The European Journal of Development Research
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713635016

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Online Publication Date: 01 June 2008

To cite this Article Benavente, José Miguel and Lauterbach, Rodolfo(2008)'Technological innovation and employment: complements or substitutes?',The European Journal of Development Research,20:2,318 — 329

To link to this Article: DOI: 10.1080/09578810802060744

URL: http://dx.doi.org/10.1080/09578810802060744

The European Journal of Development Research
Vol. 20, No. 2, June 2008, 318–329

Technological innovation and employment: complements or substitutes?

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In this paper we study the impact of innovative activities on employment in Chile. We closely follow a previous work by Harrison, Jaumandreu, Mairesse and Peters (2005) who developed an empirical strategy based on Jaumandreu (2003) which accounts for differences between product and process innovations. Using firm-level micro-data for the period 1998–2001, we find that product innovations affect employment positively and significantly. On the other hand, there is no evidence to suggest that process innovations significantly affect employment after controlling for investment and sectoral patterns.

Dans cet article, nous étudions l'impact des activités innovatrices sur l'emploi au Chili. Nous nous appuyons sur les travaux d'Harrison, Jaumandreu, Mairesse et Peters (2005) qui ont développé une stratégie empirique basée sur Jaumandreu (2003) qui explique la différence entre l'innovation des produits et des processus. En prenant des microdonnées au niveau de l'entreprise pour la période 1998–2001, nous constatons que les innovations de produit ont une répercussion positive et significative sur l'emploi. D'un autre côté, d'après les tendances de l'investissement et les données sectorielles, il n'y a aucun indice suggérant que les innovations de processus affectent l'emploi de manière significative.

Keywords: process innovation; product innovation; employment; instrumental variables methods

1. Introduction

The invention of new products and processes is largely responsible for cross-national differences in consumption and well-being. It is through these processes that developing economies can achieve sustainability, and depend less on the export of exhaustible and probably substitutable natural resources.[1] Evidence, however, shows that consensus to embrace this decision is far from clear. Among the issues that have been raised as controversial, at least in Chile, employment is by far the most frequently cited.[2]

Innovations, specially those implemented in commodity-based industries, may reduce employment. If a Hicksian labour saving technological change at a plant level is in place, instant firm's labour demand will be affected. But compensation effects may also surge. When production improvements are transferred to the final good prices, changes in demands may arise depending, among other things, on investment patterns and market structure.

Greater level of activity may also be observed in other markets. Suppliers will see increases in demands for their products and services affecting their own labour requirements. But competing companies that do not manage to reach the technological challenge will tend to disappear, impacting again on the level of employment.[3]

In summary, this is an empirical question. The aim of this study is to shed light on the net impact of innovation on employment.[4] We study a country that is thinking of following an

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ISSN 0957-8811 print/ISSN 1743-9728 online

DOI: 10.1080/09578810802060744
http://www.informaworld.com

innovation-based growth strategy[5] and for which we have detailed information about firms' process and product innovations together with relevant productive figures including employment growth.

Results suggest that although improvements in productivity diminish employment, the increase in total sales works as a compensation effect, the total effect being positive. On the other hand, product innovations only increase output and employment, if we assume that innovated goods are not merely substitutes of previous goods. We have not found evidence that allows us to affirm that process innovations significantly affect the labour demand of Chilean firms during the late 1990s.

The rest of the document is structured as follows: section 2 contains the specification of the model. The data used in this paper is presented in section 3. In section 4 we present the main results and section 5 concludes.

2. The model

Our exposition of the model follows closely that of the work by Harrison et al. (2005) in which it was developed and applied to a comparable sample of four European countries, using the data from CIS3. The model, initially developed by Jaumandreu (2003) and extended by Peters (2004), allows us to separate some of the effects of product and process innovations on employment at the firm level.

