice that $E(\pi_2 y_2)$ can be assumed to be zero or close to zero and uncorrelated with y_2[2]. Substituting g_1 and g_2 for y_1 and y_2 respectively, and reordering the expression, we obtain

$$l - g_1 = \alpha_0 + \alpha_1 + \beta g_2 + v \tag{3}$$

where $v = -\pi_1 - \beta\pi_2 y_2 + u$ (in case of a non-zero mean of π_1 the model will include $-E(\pi_1)$

[2]New product real sales will be negatively correlated with the new product price, more or less intensely according to the own price elasticity of demand for the new product and the cross price elasticity with respect to the old, and the value of $\pi_2 y_2$ is likely to vary widely across firms even for similar y_2 values.

in the intercept and $-(\pi_1 - E(\pi_1))$ in the disturbance).

To estimate the parameters of (3) consistently, we have to take into account two main problems. Firstly, 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 real ratio y_2 directly, and we can try to solve the problem by instrumenting g_2 with variables correlated with this ratio and uncorrelated with the price differences.

Secondly, the composite error term includes π_1, the change in 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. Hence, price variation is likely to be proportional (with the opposite sign) to the increase in efficiency, and firms endowed with some market power, confronted with different competitive environments, might pass on this cost decrease by different amounts. As a consequence, if efficiency increases by a (and so marginal cost also decreases by this amount), and prices are reduced by $-\gamma a$, where γ is the pass on parameter, we are only able to estimate $-a - \pi_1 = -(1-\gamma)a$. That is, we only identify the net effect of productivity on employment (once the compensating price effect has been accounted for).

In this exercise we use a system of price indices $\hat{\pi}_1$computed at a detailed disaggregation of manufacturing as a proxy for π_1(we use $l - (g_1 - \hat{\pi}_1)$ as dependent variable, which will leave in the error the term $-(\pi_1 - \hat{\pi}_1)$). With this arrangement, we are likely to identify the average gross real productivity effect, but a problem of identification remains for firms which deviate from average price behaviour. That is, if individual differences in price behaviour $(\pi_1 - \hat{\pi}_1)$ for some types of firms are, as is likely, related to individual productivity differences, with price variation only partially controlled for, we will only be able to estimate $-\alpha - (\pi_1 - \hat{\pi}_1) = -(1 - \lambda)\alpha$ say.

3. Data.

Table 1 summarises the sample innovation behaviour, the evolution of employment, and the evolution of sales split into two components (growth due to unchanged products and growth due to innovative products). During the years 1998-2000, the Spanish economy was immersed in a high growth path which heavily influences the data. Taking into account the prices' growth reported in the last column of the table (considerably higher in the Services sector), yearly real sales growth roughly averaged 10 percentage points in Manufacturing and 12 in Services. Similarly, yearly employment growth averaged 7 percentage points in Manufacturing and 12 in Services. These figures, extremely optimistic, more than double the official figures for output and employment growth during the period (4-5% and 3% respectively in Manufacturing, and 4-3% and 4% in Services; see Bank of Spain (1999,2000)). To reconcile these differences, two aspects must be taken into account. Firstly, we only give simple averages in which high growth small firms have a disproportionate weight (although this may be balanced by the lower sampling number of small firms); secondly, firms answering the questionaire, and answering it completely, may constitute a somewhat self-selected sample. In any case, the sample encompasses sufficient heterogeneity to allow for adequately general conclusions.

About 45% of manufacturing firms and 25% of services firms innovate during the years covered by the survey. Almost half of the manufacturing innovators introduce both process and product innovations, while the other half consists of two similar subsets of firms which only introduce either process or product innovations. This is somewhat different in Services, where the proportion of firms implementing both process and product innovations is lower and roughly similar to the proportions of firms introducing either process or product innovations.

Table 1 suggests that the sample is full of sales and employment effects of innovations, but also that they cannot be disentagled without the help of a model and a careful econometric modelling and estimation. This is what we try to do in the next section.

4. Econometric results.

Table 2 presents the process of specifying a valid equation for the firms in manufacturing and subjects it to a series of robustness checks. Estimate 1 shows the results of regressing by

OLS the dependent variable in nominal terms (total employment growth minus the growth of sales due to the unchanged products) on a constant, a process innovation dummy and the growth of sales due to the new products. The coefficient on this last variable is very small, suggesting inconsistent estimation due to the error in variables problem (see Section 2).