2.1 Basic concepts

This model is based on the idea that a firm can produce two different products in two periods. The firm decides whether it will produce new products during the second period. In the first period the firm produces 'old products' that correspond to the value of Y_{11}. In the second period the firm can decide to add new or significantly modified products to its production to be commercialised in the market. These 'new products', are grouped under the value of Y_{11}.[6]

We assume that the decision to innovate is determined prior to the decision to hire for a given period. The new products can replace the old ones if they are substitutes or increase their demand if they are complements. In addition, it is understood that the output of new products in the first period is equal to zero ($Y_{21} = 0$) and the production of the 'old products' at the second period is denoted by Y_{12}.

In order to produce different amounts of goods, it is assumed that firms must weigh the conventional factors of work, capital and materials in equal proportions since the production function is linear-homogenous for these factors. For simplicity we assume that work is an homogenous factor. Nevertheless, a knowledge capital exists that is a non-rival factor for the productive processes and that leads to specific efficiencies for each process.

Equation (1) for the production of the old and new products at the first and second periods can be derived after noting that knowledge proportionally increases the marginal productivity of all conventional factors by means of an efficiency parameter Θ_{it}, and that there are no economies of scale.

$$Y_{it} = \Theta_{it} F(L_{it}, K_{it}, M_{it}) \tag{1}$$

where L, K and M and represent work, capital and materials respectively. The cost function of the firm can be described by equation (2).

$$C(\omega_{1t}, \omega_{2t}, Y_{1t}, Y_{2t}, \Theta_{1t}, \Theta_{2t}) = c(\omega_{1t})\frac{Y_{1t}}{\Theta_{1t}} + c(\omega_{2t})\frac{Y_{2t}}{\Theta_{2t}} + F \tag{2}$$

where $c(\omega)$ is the marginal cost (a function of factors prices ω) and F is an arbitrary and exogenous fixed cost. According to Shephard's Lemma, we have:

$$L_{it} = c_L(\omega_{it}) \frac{Y_{it}}{\Theta_{it}} \tag{3}$$

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

2.2 The employment equation

Employment growth during the period can be separated into employment growth due to the production of the old product and employment growth due to the production of the new product in the following way (notice that $L_{21} = 0$):

$$\frac{\Delta L}{L} = \frac{L_{12} - L_{11}}{L_{11}} + \frac{L_{22}}{L_{11}} \tag{4}$$

We assume that the derivative of marginal cost with respect to wage does not change over time, and that it is equal for old and new products: $c_L(\omega_{11}) = c_L(\omega_{12}) = c_L(\bar{\omega}_1) = c_L(\bar{\omega}_2)$. This will be the case if, for example, the relative prices of factors are constant during both periods and are equal for both products.

Using the results of the previous section we can write an approximated decomposition of the employment growth in the following way:

$$\frac{\Delta L}{L} \cong -\frac{\Theta_{12} - \Theta_{11}}{\Theta_{11}} + \frac{Y_{12} - Y_{11}}{Y_{11}} + \frac{\Theta_{11} Y_{22}}{\Theta_{22} Y_{11}} \tag{5}$$

where we have used a linear approach to obtain the two first terms.

This expression says that employment growth is the result of (i) the change in the efficiency of the production process of the old products (that negatively affects the labour demand), (ii) the rate of change of the production for these products (caused in part by the new product, this effect would have to be negative if both products are substitutes and positive if they are complements), and (iii) the output expansion attributable to new products (positive sign).

The increase in the efficiency of the production process of the old product $((\Theta_{12} - \Theta_{11})/\Theta_{11})$ is expected to be greater for the companies that introduce process innovations related to the old product, although the efficiency of all the companies can grow over time. Now the effect of product innovation on employment growth depends on the difference in efficiency between the production processes of old and new products (the ratio Θ_{11}/Θ_{22}). If the new products are produced more efficiently than old products, then the ratio Θ_{11}/Θ_{22} is less than unity and employment does not grow one-to-one with the growth in output due to the introduction of new products.

Transforming our economic model into an econometric model we can see that equation (5) suggests the following population relationship after assuming two things, (i) that gains in efficiency are probably different between process innovators and non-process innovators, and (ii) that process innovations only affect the production technology of old products.

$$\ell = -\alpha_0 - \alpha_1 d + y_1 + \beta y_2 + \mu \tag{6}$$

with ℓ: employment growth rate, α_0: average efficiency growth for non-process innovators, α_1: average efficiency growth for process innovators, d: dummy variable indicating process innovations, y_1: real output growth due to old products, β: new and old product relative efficiency, y_2: real output growth due to new products, μ: error term with $E(u|d; y1; y2) = 0$.

2.3 Adjustments to the model

Next we briefly comment on the necessary conditions for the proper estimation of the model described up to this point. For more details about the model and the problem of identification that it raises, the reader should directly refer to Harrison et al. (2005).

First, the variable y_1 contains three different effects that cannot be separated in the absence of additional data: (i) the 'independent' increase of demand for old products of the firm, (ii) the 'compensation' effect induced by possible price variations resulting from a process innovation, and (iii) the demand's 'substitution effect' resulting from the introduction of new products. Since we cannot separate these three effects, y_1 will simply be subtracted from both sides of the equation.

Second, the rate of growth of the sales of new products (y_2) is an unobserved variable. In order to estimate equation (6) we must divide the observed nominal growth of sales g into the growth of sales due to old products (g_1) and the one due to new products (g_2). The growth rates g_1 and g_2 are constructed from observations of the rate between new and old products in the total sales at the end of the analysed period, s, and from the rate of growth of total sales, g. Then $g_2 = s(1 + g)$ and $g_1 = g - s(1 + g)$.

If g_1 is the nominal sales growth of old products and π_1 is the rate of increase of the prices of these products during the period, we can describe the approach $g_1 = y_1 = \pi_1$ where y_1 is the unobserved real sales growth due to old products. Now, if g_1 is the nominal sales growth due to new products and π_2 is the change in the prices of new products with respect to the prices of old products, then we can say that $g_{2=}y_2\ (1 + \pi_2) = y_2 + \pi_2 y_2)$ where y_2 is the unobserved real sales growth due to new products.

Replacing g_1 and g_2 in equation (6) and rearranging the equation we have:

$$\ell - g_1 = -\alpha_0 - \alpha_1 d + \beta g_2 + \nu \tag{7}$$

where the new unobserved error term is $\nu = -\pi_1 - \beta\pi_2 y_2 + \mu$. So now the model will include $-E(\pi_1)$ in the intercept and y $-(\pi_1 - E(\pi_1))$ in the error term. We also assume that $\pi_2 y_2$ is correlated with y_2.

It follows that g_2 is an endogenous variable. We will address this problem using instrumental variables for g_2. The instrument that will be used is the degree of utilisation of inputs that are new to the firm, as an origin of the idea that led to the innovation. The variable takes the value zero if the firm has declared that the innovative ideas did originate as a consequence of new inputs usage, and takes values between 1 and 4 according to the level at which the firm declares to have used new inputs as an origin of the innovative ideas. Whereas the innovative activities are probably not exogenous with respect to employment growth, it may be argued that the use of new inputs as an origin of innovative ideas is.

We also know that the error term includes the variable π_1, which represents the change in the prices of old products. To address this specification problem we will use a price index π_1^*,[7] disaggregated by industry, as a proxy for π_1. Thus we will use $\ell - (g_1 - \pi_1^*)$ as a dependent variable what will leave $-(\pi_1 - \pi_1^*)$ in the error term.

Finally if we assume (i) that the exogenous technological changes are not related to the firm's process innovative activities[8] and (ii) that they are not related to the error term, the parameter α_0 would show us the average efficiency growth for all the innovating and non-innovating companies, and the parameter α_1 would give us the additional growth in efficiency for the companies that make process innovations.