Estimate 2 applies TSLS, taking the growth of sales due to the new products as endogenous and using three instruments: the fraction of these sales which are considered market novelties (*Market novelties share*), current R&D expenditure over sales (*R&D effort*) and a dummy which takes the value one (1) if the firm reports that the effects of innovation have had a high to medium impact on the increase of the range of goods and services (*Improved range*). Instruments have been selected by their likely correlation with the real rate of growth of sales due to innovation and their presumed lack of correlation with the change in prices. A robust test for overidentifying restrictions (see Wooldridge 2002, page 123) indicates the validity of these instruments.

Other "effects of innovation" dummies, like the high to medium impact on improved quality of the goods (*Improved quality*) and a high to medium impact on increased market share (*Increased market share*), have very different effects. Quality could be accepted, according to the test, as an additional instrument, but the market dummy is strongly rejected (probably because market enlargement strategies are usually linked to price changes). Similarly, the innovation expenditure over sales (*Innovation effort*) or the marketing expenditures of introduction of innovations (*Marketing expenditures*) could be used as additional instruments, but the rate of growth of exports during the period is also strongly rejected. Given that the size of the coefficient is sensible, and the test repeatedly accepts the instruments, we will keep them in the rest of the estimates.

Estimate 3 introduces industry prices growth by substracting it from the nominal sales growth of unchanged products. As expected, this dramatically changes the value of the constant, which now constitutes an estimate (with negative sign) of average productivity growth in real terms. Estimate 4 introduces industry prices growth in the IV estimate. This gives a rough estimate of average productivity growth of 5% (2.5% a year), at the same time giving a sensible coefficient on the sales growth variable. This estimate must be considered consistent. The only relative surprise is the no-effect picked up by the process innovation dummy. The estimation says literally that process innovations have, on average, no effect on productivity growth. The explanation is simple: process-innovative firms are likely to pass on part of productivity increases to prices and the estimation is simply saying that process-innovative firms tend to pass on to prices just the excess of productivity gains on average productivity growth (that is, the gains derived from innovation).

Estimate 5 splits the process innovation dummy in two: firms with process innovation only and firms which introduce process and product innovations simultaneously. It does not add very much to estimate 4, but strongly confirms our interpretation. Firms which experience exclusively process innovations seem, in fact, to tend to pass on a bit more to prices than the gains from innovation (they tend to price more agressively, although the coefficient is only weakly significant). Firms which introduce process and product innovations simply pass on to prices the gains from the process innovation.

Estimates 6, 7 and 8 are carried out to check that estimates 4 and 5 are robust. Estimate 6 shows robustness to heterogeneity by introducing in the specification a set of 11 activity dummies (with coeffients constrained to add up to zero). Until now, input prices variation has been ignored. Estimate 7 includes in the equation the rate of increase of physical investment (*Investment growth)* in order to control for possible changes in employment with this origin. According to the results, only a small change in employment can be traced back to this reason. Finally, the observed employment change can be measuring only a fraction of the total effect of innovation. To test for this possibility, Equation 8 includes in regression the change expected in employment for the two years to come (as reported by the firm, *Expected employment growth*). Results show that only a tiny fraction of the change tends to be postponed.

Table 3 reproduces Estimate 5 in the first column for the ease of comparison. Estimate 2 of this table carries out another type of robustness check: when firms entering the industry are included, as well as the firms undergoing discrete changes in their size because of mergers or scissions, almost nothing changes (although the "process innovation only" dummy loses significance when mergers and scissions are introduced). Estimate 3, however, carried out for all firms available in the sample (manufacturing, services and others), reveals that things can be different for other sets of firms. Estimates 4,5 and 6 focus on the Services sample. Estimate 4 shows that the previous specification is not adequate for Services. A change in the employed instruments, substituting *Innovation effort* for *R&D effort*, and including the additional instrument of market share impact of high to medium innovation (*Increased market share*, which was rejected in the manufacturing sample), produces regressions 5 and 6.

Some characteristics are worthy of comment. Firstly, the average productivity change turns out to be non-positive for Services firms (a negative average change not fully significant is suggested). Secondly, the coefficient on sales growth due to new products seems to point to significant productive changes. Thirdly, process innovation tends to show some productivity effect. As we use only a single and rough prices indicator for all services activities, these effects should be interpreted with some care.

5.Conclusions.

This paper has used the Spanish CIS3 data base to assess the impact of innovation on employment. The exercises performed have produced sensible results, which are summarised in what follows. Firstly, it seems that a clear distinction must be made between manufacturing and services firms. In Manufacturing, all firms tend to experience an important real rate of increase in productivity, not less than 2.5 % a year (which can be attributed to the operation of factors as embodied technological progress, learning, spillovers and so on). This productivity increment seems to operate continuously against employment given output, but increases in real sales of traditional products above this rate of growth result in employment expansions. This is clearly the case in the years studied. In Services firms, however, productivity growth shows no trend, and hence lower sales increases can result in employment expansions.