3. Description of the data

Data was taken from the Third Survey of Technological Innovation and Productivity in the Manufacturing, Mining and Power Industry collected by the Chilean National Institute of

Statistics. The survey collected data on 514 manufacturing firms in all the regions of Chile in 2001. In addition, the National Survey of the Manufacturing Industry for the years 1998 to 2001 has been used to obtain the change in employment and productivity in the reference period.

In this section we summarise the most important characteristics of the data. Table 1 shows the sales, employment and price growth in the Chilean manufacturing sector for the period 1998–2001. A distinction between product innovating companies, process innovating companies and non-innovating companies is made. It is distinguished between companies that have introduced only process innovations and companies that have introduced product innovations with or without process innovations. For simplicity, we prefer not to distinguish between those companies that have introduced product and process innovations from those that have introduced product innovations only. This is due to the characteristics of the data, which do not allow observing whether both types of innovations are determined jointly.

Adding up process innovators only and product innovators, the total percentage of companies that made some type of innovation is obtained: this figure is equivalent to 82% of the 514 companies included in the sample.

In Table 1 we can see that those companies that did not innovate registered on average a decrease in personnel. The companies that made only process innovation registered an increase of 25% in their employment, whereas product only innovators or product and process innovators registered on average an increase in employment of more than 6.7%.

Table 1. Process and product innovation, employment and sales 1998–2001.

Number of firms	514
Non-innovators (%)	17
Process only (%)	5
Product innovators[1] (%)	77
Process and product innovators (%)	76
Employment growth (%)	
All firms	5.6
Non-innovators	−3.3
Process only	25.4
Product innovators[1]	6.7
Nominal sales growth (%)	
All firms	30.0
Non-innovators	9.6
Process only	29.0
Product innovators[1]	35.2
Nominal productivity growth (%)	
All firms	24.4
Non-innovators	12.9
Process only	3.6
Product innovators[1]	28.9
Prices growth[2] (%)	
All firms	17.5
Non-innovators	17.2
Process only	14.8
Product innovators[1]	17.8

Notes: Rates of growth for the whole period 1998–2001. Population is firms with 10 or more employees. Entrant firms and firms affected by mergers and scissions not considered.
[1] Products innovators only + product and process innovators.
[2] Prices computed for a set of industries and assigned to firms according to their activity.

The total nominal sales registered an important average increase of 30% during the period for the total sample. This increase was only 9.6% for the case of the non-innovating companies, whereas for process innovators it was 29% and for product innovators it was 35%. The change in sales reported in this table is not deflated. In the case of non-innovating firms total sales have fallen over the period after considering the change in prices.

We now obtain nominal productivity growth by subtracting employment growth from the nominal output growth. Average nominal productivity increases in product innovating companies (28.9%), as well as in non-innovating firms (12.9%) and process only innovating firms (3.6%). It is important to note that real productivity growth (after considering the price changes) is negative for non-innovating firms and process only innovating firms.

Finally, Table 1 shows that the average price change during the studied period is near 17.2% for non-innovators, 14.8% for process only innovators and 17.8% for product innovators.

4. Results

We have briefly reviewed the conditional relationships that we suppose exist between the variables from our theoretical model. Table 2 presents an OLS estimation, where the dependent variable is the change in total employment during the period. The independent variables are deflated total sales growth, a dummy variable for 'only process innovation', another dummy for 'product innovation', and the control variables.

The coefficient on real sales growth is very significant and far below unity, leading us to conclude that although the increase in sales is positively correlated with the increase in employment it is less than proportionate. The coefficients of the variables 'process only innovation' and 'product innovation' are both insignificant. These results are not very useful to define the displacement and compensation effects of innovation on employment growth at the level of the companies. For this reason, next we will use the structure of our theoretical model and information on the participation of new and old products in total sales.

4.1 Employment effects of product innovations

Table 3 displays the results of considering equation (7) after replacing y_1 by g_1 and rearranging the equation. The dependent variable is now employment growth minus the growth of the sales due to old products deflated by a price index for each economic sector. According to the model that we have specified, the value of the constant is an estimation (with negative sign) of the average growth in real productivity (in a three-year period) on the production of the old goods,

Table 2. Preliminary OLS regression.

Variable	Coefficient
Sales growth ($g - \pi^*$)	0.200
	(0.059)
Only process innovation	0.206
	(0.220)
Product innovation	0.049
	(0.055)
Constant	0.237
	(0.081)
No. of firms	514

Notes: Dependent variable: ℓ. Coefficients and standard errors robust to heteroscedasticity. All regressions include industry dummies, and investment/sales controls.

Table 3. Innovation effects on employment.

Explanatory variables	A: OLS	B: IV[1]	C: IV[2]
New product sales growth	0.358	0.532	0.523
	(0.090)	(0.191)	(0.195)
Constant	−0.326	−0.414	−0.409
	(0.072)	(0.122)	(0.123)
No. of firms	514	514	514
Test of over-identifying restrictions			0.086
(degrees of freedom)			(1)
Prob > chi2			0.769

Notes: Dependent variable: $\ell - (g_1 - \pi_1^*)$. Coefficients and standard errors robust to heteroscedasticity. All regressions include industry dummies, and investment/sales controls.
[1] Unique instrument used is new inputs utilisation as an origin of the innovative idea.
[2] Instruments are new inputs utilisation as an origin of the innovative idea and increased range.

after any compensation effect of the prices. The regressions control by sectoral dummies and investment/sales ratio during the period under consideration. We have decided to include an investment/sales control variable because investment could be an important factor in determining productivity growth. A negative value of the parameter that accompanies this variable means that new investments increase labour productivity among the firms included in the sample.

Panel A presents the results of the OLS regression. The coefficient that accompanies the variable 'new product sales growth' represents an estimation of the relative efficiency in the production of new and old products. Since this value is far below unity and it turns out to be significant, we can conclude that the new products are produced with a smaller amount of work than old products, i.e. with a greater level of efficiency.

In panel B a two-stage least squares approach has been used. The variable 'new product sales growth' has been considered as an endogenous variable and a single instrument has been used. The appropriate instrument for this case is one that is related to new products sales but not to the price changes of new products compared with old products. The instrument used is the degree of usage, on the part of the company, of new inputs as an origin of the innovative ideas.[9] This variable takes the value zero if the innovative idea, as declared by the firm, is not a result of the recent introduction of new inputs and takes values between 1 and 4 according to the level at which the company declares innovative ideas were originated in the usage of new inputs. Whereas the innovative activities could not be exogenous with respect to employment growth, it is possible that the usage of new inputs as an origin of innovative ideas is.

The estimation of the coefficient 'sales growth due to new products' is considerably greater than the OLS estimation. This is consistent with a negative bias due to non-observed price changes in the OLS estimation. The coefficient is far below one suggesting that the new goods are produced with a greater level of efficiency than the old goods.

From the constant we can obtain an estimation close to 0.4% of the average productivity growth (in a three-year period) in the production of old goods.

In panel C we use an additional instrument, namely the degree of impact of the innovation in the increase of the range of goods produced by the company. This instrument has a smaller correlation with the endogenous variable than the instrument used in the previous regression. Nevertheless, we have no reason to think that this variable could be related to the price change of new products compared with old products. We have checked the validity of the additional instrument with a test of over-identifying restrictions.[10] We fail to reject the null hypothesis suggesting that instruments are valid. The estimated parameters of panels B and C are almost identical.

4.2 The effects of process innovation on employment

Table 4 contains the results obtained using the specification of the model expressed in equation (7). That is to say, the specification allows process innovations to affect the growth of productivity and, therefore, to influence the change in employment. The dependent variable is employment growth minus the growth of sales due to old products deflated by an industry-level price index.