Secondly, in this context, product innovations have a clearly positive effect on employment, both in Manufacturing and Services. Firms' employment has at least unit elasticity with respect to innovative sales in Manufacturing, although this elasticity may be somewhat lower in Services as a result of the change in productive processes associated with the new product sales. In any case, innovative sales are to some degree a substitute for the sales of the old product, and hence a net effect of product innovation could also be distinguished. But net effects will also turn out to be positive while innovative sales contribute a net increase in total sales.

Thirdly, without individual price data, the gross effects of process innovation cannot be identified. Regressions clearly show that firms implementing process innovations tend to pass on the extra productivity increments to prices, generating an expansion effect which tends to balance their "displacement" effect of employment. This seems pretty clear for the manufacturing firms which introduce only process innovations, and which seem to price rather aggressively. It also cannot be rejected as average behaviour for the manufacturing firms introducing process and product innovations and the services firms introducing innovations of all kinds.

Fourthly, as a general conclusion, evidence shows that process innovation is not responsible for employment decreases, while product innovation is at least responsible for the increase in employment due to the net sales increase effect of innovative sales. However, evidence also shows that the net increase in employment during the period was the result of a big boom of all sales, and that underlying manufacturing productivity increases may be difficult to balance in other periods.

Data Appendix

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 usually 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.

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

Entry, merger or scission: When the firm answers yes to any of the questions about significant changes during the period (establishment, turnover increase by merger or turnover decrease by sale or closure)

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

Exports growth: Rate of change of the firm's exports 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-exports in the base year).

Increased market share: Dummy variable which takes the value 1 if the firm reports that an effect of innovation has been a high to medium impact on increased market or market share.

Increased range: Dummy variable which takes the value 1 if the firm reports that an effect of innovation has been a high to medium impact on an increased range of goods and services.

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 1 if the firm reports that an effect of innovation has been a high to medium impact on improved quality in goods or services.

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: 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.

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.

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

Process and product innovation, employment and sales, 1998-2000[1].

Firm type	Nº	Proportion (%)	Employment growth (%)	Sales growth (%) Total	Unchanged product	New product	Prices growth[2] (%)
Industry							
Non-innovators	2519	55.4	12.6	21.7	21.7	0.0	4.0
Process innovators	554	12.2	16.2	23.6	23.6	0.0	4.2
Product innovators	563	12.4	16.2	25.7	-13.9	39.6	3.4
Process & product innov.	912	20.0	16.2	25.7	-13.6	39.2	3.9
Total[3]	4548	100.0	14.2	23.2	10.4	12.8	3.9
Services							
Non-innovators	2452	74.7	22.4	29.0	29.0	0.0	7.3
Process innovators	277	8.4	21.6	30.5	30.5	0.0	7.3
Product innovators	253	7.7	28.1	32.2	-7.8	40.0	7.3
Process & product innov.	300	9.1	28.1	41.4	-6.9	48.3	7.3
Total[3]	3282	100.0	23.3	30.5	23.0	7.5	7.3

[1] Rates of growth for the whole period 1998-2000.
[2] Prices computed for a set of industies and assigned to firms according to their activity.
[3] Entrant firms and firms afected by mergers and scissions not considered.

Table 2
The effects of innovation on employment
Manufacturing firms
Results from the estimation of equation[1] $l - g_1 = \alpha_0 + \alpha_1 + \beta g_2 + v$

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

Method	OLS	IV	OLS	IV	IV	IV	IV	IV
Regression	1	2	3	4	5	6	7	8
Explanatory variables								
Constant	-8.05 (-11.7)	-9.38 (-12.5)	-4.14 (-6.1)	-5.23 (-7.0)	-5.45 (-6.5)	-6.08 (-6.7)	-5.97 (-6.5)	-5.85 (-6.4)
Process innovation	3.23 (2.7)	0.07 (0.1)	3.41 (2.9)	0.81 (0.6)				
Process innovation only					2.35 (1.3)	2.43 (1.4)	2.44 (1.4)	2.58 (1.4)
Process & product innov.					-0.96 (-0.4)	-1.28 (-0.5)	-1.18 (-0.4)	-1.51 (-0.56)
Sales growth due to new products	0.84 (28.8)	1.03 (22.1)	0.84 (29.0)	0.99 (21.5)	1.02 (14.7)	1.04 (14.4)	1.04 (14.4)	1.05 (14.2)
Investment growth							-0.01 (-2.0)	
Expected employment								-0.09 (-1.6)
Industry dummies						Included	Included	Included
N^o of firms	4548	4548	4548	4548	4548	4548	4548	4548
Standard error	36.2	36.6	36.0	36.3	36.4	36.3	36.3	36.3
Test of overidentifying restrictions		1.18		0.81	0.50	0.38	0.36	0.41
(degrees of freedom)		(2)		(2)	(2)	(2)	(2)	(2)

[1]Coefficients and t-ratios (standard errors robust to heteroskedasticity).