Panel A presents the OLS results. The value of the coefficient 'new products sales growth' represents an estimation of the relative efficiency between the new and old product outputs. This value is significant and smaller than 1, letting us conclude again that new products are produced with a greater level of efficiency than old products. The coefficient that accompanies the variable 'only process innovation' is insignificant.

In panel B we present the estimation by instrumental variables. The instrument used is the degree of use on the part of the company of new inputs, as an origin of the innovation ideas. The estimation of the coefficient 'new products sales growth' is considerably greater than in the estimation by OLS. This is consistent with a negative bias due to non-observed price changes in the estimation by OLS.

We have found evidence indicating that the productivity growth in the production of old products is very small and approximately equal to 0.4% in three years. Slow productivity growth may be associated with a decrease in the gross fixed capital formation of 15.4% over the same period.

The coefficient that accompanies the variable 'process only innovation' is insignificant, indicating that the net effect of process innovation over employment is not different from zero. A possible explanation for this result is that there is no additional efficiency in the production of old goods due to process innovation after considering the pass-through of productivity improvements to prices.[11] Alternatively, this result could reflect reactive process innovation in response to negative productivity growth shocks. Further study needs to be done using updated data in order to evaluate this exploratory finding.

The 0.5 coefficient found for the new product sales is surprisingly far below unity, which means that productivity growth seems to come mainly from the replacement of old products by new products. It is important to emphasise that this is a firm-level study and this way the sales growth due to innovation processes cannot be separated between market expansion and changes in composition. If the sales growth generated by innovation processes had to do with changes in

Table 4. The effects of process innovation on employment.

Explanatory variables	A: OLS	B: IV[1]	C: IV[2]
New product sales growth	0.358	0.557	0.549
	(0.090)	(0.179)	(0.180)
Process only innovation	0.133	0.132	0.132
	(0.241)	(0.241)	(0.241)
Investment/sales during the period	−0.235	−0.366	−0.361
	(0.095)	(0.158)	(0.180)
Constant	−0.323	−0.423	−0.419
	(0.073)	(0.121)	(0.121)
No. of firms	514	514	514
Test of over-identifying restrictions			0.046
(degrees of freedom)			(1)
Prob > chi2			0.829

Notes: Dependent variable: $\ell - (g_1 - \pi_1^*)$. Coefficients and standard errors robust to heteroscedasticity. All regressions include industry dummies, and investment/sales controls.
[1] Unique instrument used is new inputs utilisation as an origin of the innovative idea.
[2] Instruments are new inputs utilisation as an origin of the innovative idea and increased range.

the market composition and not with a net expansion of the market, the added impact of innovation on employment would be smaller than the firm-level effect that we have calculated.

It would be very useful to evaluate which economic sectors have the highest productivity growths associated with 'new products sales growth'. Unfortunately the limited number of observations does not allow us to distinguish the effect of new products sales growth over employment among different economic sectors.

In panel C we have added an additional instrument and evaluated the specification by means of a test for over-identifying restrictions. The additional instrument that we have used is the degree of impact of the innovation on the increase of the range of goods produced by the company. Even though this instrument has a smaller correlation with the endogenous variable than the instrument used in the previous regression, we have no reason to think that this variable could be related to the change in the prices of new products compared with old products. After performing the test with no rejection of the null hypothesis, we can conclude that used instruments are valid.

Observing the standard errors of our estimations, we can conclude that the confidence intervals of the OLS and the IV estimations are overlapped, which tells us that they could not be significantly different. It is important to consider that the standard errors of all independent variables are inflated due to the presence of measurement error in the dependent variable $\ell - (g_1 - \pi_1^*)$. The reason for the dependent variable to be measured with error is that its second term is not observed directly but it is constructed with the available data. Moreover, the parameter of the variable g_2 is negatively biased because it also has a measurement error and it has not been completely isolated from the price effects. Hence, we have reason to believe that the IV estimations could well be underestimating the effect of g_2 on employment.

All regressions have been controlled for investment during the period and sectoral dummies according to ISIC, Rev. 2 classification.[12] Estimating the same equations without control variables in previous stages of our work resulted in biased parameters. The result of including the investment control variable has been reported only for the estimations of Table 4.

In Table 5 we introduce separately the process innovations of firms that also perform product innovations. Since we do not know whether these process innovations refer to the production of

Table 5. Innovation effects on employment, interacting process and product innovations.

Explanatory variables	A: IV[1]	B: IV[2]
New product sales growth	0.553	1.099[3]
	(0.224)	(3.219)
Process only innovation	0.130	0.135
	(0.250)	(0.232)
Process and product innovation	−0.002	
	(0.078)	
New product sales growth * process and product innovation		−0.530
		(2.967)
Constant	−0.418	−0.428
	(0.124)	(0.169)
No. of firms	514	514

Notes: Dependent variable: $\ell - (g_1 - \pi_1^*)$. Coefficients and standard errors robust to heteroscedasticity. All regressions include industry dummies, and investment/sales controls.
[1] Instruments are new inputs utilisation as an origin of the innovative idea and increased range.
[2] Instruments are new inputs utilisation as an origin of the innovative idea and increased range and both of these variables interacted with 'process and product innovation'.
[3] Covariance between parameters 'Sales growth due to new products' and 'Sales growth due to new products * Process and product innovation' is −9.54.

the old or new products we try both alternatives. In Panel A we assume that all the process innovations of product innovators refer to production of the old product, while in Panel B we assume that they all refer to production of the new product.

The coefficient on process and product innovation in Panel A is negative but very small and insignificant, apparently suggesting that process innovations of product innovators are not as associated with the production of the old product as they may be with the production of new products.

In Panel B we introduce an interaction between the process and product innovation dummy and sales growth due to the introduction of new products.[13] This allows the productivity in the production of new products to be different for firms that also introduce process innovations.

Our results show that productivity growth is not associated directly with the introduction of new products only, since the parameter that accompanies sales growth due to new products is even larger than unity. Moreover, we find that there is an important element of productivity growth associated with the introduction of both process and product innovations. For process and product innovating firms, the total impact of 'new products sales growth' on the dependent variable is 0.569 and this result is highly significant. For product only innovating firms (only eight firms of the sample), the impact of 'new products sales growth' on the dependent variable is non-significant.

Given the available data, we are not able to distinguish whether the hypothesis embodied in Panel B is true. These findings are still of an exploratory nature and will need confirmatory evidence provided by further data. For this reason, our preferred specification is that in Panels B and C of Table 4, where we can be sure that the process innovations of firms that do not introduce new products relate to the production of the old product.

5 Concluding remarks

This study has evaluated the impact of process and product innovations on the change of total employment at the firm level in Chile during the late 1990s. To this end data collected following the OECD, Oslo Manual (2005) directions has been used.

We found that product innovations positively and significantly affect employment in Chilean firms. Surprisingly, the magnitude of this impact was found to be half of the impact found in previous studies, suggesting a very high labour productivity growth associated with the introduction of new products in Chilean firms.

When including process innovation in the model, we have not found evidence to conclude that employment is significantly affected by this kind of innovation. According to our model, this result means that the effect of productivity growth on employment associated with process innovations is being compensated through final goods price reductions.

Results showed that for the production of 'old goods', productivity growth of firms is approximately 0.4% in a three-year period. Therefore, evidence from this work suggests that the increase in productivity of the Chilean firms during the late 1990s is mainly due to the introduction of new products.

The results obtained so far should be confirmed by further careful analyses, using better and richer data and developing more complex models encompassing the simple yet stimulating approach followed in Harrison et al. (2005) and in the present paper.

Acknowledgements

We would like to thank Bronwyn Hall, Jacques Mairesse, Pierre Mohnen, Tomas Rau, and specially two anonymous referees for their comments and suggestions. A first version of this paper was presented at the MEIDE conference that took place on 31 May and 1 June 2007 at UNU-Merit University in the Netherlands. All disclaimers apply.