Table 3
The effects of innovation on employment
Manufacturing, All firms and Services
Results from the estimation of equation[1] $l - g_1 = \alpha_0 + \alpha_1 + \beta g_2 + v$

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

Method	IV	IV	IV	IV	IV	IV
Regression	1	2	3	4	5	6
Explanatory variables						
	Manufacturing		All firms		Services	
Constant	-5.45 (-6.5)	-5.35 (-6.2)	-2.48 (-4.1)	1.56 (1.8)	1.21 (1.5)	1.22 (1.4)
Process innovation				-1.23 (-0.6)	-3.20 (-1.5)	
Process innovation only	2.35 (1.3)	0.99 (0.5)	-0.70 (-0.5)			-2.90 (-1.1)
Process & product innov.	-0.96 (-0.4)	-2.58 (-1.0)	-1.31 (-0.5)			-3.40 (-0.7)
Sales growth due to new products	1.02 (14.7)	1.05 (14.5)	0.95 (15.8)	0.83 (10.0)	0.92 (12.8)	0.92 (9.7)
Entry, mergers and scissions		Included				
Industry dummies						
N^o of firms	4548	4901	8458	3282	3282	3282
Standard error	36.4	39.3	39.6	41.3	41.3	41.3
Test of overidentifying restrictions	0.50	0.79	4.51	5.73	3.40	3.69
(degrees of freedom)	(2)	(2)	(2)	(2)	(3)	(3)

[1] Coefficients and t-ratios (standard errors robust to heteroskedaticity).

Innovation and employment

Firm-level evidence using German CIS3 data

Bettina Peters[1]

Priliminary results prepared for discussion as part of the European project "Innovation and Employment in European Firms: Microeconometric Evidence"

Comments on data:

The data set used is based on the 2001 official innovation survey in German manufacturing and services industries which has been the German part of the Community Innovation Surveys CIS3. The survey covers legally independent German firms with at least 5 employees from the sectors mining and quarrying, manufacturing, electricity, gas and water supply as well as construction (NACE classes 10-14, 15-37, 40-41 and 45) and from various service sectors (NACE 50-52, 60-64, 65-67, 70-74, 90). The sample of the innovation survey is drawn as stratified random sample. Firm size (8 size classes according to the number of employees), branch of industry (according to two-digit NACE classes) and region (East and West Germany) serving as stratifying variables. The innovation survey is a voluntary mail survey.

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, quarrying, electricity, gas and water supply and construction.

To compare our results with the study of Jaumandreu (2003), "Does innovation spur employment? A firm-level analysis using Spanish CIS data." we restrict our sample to firms with 10 or more employees. Furthermore, we restrict the service sector to the branches which are covered by CIS 3, i.e. 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

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(services) sample we further exclude 100 (92) firms established during 1998-2000 (if employment or sales are zero or missing for 1998) or affected strongly by mergers, sales or closure (turnover increased or decreased by more than 10 per cent). Besides that we eliminated 6 (16) outliers (employment growth or labor productivity growth turns out to be higher than 300 %) and dropped 297 (189) firms with incomplete data for all relevant variables. 1319 (849) manufacturing (services) firms remain for the empirical analysis.

An overview on the branches and their distribution in the total and innovative samples is given in table 6. Table 7 contains information on the distribution of the total and innovative samples by size classes.

Comments on tables:

All tables and columns are equivalent to those in Jaumandreu (2003).

Exceptions:

Table 2 includes additional columns 9 and 10 and Table 3 has additional columns 3a and 7. In all other estimations I used the instruments proposed by Jaumandreu (2003) for the endogenous right hand variable "growth of sales due to new products", i.e. in most cases market novelties share, R&D effort and improved range. However, in several regressions the test of overidentifying restrictions rejected the null hypothesis of valid instruments. Using a difference-in-Sargan statistic (C statistic[2]), which allows a test of a subset of the orthogonality conditions (i.e. it is a test of the exogeneity of one or more instruments), we found, that it is the R&D effort which is often rejected as a valid instrument. In Table 2, column 9 the innovation effort was used instead, but again Hansen's J statistic rejected the null hypothesis of the validity of the moment restrictions. A dummy variable which takes the value one if the firm is continously engaged in intramural R&D activities and zero else was used as an alternative instrument in Table 2, column 10 and Table 3, columns 3a and 7. Using this set of instruments, the null hypothesis that the orthogonal restrictions are valid was accepted.

[2] It is defined as the difference of the Hansen-Sargan statistics of the unrestricted equation (with the smaller set of instruments) and restricted equation (with the larger set of instruments). Under the null hypothesis that both the restricted and unrestricted equations are well-specified, the C statistic is distributed as chi-squared in the number of instruments tested. The acceptance of the null that the subset of orthogonality conditions is valid requires that the full set of orthogonality conditions be valid.

Comments on variables:

All variable are computed in accordance to Jaumandreu (2003).

To compute the price growth rates, we used producer price indices on a 3-digit NACE level for manufacturing, mining and water and energy supply (NACE 10-41) if available. That is, in Germany producer price indices are published for 87 3-digit classes in manufacturing (resp. 93 in manufacturing, mining, water and energy supply). However, no producer price indices are published for the NACE classes 17.3, 18.3, 20.5, 21.1, 22.3, 23.3, 28.5, 28.6, 29.6, 33.3, 35.3, 35.4, 35.5, 37.1, 37.2. In the latter cases we used the producer price indices on the corresponding 2-digit NACE level. All price indices are elaborated and published by the German Statistical Office (Destatis).

For service sector firms, we are only able to apply 7 different price indices. The German Statistical Office publishes price indices for wholesale, shipping, air traffic and railway transport which were applied for NACE 51, 61, 62 and 60.1. For NACE 60 (except 60.1) and 63 as well as 64 we use the traffic resp. telecommunication component of the consumer price index. For all other service sectors price growth rates are computed from the services component of the consumer price index.

Table 1
Employment and sales growth rates for innovators and non-innovators, 1998 – 2000.

Firm type	No.	Proportion (%)	Employment growth Mean in % (s.d.)	Sales growth Mean in % (s.d.) Total	Unchanged product	New product	Price growth Mean in % (s.d.)
Manufacturing							
Non-innovators	547	41.5	2.4 (20.0)	10.8 (31.2)	10.8 (31.2)	0.0 (0.0)	1.1 (4.8)
Process only	134	10.2	6.0 (22.7)	21.7 (44.1)	21.7 (44.1)	0.0 (0.0)	2.4 (7.0)
Product only	277	21.0	8.1 (28.2)	15.2 (31.8)	-18.4 (31.5)	33.6 (35.1)	1.4 (5.5)
Product & Process	361	27.4	9.4 (28.2)	19.3 (36.0)	-15.9 (34.0)	35.2 (35.5)	1.2 (3.4)
All firms	1319	100.0	5.9 (24.7)	15.2 (34.4)	-1.5 (36.9)	16.7 (30.0)	1.3 (4.9)
Services							
Non-innovators	436	51.4	5.9 (33.7)	14.4 (52.8)	14.4 (52.8)	0.0 (0.0)	5.0 (5.8)
Process only	79	9.3	6.1 (28.8)	11.2 (32.6)	11.2 (32.6)	0.0 (0.0)	4.7 (5.8)
Product only	150	17.7	17.9 (34.3)	25.8 (55.8)	-11.3 (49.2)	37.2 (42.4)	3.2 (3.1)
Product & Process	184	21.7	16.1 (38.9)	25.4 (48.1)	-19.6 (39.6)	45.0 (52.8)	2.8 (2.8)
All firms	849	100.0	10.2 (34.9)	18.5 (51.0)	2.2 (50.1)	16.3 (36.5)	4.2 (5.0)

Notes: Rates of growth for the whole period 1998–2000; Entrants and firms affected by merger, sale or closure are excluded, as are firms with less than 10 employees in 2000 and with incomplete information.

Table 2

The effects of Innovation on Employment for Manufacturing Firms

Results from estimation of the equation: $l - g_1 = a_0 + a_1 process + bg_2 + v$