Notes

1. The measurement of the innovative process, the importance of innovation and the relation between innovation and productivity has been previously studied in Mairesse and Mohnen (2001), and Crepon, Duguet and Mairesse (1998). There is also evidence of a link between innovation and competitiveness, see Geroski (1995).
2. Results from the Chilean National Innovation Survey – based on the CIS structure, show that labour-related issues are the main obstacle to innovate in the Chilean manufacturing firms (Benavente 2005a).
3. A similar pattern may be deduced for the product innovation case. See Harrison et al. (2005) for a detailed discussion.
4. There are several studies previously dealing with this question. Most, if not all of them, focused on developed countries. Alonso-Borrego and Collado (2001), and García, Jaumandreu and Rodriguez (2004) for Spain. Piva and Vivarelli (2003) for Italy and Peters (2005) for Germany. A comparative study on this issue between France, Germany, Spain and UK can be found in Harrison et al. (2005) On the other hand, Chennells and Van Reenen (1999) studied the impact of innovation on the composition of employment using British data.
5. For a detailed discussion about what Chile is doing related with innovation see Benavente (2005b)
6. Notice that the first index refers to the type of product – old or new – and the second to the period − 1 or 2.
7. This index has been obtained from the work by Benavente, De Grogorio and Nuñez (2006).
8. This is possible, for example, under the assumption that exogenous technological change comes from outside of the companies as a set of shocks and that these are, on average, identical for all the companies in the economy.
9. The correlation between this instrument and the endogenous variable is 0.24.
10. See Wooldridge (2002) for a detailed explanation of this test.
11. Large pass-through of productivity improvements in prices could be related to the high levels of nominal price growth in the same period.
12. International Standard Industrial Classification of All Economic Activities disaggregated with two digits.
13. We also introduce as additional instruments the interaction between process and product innovation dummy and the existing instruments.

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Appendix: Variable definitions

- Clients as source of information: Variable that takes value 0 if the company reports that it has not used clients as a source of information for the innovation process, and values from 1 to 4 according to the intensity of use of clients as a source of information.
- Permanent R&D engagement: Variable dummy that takes value 0 if the company reports not to have an R&D department and 1 in the opposite case.
- Employment growth: $\dfrac{empl2001 - empl1998}{empl1998}$.
- Increase in the product range: Variable that takes value 0 if the company reports that the effect of the innovation has been irrelevant for the range of goods produced by the company; and values between 1 and 8 according to the intensity which the innovation has increased the range of products.
- New inputs: Variable that takes value zero if the innovative idea is not related to the use of new inputs, and takes values between 1 and 4 according to the level in which the company declares to have used new inputs as an origin to the innovative ideas
- Effort in R&D: Ratio between total R&D cost and income.
- Investment/Sales: Proportion of the income invested during the period.
- Process and product innovation: Dummy variable that takes value 1 if the company reports to have introduced new or significantly improved products and to have introduced new or significantly improved processes during the period. Otherwise it takes value 0. The innovation of design and packaging has been considered product innovation.
- Process innovation: Dummy variable that takes value 1 if the company reports to have introduced new or significantly improved processes during the period and takes value 0 otherwise. Innovation in administrative management has been considered a process innovation.
- Process and product innovation: Dummy variable that takes value 1 if the company reports to have introduced new or significantly improved processes and products during the period and takes value 0 otherwise.
- Process only innovation: Dummy variable that takes value 1 if the company reports to have introduced new or significantly improved processes during the period but no new or significantly improved products.

- Growth of the sales: $g = \dfrac{P_{22}Y_{22} + P_{12}Y_{12} - P_{11}Y_{11}}{P_{11}Y_{11}}$.
- Proportion of innovated products: $s = \dfrac{new\_product\_sales}{total\_sales}$.
- Sales growth due to new products: $g_2 = s(1 + g)$.
- Sales growth due to old products: $g_1 = g - s(1 + g)$.