Method	OLS	IV	OLS	IV	IV	IV	IV	IV	IV	IV
Regression	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Explanatory Variables										
Constant	-6.684 (-6.09)	-8.707 (-6.98)	-5.417 (-4.93)	-7.461 (-5.95)	-7.341 (-5.53)	-5.975 (-3.66)	-5.743 (-3.44)	-6.363 (-3.83)	-6.086 (-3.63)	-6.057 (-3.70)
Process innovation	-1.769 (-1.06)	-4.344 (-2.48)	-1.344 (-0.80)	-3.947 (-2.25)						
Process innovation only					-5.994 (-1.97)	-6.027 (-2.03)	-5.937 (-1.97)	-5.313 (-1.81)	-6.344 (-2.06)	-7.417 (-2.25)
Process & product innovation					-2.978 (-1.30)	-2.672 (-1.14)	-2.750 (-1.18)	-2.453 (-1.02)	-2.637 (-1.14)	-3.069 (-1.38)
Sales growth due to new products	0.884 (13.77)	1.063 (12.56)	0.887 (13.74)	1.058 (13.77)	1.047 (11.14)	1.065 (10.59)	1.059 (10.46)	1.086 (10.29)	1.059 (10.50)	1.090 (12.62)
Investment growth							-0.002 (-0.26)			
Expected Employment Growth								-0196 (-2.25)		
Industry dummies						Included	Included	Included	Included	Included
No of firms	1319	1319	1319	1319	1319	1319	1319	1319	1319	1319
Root MSE	27.3	28.0	27.3	28.0	28.0	28.0	28.0	28.0	28.0	27.0
Hansen J statistic (degrees of freedom) p-value		4.23 (2) 0.121		4.24 (2) 0.120	4.48 (2) 0.107	5.76 (2) 0.056	6.01 (2) 0.0496	7.33 (2) 0.026	6.97 (2) 0.031	1.03 (2) 0.597

Notes: Dependent variable is $l - g_1$ in columns (1) and (2) and $l - (g_1 - \tilde{p}_1)$ in other columns; t-statistics in brackets (standard errors robust to heteroscedasticity); instruments: see Table 4. Hansen J reports the teststatistic of a test of overidentifying restrictions. Under the null hypothesis J follows a $X^2(m)$ distribution with m the number of overidentifying restrictions.

Table 3
The effects of Innovation on Employment for Manufacturing / Services / All Firms
Results from estimation of the equation: $l - g_1 = a_0 + a_1 process + bg_2 + v$

Method	IV	IV	IV	IV	IV	IV	IV	IV
Regression	(1)	(2)	(3)	(3a)	(4)	(5)	(6)	(7)
Explanatory Variables	Manufacturing		Man & Services & Others		Services			
Constant	-7.341 (-5.53)	-7.554 (5.76)	-4.780 (-4.84)	-4.624 (-4.80)	-2.390 (-1.48)	-2.453 (-1.53)	-2.420 (-1.49)	-2.305 (-1.44)
Process innovation					2.502 (1.05)	2.917 (1.19)		2.566 (1.05)
Process innovation only	-5.994 (-1.97)	-7.938 (-2.25)	-3.869 (-1.76)	-4.636 (-1.92)			1.738 (0.56)	
Process & product innovation	-2.978 (-1.30)	-3.568 (-1.53)	-1.405 (-0.74)	-1.309 (-0.70)			3.526 (1.10)	
Sales growth due to new products	1.047 (11.14)	1.063 (11.44)	0.954 (14.50)	0.955 (15.01)	0.850 (11.38)	0.826 (11.35)	0.822 (10.37)	0.853 (11.17)
Mergers, sales and closures		Included						
No of firms	1319	1382	2255	2140	849	849	827	802
Root MSE	28.0	29.0	30.0	30.0	34	34	34	33
Hansen J statistic	4.48	3.41	11.90	0.953	7.95	10.53	10.55	3.10
(degrees of freedom)	(2)	(2)	(2)	(2)	(2)	(3)	(3)	(3)
p-value	0.107	0.183	0.003	0.621	0.019	0.015	0.015	0.376

Notes: Dependent variable is $l - (g_1 - \tilde{p}_1)$; robust t-statistics in brackets; t-statistics in brackets (standard errors robust to heteroscedasticity); instruments: see Table 5.
Hansen J reports the teststatistic of a test of overidentifying restrictions

Table 4
Used instruments for endogenous rhv "growth of sales due to new products" in Table 2

Column Instruments	2	4	5	6	7	8	9	10
Market Novelties Share	X	X	X	X	X	X	X	X
Improved Range	X	X	X	X	X	X	X	X
R&D effort	X	X	X	X	X	X		
Innovation effort							X	
Continous intramural R&D engagement								X

Table 5
Used instruments for endogenous rhv "growth of sales due to new products" in Table 3

Column Instruments	1	2	3	3a	4	5	6	7
Market Novelties Share	X	X	X	X	X	X	X	X
Improved Range	X	X	X	X	X	X	X	X
R&D effort	X	X	X		X			
Innovation effort						X	X	
Increased Market Share						X	X	X
Continous intramural R&D engagement				X				X

Table 6
Sample by Industries.

		Total		Non-Innovators		Process only		Product only		Product and Process	
Sectors	Nace	No.	%	No.	%	No.	%	No.	%	No.	%
Manufacturing											
Food	15-16	113	8.6	72	13.2	7	5.2	13	4.7	21	5.8
Textile	17-19	77	5.8	48	8.8	7	5.2	16	5.8	6	1.7
Wood/Paper/Printing	20-22	112	8.5	58	10.6	21	15.7	11	4.0	22	6.1
Chemicals	23-24	92	7.0	28	5.1	10	7.5	21	7.6	33	9.1
Plastic/Rubber	25	116	8.8	39	7.1	10	7.5	28	10.1	39	10.8
Glass/Ceramics	26	78	5.9	39	7.1	4	3.0	14	5.1	21	5.8
Metals	27-28	227	17.2	113	20.7	40	29.9	23	8.3	51	14.1
Machinery	29	184	14.0	58	10.6	14	10.5	55	19.9	57	15.8
Electrical engineering	30-33	214	16.2	46	8.4	9	6.7	75	27.1	84	23.3
Vehicles	34-35	53	4.0	21	3.8	4	3.0	11	4.0	17	4.7
Furniture/Recycling	36-37	53	4.0	25	4.6	8	6.0	10	3.6	10	2.8
All firms		1319	100.0	547	100.0	134	100.0	277	100.0	361	100.0
Services											
Wholesale	51	204	24.0	131	30.1	16	20.3	28	18.7	29	15.7
Transport/Storage	60-63	204	24.0	143	32.8	20	25.3	18	12.0	23	12.5
Post/Telecommunication	64	26	3.1	19	4.4	1	1.3	2	1.3	4	2.2
Financial Intermediation	65-67	97	11.4	36	8.3	10	12.7	12	8.0	39	21.2
Computer	72	80	9.4	16	3.7	4	5.1	33	22.0	27	14.7
Research & Development	73	75	8.8	15	3.4	8	10.1	20	13.3	32	17.4
Technical Servcies	742-743	163	19.2	76	17.4	20	25.3	37	24.7	30	16.3
All firms		849	100.0	436	100.0	79	100.0	150	100.0	184	100.0

Notes: Entrants and firms affected by merger, sale or closure are excluded, as are firms with less than 10 employees in 2000 and with incomplete information.

Table 7
Sample by Size Classes.

	Total		Non-Innovators		Process only		Product only		Product and Process	
Employees	No.	%	No.	%	No.	%	No.	%	No.	%
Manufacturing										
10-19	193	14.6	115	21.0	18	13.4	35	12.6	25	6.9
20-49	321	24.3	177	32.4	30	22.4	63	22.7	51	14.1
50-99	245	18.6	109	19.9	23	17.2	53	19.1	60	15.6
100-199	198	15.0	74	13.5	25	18.7	44	15.9	55	15.2
200-499	220	16.7	47	8.6	25	18.7	54	19.5	94	26.0
500-1000	91	6.9	17	3.1	10	7.5	18	6.5	46	12.7
>1000	51	3.9	8	1.5	3	2.2	10	3.6	30	8.3
All firms	1319	100.0	547	100.0	134	100.0	277	100.0	361	100.0
Services										
10-19	266	31.3	159	36.5	21	26.6	48	32.0	38	20.7
20-49	257	30.3	153	35.1	20	25.3	46	30.7	38	20.7
50-99	127	15.0	59	13.5	18	22.8	21	14.0	29	15.8
100-199	87	10.3	35	8.0	7	8.9	15	10.0	30	16.3
200-499	46	5.4	18	4.1	5	6.3	8	5.3	15	8.2
500-1000	33	3.9	7	1.6	5	6.3	8	5.3	13	7.1
>1000	33	3.9	5	1.2	3	3.8	4	2.7	21	11.4
All firms	849	100.0	436	100.0	79	100.0	150	100.0	184	100.0

Notes: Entrants and firms affected by merger, sale or closure are excluded, as are firms with less than 10 employees in 2000 and with incomplete information.

Innovation and employment

Firm-level evidence using UK CIS3 data

Rupert Harrison

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All tables and columns are equivalent to those in Jaumandreu (2003), "Does innovation spur employment? A firm-level analysis using Spanish CIS data". The only exception is that column (8) of Table 2 is not included because the "expected employment" variable is not available in the UK CIS3 data.

Table 1. Employment and sales growth rates for innovators and non-innovators, 1998 – 2000

Firm type	No.	Proportion (%)	Employment growth (%)	Sales growth (%)			Price growth (%)
				Total	Unchanged product	New product	
Manufacturing							
Non-innovators	1509	60.5	5.6	10.8	10.8	0.0	0.1
Process only	275	11.0	8.0	16.3	16.3	0.0	-0.2
Product only	355	14.2	8.4	15.4	-18.6	34.0	-0.6
Product & Process	354	14.2	8.7	12.4	-24.3	36.8	-0.2
All firms	2493	100.0	6.7	12.3	2.2	10.1	-0.1
Services							
Non-innovators	1718	73.9	13.4	21.0	21.0	0.0	4.0
Process only	178	7.7	15.9	20.9	20.9	0.0	3.5
Product only	250	10.8	24.4	25.4	-11.3	36.6	4.6
Product & Process	179	7.7	23.0	33.8	-14.0	47.9	3.6
All firms	2325	100.0	15.5	22.5	14.8	7.6	4.0

Notes: rates of growth for the whole period 1998 – 2000; prices are computed for 184 industries at the four-digit NACE level for manufacturing, and using 6 two-digit or more aggregated groups for services; entrants and firms affected by merger, sale or closure are excluded, as are firms with less than 10 employees in 2000

Table 2. Innovation and employment for manufacturing firms

Results from estimation of the equation: $l - g_1 = \alpha_0 + \alpha_1 process + \beta g_2 + v$

	OLS (1)	IV (2)	OLS (3)	IV (4)	IV (5)	IV (6)	IV (7)
Constant	-4.19 (-5.99)	-5.30 (-7.17)	-4.14 (-4.57)	-5.24 (-5.28)	-4.60 (-4.51)	(not yet done)	(not yet done)
Process innovation	2.75 (1.69)	0.32 (0.21)	2.79 (1.62)	0.40 (0.24)			
Process only					-3.90 (-1.77)	-3.84 (-1.72)	-3.74 (-1.68)
Process & product					6.21 (2.51)	5.51 (2.26)	5.48 (2.24)
Sales growth due to new products	0.79 (13.93)	0.96 (19.37)	0.78 (12.94)	0.95 (17.01)	0.85 (12.03)	0.90 (12.26)	0.90 (12.26)
Investment growth							-0.01 (-1.27)
Industry dummies						Included	Included
No of firms	2493	2493	2493	2493	2493	2493	2493
Root MSE	30.2	30.6	30.6	30.9	30.6	30.5	30.5
Test of over-identifying restrictions		1.40		1.09	0.97	1.19	1.15
(degrees of freedom)		(4)		(4)	(4)	(4)	(4)

Notes: dependent variable is $l - g_1$ in columns (1) and (2) and $l - (g_1 - \tilde{\pi}_1)$ in other columns; robust t-statistics in brackets; standard errors clustered on 184 four-digit NACE industries apart from columns (1) and (2); instruments are market novelties share, R&D effort, improved range, improved quality, and increased market share

Table 3. Innovation and employment for manufacturing, all firms, and services

Results from estimation of the equation: $l - g_1 = \alpha_0 + \alpha_1 process + \beta g_2 + v$

	IV (1)	IV (2)	IV (3)	IV (4)	IV (5)	IV (6)
	Manufacturing		Man & Services	Services		
Constant	-4.60 (-4.51)	-5.15 (-5.20)	-3.90 (-4.74)	-2.88 (-0.97)	-2.89 (-0.97)	-3.25 (-1.12)
Process innovation				-2.42 (-2.07)	-2.43 (-2.07)	
Process only	-3.90 (-1.77)	-3.28 (-1.62)	-1.84 (-1.09)			1.77 (0.88)
Process & product	6.21 (2.51)	6.83 (2.83)	0.32 (0.10)			-9.61 (-2.15)
Sales growth due to new products	0.85 (12.03)	0.81 (13.15)	0.96 (12.27)	1.04 (42.07)	1.04 (41.70)	1.12 (19.95)
Mergers, sales and closures		Included				
No of firms	2493	2790	4818	2325	2325	2325
Root MSE	30.6	32.9	34.4	37.8	37.8	38.0
Test of over-identifying restrictions	0.97	4.30	0.55	15.22	2.21	1.14
(degrees of freedom)	(4)	(4)	(3)	(4)	(3)	(3)

Notes: dependent variable is $l - (g_1 - \tilde{\pi}_1)$; robust t-statistics in brackets; standard errors clustered on 184 four-digit NACE industries in columns (1) and (2), and on 6 industries at the two-digit NACE or more aggregated level in other columns; instruments are market novelties share, R&D effort, improved range, improved quality, and increased market share, except for columns (3), (5) and (6) where R&D effort is not included as an instrument